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CONTENTS

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J. Res. ANGRAU 50 (4) 01-09, 2022

MORPHOLOGICAL CHARACTERIZATION OF FALSE SMUT OF RICE (*Ustilaginoidea virens*) IN TAMIL NADU

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ABSTRACT

The rice false smut caused by *Ustilaginoidea virens* (perfect stage = *Villosiclava virens*) is a serious threat to rice production. The lab experiment was conducted during the year 2021 in Tamil Nadu under *in-vitro* conditions to investigate the pathogen and its character. On PSA medium the colony was creamy white to white, flat, circular and raised. The fluffy, compact, leathery hyaline mycelium showed septation and the width of the mycelia was about 4.26 µm. On the obverse side of the Petri plate, a slight olive-green tinch was observed. The colony diameter ranged from 30 mm to 70 mm. Conidia were hyaline, spherical to globose in shape and warty with a width of 5.24 µm approximately. The chlamydospores were echinulated and spines were prominently decorated. Overall, the results of the investigation showed that the collected isolates of false smut were confirmed based on morphological characteristics.

Keywords: Chlamydospores, Conidia, Mycelia**,** *Ustilaginoidea virens*, Warty

INTRODUCTION

Rice is widely consumed as a staple food for a large part of the world's human population especially in Asia and Africa. *Ustilaginoidea virens* (Cook) Takahashi (teleomorph: *Villosiclava virens*), a pathogenic ascomycete fungus causes a devastating grain disease in rice (Sun *et al*., 2020). The disease was first reported by Cooke in 1878 from the Tirunelveli district of Tamil Nadu. Late in the season, the fungus produces chlamydospores and sclerotia, which remain in the soil and may survive winter. Sclerotia germinate to form ascocarps consisting of ascospores which are the primary source of inoculum and secondary spread through air borne chlamydospores (Atia 2004).However, the histology analysis revealed that the pathogen may infect the rice plant's root at the young stage and may colonise the entire plant without producing symptoms (Schroud and Te Beest, 2005; Te Beest, 2010). *Ustilaginoidea virens* are visible after flowering when the fungus transforms individual grains of the panicle into a yellowish smut ball, which changes to yellowish orange, green, olive

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green and finally to greenish black. Furthermore, the fungi's ustiloxins degrade rice grain quality and are inadvertently added to the harvest (Lu *et al*., 2009). False smut has emerged as one of the major diseases in recent times in India including Tamil Nadu. The study has been undertaken to characterize the isolates of *Ustilaginoidea virens* prevalent in different rice-growing tracts of Tamil Nadu.

MATERIALS AND METHODS

Collection and Isolation of false smut pathogen

Rice grains infected with false smut pathogens were collected from various rice-growing areas of Tamil Nadu by conducting roving surveys in 2021 and 2022 (Table 1). The infected grains showing smut ball symptoms were collected in a polythene bag and bought to the laboratory. The balls were surface sterilized twice with 70% ethanol and washed three times consequently with sterile distilled water and air dried with sterilized tissue paper. Using a sterilized scalpel, the smut balls were cut into two halves and the inner region alone was streaked using an inoculation needle against Potato Sucrose Agar (PSA) medium amended with streptomycin sulphate @ 100 ppm (Ladhalakshmi *et al*., 2012). The inoculated plates were incubated at 27°C for seven days. After 7 days yellowish creamy white colonies emerged from the streaked area and individual colonies were streaked in new PSA plates. Then the plates are stored at 4ºC for further use.

Cultural characteristics

Totally 13 isolates of *U.virens* were isolated and used for further characterization. The 8 mm actively growing mycelial discs were cut from 20-day old culture of *U.virens* and placed in the Petri plate containing 15 ml of PSA medium and the plates were incubated at 27 ºC maintaining three replications in each isolate. The colony diameter of all the isolates was measured at different time interval *viz.* 10th, 20th and 30th days.

Phase contrast microscopy

Orangish yellow false smut spores and mycelia from the culture plate were spread on an individual clean glass slide with a drop of distilled water, covered with a cover slip, and observed under phase contrast microscope LEICA at 40 X. Plate-formed chlamydospores were observed under oil immersion at 100 X. The Colour and shape of the mycelia and spores were recorded.

Scanning electron microscopy

The chlamydospores formed both *in-vitro* (Petri dish) and *in vivo* (field) condition of FS 10 and its mycelium, were coated over the specimen stub and palladium was used for sputter coating. The specimens were then examined under a high vacuum and viewed using a Quanta 250 TM FEG. The size, breadth and spines of chlamydospores were measured and photographed.

RESULTS AND DISCUSSION

Collection and isolation of false smut pathogen

The infected samples were collected from various regions of Tamil Nadu in different rice varieties. Among the collected rice samples, CO43, BPT 5204 and CR 1009 were heavily infested with the false smut pathogen. *U. virens* was more frequently isolated from the yellow colour smut balls which were observed at the initial stage because the inner region was highly protected from outer environmental conditions and surface sterilization. Hence the inner regions of the balls were used for

inoculation and collected inoculum was streaked in the PSA medium using an inoculation loop similar results were reported earlier by (Ladhalakshmi *et al*., 2012, Bashyal *et al*., 2020 and Savitha *et al*., 2022).

Cultural characteristics

A total of 13 isolates were obtained from the collected samples. A variation in growth pattern was observed among 13 isolates. The *U. virens* isolates showed slow growth in culture medium. The colony was creamy white to white, flat, circular, raised, mycelium fluffy, compact and leathery, on the obverse side with slight olive green tinch and yellowish pigmentation (Table 2). The colony diameter ranged from 38 mm to 66.66 mm after 30 days of incubation. The maximum colony diameter was observed in the isolate FS 10 (66.66 mm) while the minimum diameter in FS 4 (38 mm) (Table 3, Fig. 5). The results were in accordance with Baite *et al*. (2015), Pramoda (2016), Savitha *et al*. (2022) and Goswami *et al*. (2022), wherein, the diameter of the colonies was 34.5 mm, 66.5 mm, 71.75 and 77 mm, respectively. All the isolates produced chlamydospores either in the centre of the colony or in the middle. The spores were yellow followed by dark green at maturity. The results agreed with Ladhalakshmi *et al*. (2012). On the obverse side, all the isolates showed a faint olive green tinch or yellowish pigmentation and the mycelium was creamy white to white, flat, circular, elevated, fluffy, compact and leathery. Baite *et al*. (2014) reported that *U.virens* had a creamy white colony that was flat or raised with few undulations and mycelium that was fluffy, compact, and leathery. Chlamydospores developed near the colony's centre or edge, first appearing orange or yellow and then turned green. Lin *et al*. (2018) reported the colony morphology was milky white and olive green with fluffy mycelium, flat or slightly convex surfaces, compact and leathery. Bashyal *et al*. (2020) reported that fluffy mycelia were transformed into silky white, extremely dense leathery growth after 20 days of incubation. Some of the isolates had yellow chlamydospores that appeared in the middle or margins of the colony and eventually turned green. Goswami *et al*. (2022) reported the characteristics of white-reddish yellow, fluffy, compact, undulated colony to without undulation, wavy colony edge and white-greenish grey to black colony.

Microscopic studies

Initially, the balls were white in colour (Fig. 1A) later turned to orangish yellow colour (Fig. 1B) followed by dark olive green colour (Fig. 1C). The infected smut balls were cut into two halves and examined the inner region consisting of three layers. In the case of white balls, the innermost and second layer showed white colour and yellow in the outer layer (Fig. 2A). In the case of orangish yellow balls, the innermost layer was white, while the outer two layers were yellow in colour (Fig. 2B). In the case of dark olive green balls, the inner region was white, the second region was yellow and the outer was dark green (Fig. 2C). Similar results were documented by Nessa (2017) with slight differences. The yellow smut spores were round to globose in nature, olive green in colour and two walled and no prominent spines were noticed under phase contrast microscope and its size was 5.24 µm approximately (Fig. 3A). The germination of chlamydospores producing aseptate conidiophore bearing hyaline, oval conidia at the tip was observed at 40 X (Fig. 3B). The similar findings were reported by Ladhalakshmi *et al*. (2012), Prakobsub and Ashizawa (2017) and Savitha *et al*. (2022).

Table 1. Details of collection of samples of 13 isolates

S.No.	Isolates name	Places of sample collection		GPS coordinates
		District	Village	
1	FS 1	Thanjavur	Pathirakudi	10.7870^{0}N, 79.1378^{0}E
2	FS 2	Madurai	Otthakadai	9.9584^{0}N, 78.1877^{0}E
3	FS 3	Tirunelveli	Ambasamudram	8.7093^{0}N, 77.4530^{0}E
4	FS 4	Nagapattinam	Nallanayakipuram	11. 1940^{0}N 79.4359^{0}E
5	FS 5	Erode	Sathyamangalam	11.5034^{0}N, 77.2444^{0}E
6	FS 6	Dharmapuri	Kondampatti	12.1211^{0}N, 78.1582^{0}E
7	FS 7	Coimbatore	Paddy Breeding Research Station	10.9954^{0}N, 76.9156^{0}E
8	FS 8	Villupuram	Poipakkam	11.9459^{0}N, 79.4974^{0}E
9	FS 9	Cuddalore	Vadalur	11.3229^{0}N, 79.3444^0 E
10	FS 10	Cuddalore	Panrutti	11.4635^{0}N, 79.3396^{0}E
11	FS 11	Salem	Santhiyur	11.5628^{0}N, 78.1439^{0}E
12	FS 12	Kallakurichi	Aviyur	11.7381^{0}N, 78.9638^{0}E
13	FS 13	Vellore	Chinnaudayamuthur	12.4950^0 N, 78.5678^{0}E

The mycelium was hyaline, septate with a width of about 4.26 µm under 40 X (Fig. 3C). The plate-formed chlamydospores of FS 10 isolate was warty, spherical to globose, light brown in colour at 40 X and 100 X (Fig. 3D and 3E). Kim (2007) documented that conidia were 3-5 µm, warty and round to elliptical. Ladhalakshmi *et al.* (2012) documented the shape of conidia was spherical to elliptical, double walled and thick. The chlamydospores size was approximately 5.24 µm, warty, round to globose, olive green in colour without spines at 40 X. Baite *et al*. (2014) reported the spore was warty in nature and globose to spherical.

The SEM image of chlamydospores at 10000 X magnification revealed their spiny nature. They were globose to spherical in shape. The spines were either sharp at the tip or irregularly curved. The size of the field and plate-formed chlamydospores of FS 10 isolate varied from 4.75 µm and 5.65 µm, respectively (Fig. 4A, 4B). The plate-formed spores were larger in size compared to field-formed chlamydospores and the mycelium was septate (Fig. 4C). The results were in accordance with Kim (2007), Baite *et al*. (2014), Pramoda (2016), Kumari and Sharma (2017) and Goswami *et al*. (2022) reported that the chlamydospores were found to be 3-5 µm in size, globose to spherical and adorned with prominent spines (200-500 nm).

CONCLUSIONS

False smut pathogen was confirmed morphologically based on their cultural character growth pattern and microscopic observation. Among the 13 isolates, FS 10 isolate was fast-growing with a mycelial growth of 66.66 mm. The chlamydospores produced *in vitro* by FS 10 were bigger in size compared to *in vivo* collected chlamydospores. In connection with the above findings, further confirmation will be useful to identify the variability among all the 13 isolates.

Table 2. Mycelial characteristics of different isolates of *U. virens* on PSA medium

S. No.	Isolates name	Mycelial colour		Growth type	Sporulation
		Front side	Obverse side		
1	FS 1	White to yellow	Concentric rings, Yellow with olive green tinch	Flat and circular	+++
2	FS 2	Creamy white	Concentric rings with dark olive green tinch	Flat and irregular	++
3	FS 3	Creamy white	Creamy white with olive green tinch	Fluffy, raised and irregular	++
4	FS 4	Creamy white	Creamy white with yellow tinch	Flat and circular	+
5	FS 5	Creamy white	Creamy white	Flat and circular	+++
6	FS 6	Creamy white	Creamy white with olive green concentric ring	Flat, fluffy and circular	++
7	FS 7	Cottony white	Creamy white with yellowish olive green concentric rings	Flat and regular with undulations	++
8	FS 8	White to light yellow	Creamy white with yellow tinch	Flat and circular	+
9	FS 9	Creamy white	Creamy white with olive green concentric rings	Fluffy, raised and regular	+++
10	FS 10	Creamy white	Creamy white with yellow tinch	Raised, fluffy and circular	++
11	FS 11	Creamy white	Yellow to olive green concentric rings	Fluffy, flat and circular	+
12	FS 12	Whitish yellow	Creamy white with olive green tinch	Yellow pigmentation with olive green concentric rings	+++
13	FS 13	Cottony white	Creamy white with light olive green tinch	Flat and regular	++

Note: + - Low; ++ - Medium; +++ - High

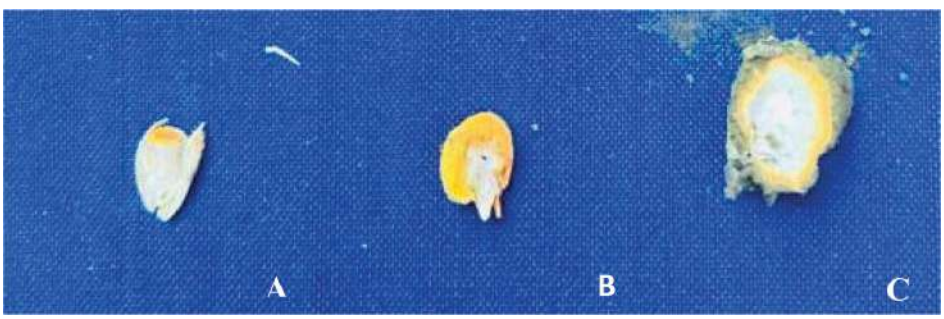
Table 3. Growth characteristics of isolates at the different time intervals

S.No.	Isolates name	Radial mycelium growth (mm)		
		10th day	20th day	30th day
1	FS 1	20.00^{a}(26.54)	31.00^{e}(33.83)	50.67^{cd}(45.38)
2	FS 2	28.66a^{b}(32.34)	48.33^{b}(41.55)	58.00^{b}(49.60)
3	FS 3	13.33^{g}(21.39)	25.67^{fg}(30.41)	43.33^{ef}(41.16)
4	FS 4	22.33^{de}(28.19)	27.33^{f}(31.50)	38.00^{fg}(38.05)
5	FS 5	13.67^{g}(21.67)	21.00^{h} (27.27)	36.67^{g}(37.26)
6	FS 6	23.33^{cde}(28.87)	39.33^{c}(38,83)	54.33^{de}(43.61)
7	FS 7	21.00^{def}(27.27)	22.33^{h}(28.17)	34.33^{g}(35.86)
8	FS 8	14.00^{g}(21.91)	23.33^{gh}(28.87)	40.00^{fg}(39.23)
9	FS 9	20.00^{ef}(26.53)	36.00^{d}(36.86)	50.33^{cd}(45.19)
10	FS 10	29.67^{a}(33.41)	48.33^{a}(44.04)	66.67^{a}(54.73)
11	FS 11	24.00^{cd}(29.32)	42.67^{b}(40.78)	60.00^{b}(50.76)
12	FS 12	26.33^{bc}(30.86)	43.33^{b}(41.16)	56.33^{bc}(48.64)
13	FS 13	18.33^{f} (25.34)	28.00^{ef}(31.93)	43.33^{ef}(41.16)
	CD @ 5%	**3.41**	**1.92**	**3.67**

* Values are mean of three replications; Figures in parentheses are arcsine transformation values Means in a column followed by same superscript letters are not significantly different according to DMRT at P ≤ 0.05.

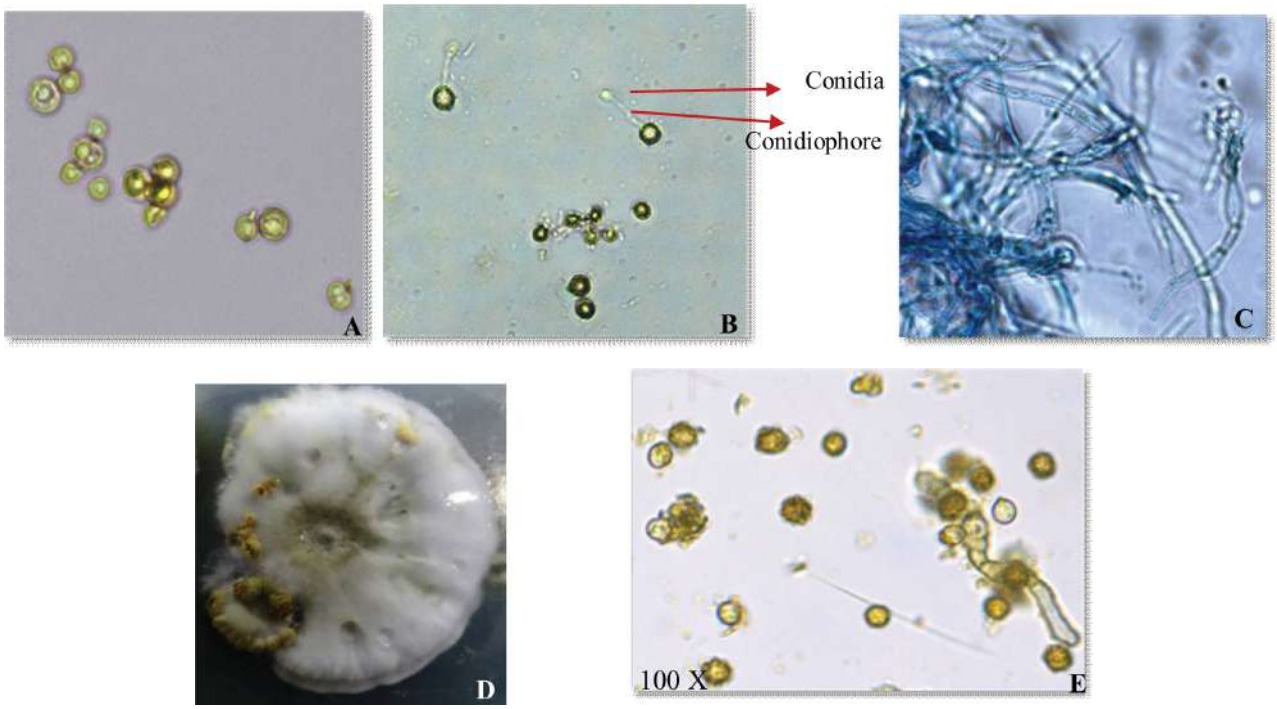
(A) Initial stage (B) Intermittent stage (C) Matured stage

Fig. 1. Developmental stages of false smut balls



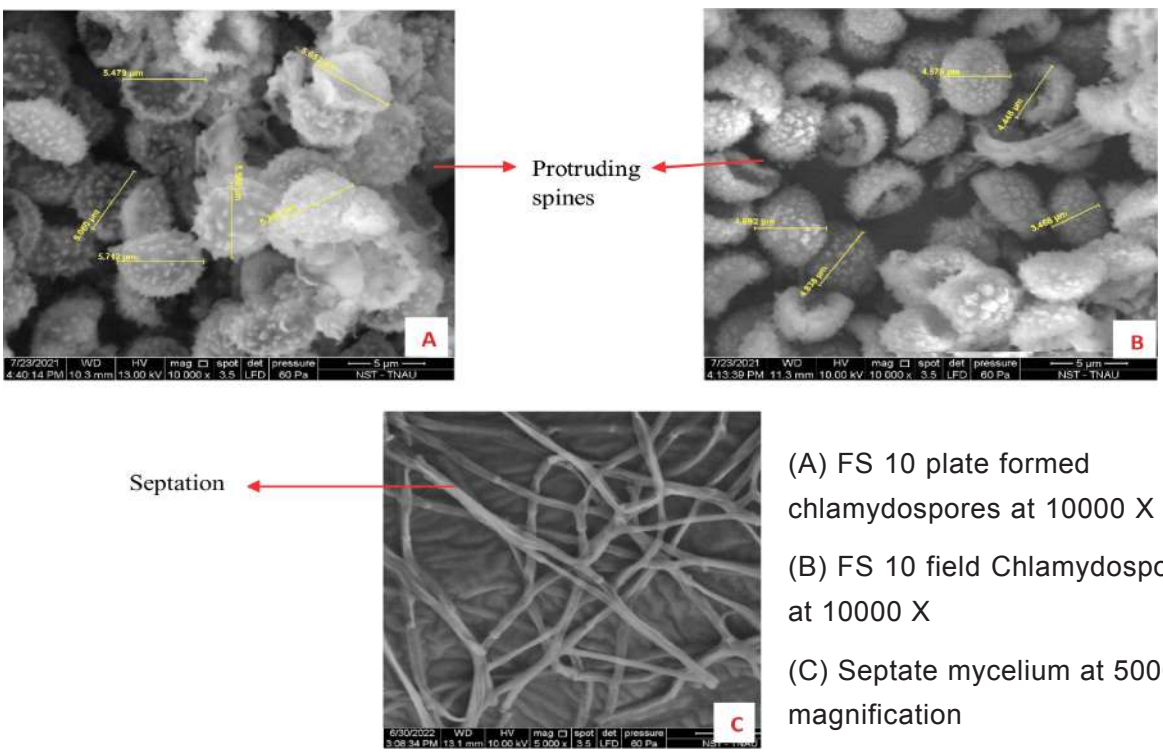
(A) White ball (B) Yellow ball (C) Dark olive green ball

Fig. 2. Cross–sectional view of smut balls



(A) Double-walled Chlamydospore at 40 X (B) Chlamydospore germination forming conidia at 40 X (C) Hyaline, sepate mycelia at 40 X (D) (E) FS 10 plate formed spores

Fig. 3. Phase contrast images of chlamydospores and mycelium



(A) FS 10 plate formed chlamydospores at 10000 X

(B) FS 10 field Chlamydospores at 10000 X

(C) Septate mycelium at 5000 X magnification

Fig. 4. SEM photograph revealing the ornamental nature of smut spores and mycelium

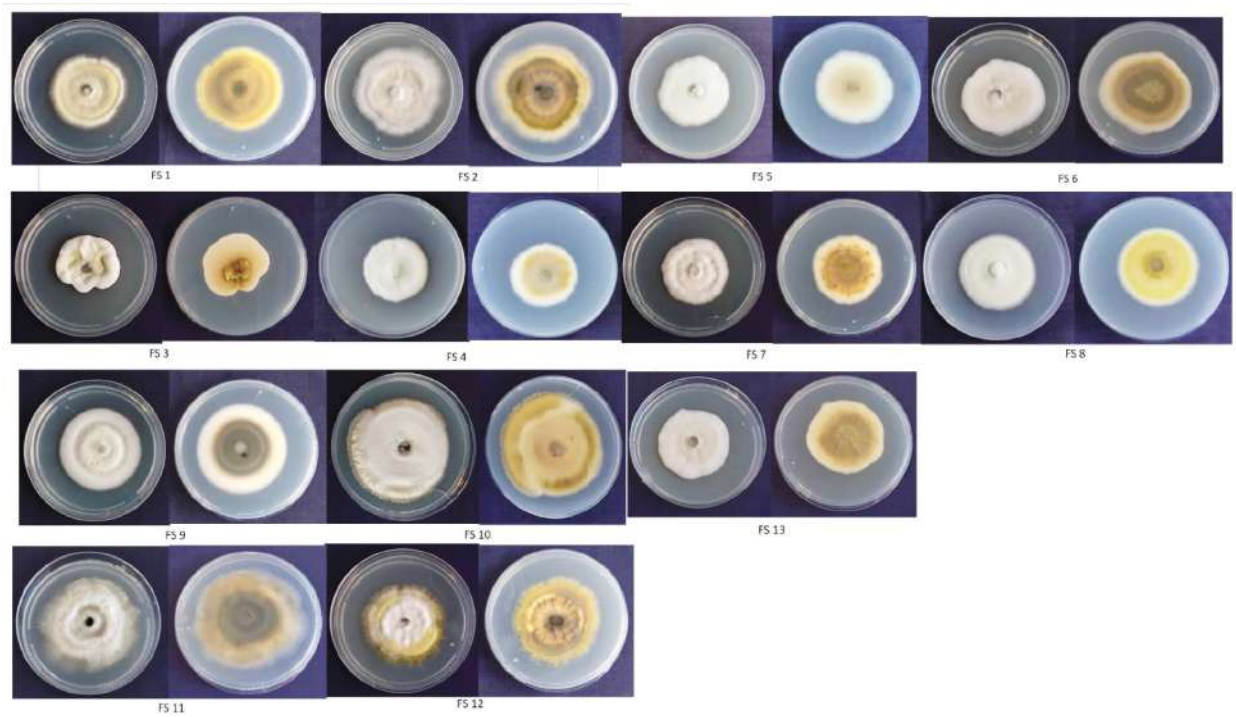


Fig. 5. Culture plate photos of 13 isolates showing the front and obverse sides

REFERENCES

Atia, M.M.M. 2004. Rice false smut (*Ustilaginoidea virens*) in Egypt. Journal of Plant Disease Protection. 111(1): 71-82.

Baite, M.S and Sharma, R.K. 2015. Isolation technique and culture conditions of false smut pathogen (*Ustilaginoidea virens*) on rice. Indian Phytopathology. 68(1):50-55.

Baite, M.S., Sharma, R.K., Devi T.P., Sharma, P.R and Kamil, D.E. 2014. Morphological and molecular characterization of *Ustilaginoidea virens* isolates causing false smut of rice in India. Indian Phytopathology. 67(3):222-227.

Bashyal, B.M., Parmar, P., Zaidi, N.W., Sunani, S.K., Prakash, G and Aggarwal, R. 2020. Improved methodology for the isolation of false smut pathogen *Ustilaginoidea virens* of rice. Indian Phytopathology. 74(1):249-252.

Goswami, S.K., Thakur, C., Choudhary, P., Verma, S., Tiwari, P., Das, S., Shahid, M., Singh, B.N., Chakdar, H., Kumar, M and Srivastava, A.K. 2022. Characterization of *Ustilaginoidea virens* causing rice false smut and its bio-control in North India. Indian Phytopathology. 75:565-571.

Kim, K.W and Park, E.W. 2007. Ultrastructure of spined conidia and hyphae of the rice false smut fungus *Ustilaginoidea virens*. Micron. 38(6):626-631.

Kumari, P and Sharma, R.K. 2017. Histopathological and molecular characterization of *Ustilaginoidea virens* in rice. Indian Phytopathology. 70(3):326-330.

Ladhalakshmi, D., Laha, G.S., Singh, R., Karthikeyan, A., Mangrauthia, S.K., Sundaram, R.M., Thukkaiyannan, P and Viraktamath, B.C. 2012. Isolation and characterization of *Ustilaginoidea virens* and survey of false smut disease of rice in India. Phytoparasitica. 40(2):171-176.

Lin, X., Bian, Y., Mou, R., Cao, Z., Zhu, Z and Chen, M. 2018. Isolation, identification and characterization of *Ustilaginoidea virens* from rice false smut balls with high ustilotoxin production potential. Journal of Basic Microbiology. 58(8):670-678.

Lu, D.H., Yang, X.Q., Mao, J.H., Ye, H.L., Wang, P., Chen, Y.P., He, Z.Q and Chen, F. 2009 Characterising the pathogenicity diversity of *Ustilaginoidea virens* in hybrid rice in China. Journal of Plant Pathology. 91(2):443-451

Nessa, B.O. 2017. Rice false smut disease in Bangladesh: Epidemiology, yield loss and management. Ph. D. Thesis submitted to University of Sylhet, Bangladesh.

Prakobsub, K and Ashizawa, T. 2017. Intercellular invasion of rice roots at the seedling stage by the rice false smut pathogen, *Villosiclava virens*. Journal of General Plant Pathology. 83(6):358-361.

Pramoda, S. 2016. Studies on screening germplasam against false smut (*Ustilaginoidea virens*) and brown spot (*Bipolaris oryzae*) and their management in rice. M. Sc. Thesis submitted to Tamil Nadu Agricultural University, Tamil Nadu.

Savitha, A.S., Nagaraja, A and Ajith Kumar, K. 2022. Variability studies of *Ustilaginoidea virens* isolates causing false smut and its severity in different rice growing ecosystems of Karnataka. The Pharma Innovation Journal. 11(2):01-08.

Schroud, P and Te Beest, D. O. 2005. Germination and infection of rice roots by spores of *Ustilaginoidea virens.* AAES Research Series. 540:143-151.

Sun, W., Fan, J., Fang, A., Li, Y., Tariqjaveed, M., Li, D., Hu, D and Wang, W.M. 2020. *Ustilaginoidea virens*: insights into an emerging rice pathogen. Annual Review of Phytopathology. 25:363-385.

Te Beest, D. 2010. Infection of rice by *Ustilaginoidea virens*. Phytopathology. 100:125.

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PROGRESS OF FUNGAL FOLIAR DISEASES IN RELATION TO WEATHER PARAMETERS IN COTTON

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ABSTRACT

Progress of fungal foliar diseases as influenced by different weather parameters in two BG II cotton hybrids (Jaadoo and RCH 2) and one straight variety (L 1060) was studied during *kharif* 2019-20.Disease severity was scored by adopting a standard scale of 0 to 4 in ten plants tagged randomly in each plot. Weather parameters were recorded at the meteorological observatory, RARS, Lam, Guntur.Correlation and multiple regression analysis were carried out between per cent disease index and weather parameters using MS-Excel program version 2010. Multiple regression analysis revealed certain differences in weather factors influencing the progress of diseases in different genotypes.Sunshine hours, the number of rainy days and wind speed are the common critical parameters contributing to the development of Alternaria and Corynespora leaf spots; minimum temperature and wind speed in case of grey mildew; RH II for rust are favourable parameters in cotton.

Keywords: Aternaria leaf spot, Corynespora leaf spot, Cotton, Disease progress, Grey mildew, Weather

INTRODUCTION

Cotton is an important commercial crop in India with a production of 371 lakh bales of 170 kg lint from an area of 129.57 lakh ha and a productivity of 487kg ha^{-1} in 2020-2021, which is far behind the leading countries like Australia (2059 kg ha^{-1}), China (1943 kg ha^{-1}) and Brazil (1727 kg ha$^{-1)}$. Andhra Pradesh stood 8th in the area (5.24 lakh ha) and production (18.0 lakh bales) but 3rd in productivity (584 kg ha^{-1}) (ICAR-AICRP on Cotton, 2021). Fungal diseases including leaf spots, grey mildew and rust are of regular occurrence in cotton. In India, foliar diseases have been estimated to cause yield losses up to 20 to 30 percent. Losses due to Alternaria leaf spot/blight were to the tune of 38.23% in cotton variety LRA 5166 (Bhattiprolu and Prasada Rao, 2009) and 33.43% in variety Jayadhar (Chattannavar *et al.*, 2010).

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$$PDI = \frac{\text{Sum of numerical ratings}}{\text{Total number of leaves scored X maximum rating}} \times 100$$

Corynespora target spot caused lint yield loss in susceptible cotton cultivars as high as 224-448 kg ha^{-1} equivalent to 5% to 40% (Conner *et al*., 2013; Hagan *et al.,* 2015). Losses due to grey mildew up to 29.20 percent were estimated (Monga *et al*., 2013). Avoidable losses due to rust disease were estimated to be 21.7% in Bunny Bt (Monga *et al*., 2013) and 34.05% in RCH 2 BG II (Bhattiprolu, 2015). Understanding the influence of weather factors on host stage and disease development is a prerequisite to strategically manage these diseases. In view of the importance of Alternaria leaf spot, Corynespora leaf spot, grey mildew and rust in cotton, the experiment was conducted to assess the progress of these diseases in relation to weather factors along with thephenological stage of the crop.

MATERIALS AND METHODS

The field experiment was conducted to assess the severity of fungal foliar diseases of cotton in relation to weather parameters through correlation and regression analysis during *kharif* 2019-20 at RARS, Lam, Guntur. Two hybrids *i.e.,* Jaadoo BG II, RCH 2 BG II and one variety, L 1060 were sown on 26.07.2019 in an area of 150 sq. m with a spacing of 105 cm x 60 cm. Disease severity was scored in ten plants tagged randomly in each plot. Data on the severity of fungal foliar diseases were recorded from 15 DAS up to harvesting at four days intervals in each plot by adopting a 0-4 scale where 0 = No disease; 1 = 0 to 5%; 2 = 5.1 to 20%; 3 = 20.1 to 40% and 4 = >40% leaf area are diseased. Depending on the scores collected, percent disease index (PDI) was calculated by using the formula of Wheeler (1969) as given above.

Weather parameters were recorded at the meteorological observatory, RARS, Lam, Guntur. Mean of each parameter was calculated at four days interval, whereas rainfall was pooled for four days. Correlation and multiple regression analysis were carried out between PDI and weather parameters, *viz*., maximum temperature (Tmax, °C), minimum temperature (Tmin,°C), morning relative humidity (RH I %), evening relative humidity (RH II rainfall (mm), number of rainy days (Rd), sunshinehours (SSH), wind velocity (WS, kmph) and evaporation (mm) using MS-Excel program version 2010 to identify the critical parameters for the development of fungal foliar diseases.

RESULTS AND DISCUSSION

Alternaria leaf spot: The disease first appeared at 43 DAS in Jaadoo BG II with 2.00 PDI and reached the peak at squaring and flowering stage at 87 DAS with 16.25 PDI (Table 1). Assessment of correlation coefficient (r) values revealed significant positive correlation of PDI with RH I and RH II; significant negative correlation with minimum temperature, sunshine hours and wind speed. Significant positive correlation with Rd was observed in case of RCH 2 BG II and L 1060 only. Multiple regression analysis revealed certain differences in weather factors influencing the progress of diseases in different genotypes. Sunshine hours alone accounted for 71.10 percent (R2=0.711) variation in Jaadoo

BG II. SSH coupled with Tmin caused 77% variation in PDI. RH I, RH II and Rd significantly influenced PDI in RCH 2 BG II with R^2 value of 0.692. In case of L 1060 SSH accounted for 77.43 percent (R^2=0.774) variation and WS accounted for 43.78 percent (R^2=0.437) variation. SSH together with wind speed caused 85% variation in PDI.

Corynespora leaf spot: Maximum, minimum temperatures, Rf and Rd expressed significant negative correlation, whereas, evaporation showed significant positive correlation with PDI. RH II registered significant positive correlation in RCH 2 BG II only; sunshine hours showed significant positive correlation with PDI in RCH 2 BG II as well as L 1060. Maximum temperature, RH I, RH II, Rd, SSH and WS significantly influenced the progress of disease in all the three genotypes whereas, minimum temperature also contributed for disease progress in Jaadoo BG II and L 1060 (R^2= 0.949 and 0.977, respectively) and evaporation contributed in RCH 2 BG II (R^2 =.0.986).

Grey mildew: Maximum, minimum temperatures and sunshine hours exhibited significant negative correlation, whereas, RH II showed significant positive correlation with PDI; RH expressed significant negative correlation in L 1060. Minimum temperature and wind speed commonly influenced the diseases progress in all the three genotypes. RH I and RH II contributed in Jaadoo BG II to give R2 value of 0.978. Similarly, Rf and Rd contributed in RCH 2 BG II (R2=0.945) and L 1060 (R2=0.990); SSH also contributed for disease progress in L 1060.

Rust: RH I showed significant negative correlation; wind speed and evaporation showedsignificant positive correlation with PDI. RH II was common contributing factor in all the three genotypes. Maximum temperature, Rd, WS also contributed in RCH 2 BG II (R2= 0.997) and L 1060 (R^2=0.998). Minimum temperature and RH I also promoted rust in Jaadoo BG II (R^2=0.85), whereas, RH I contributed in L 1060.

Chattannavar *et al.* (2002) reported that severity of Alternaria blight on cotton was more between 20-28°C temperature, 65-90 percent relative humidity associated with frequent rainfall. Gowdar *et al.* (2007) recorded negative correlation of incidence of Alternaria leaf spot with weather parameters except maximum temperature. Hosagoudar (2012) observed that maximum, minimum temperatures, RH (morning and evening) and rainy days significantly influenced the intensity of Alternaria leaf spot in cotton.Temperature regime of 20 - 30°C with prolonged high humidity (>80%) and frequent rains favoured *Alternaria macrospora* infection and disease development in cotton (Johnson *et al.*, 2013). Minimum temperature and afternoon relative humidity werefound critical to forecast the Alternaria blight disease in cotton genotypes (Venkatesh *et al.*, 2013). Singh and Ratnoo (2013) observed that 28.8-31 °C and 86-93% RH were conducive for Alternaria leaf spot (*A. gossypina*) and recorded negative correlation of PDI with minimum temperature and positive correlation with maximum relative humidity. Significant negative correlation of PDI with maximum, minimum temperatures and positive correlation with morning RH and sunshine

Table 1. Progression of fungal foliar diseases in relation to phenological stages of the cotton crop during *kharif* 2019-20

Std wk	Date of observation	Phenological stage	Per cent Disease Index (PDI)											
			Alternaria leaf spot			Corynespora leaf spot			Grey mildew			Rust		
			Jaadoo BG II	RCH 2 BG II	L 1060	Jaadoo BG II	RCH 2 BG II	L 1060	Jaadoo BG II	RCH 2 BG II	L 1060	Jaadoo BG II	RCH 2 BG II	L 1060
36	06.09.19	Vegetative stage	2.00											
37	10.09.19	Square initiation	3.25	1.25										
37	14.09.19	Squaring	4.50	3.00	1.25									
38	18.09.19	Squaring and flower initiation	6.25	4.50	3.00	2.75	3.50	3.50						
38	22.09.19	Flowering	8.00	6.00	4.50	4.25	5.25	4.75						
39	26.09.19	Flowering	10.50	7.25	6.00	7.25	7.50	6.75						
39	30.09.19	Flowering	11.25	8.75	7.50	9.25	9.00	7.50						
40	04.10.19	Squaring and flowering	12.00	9.25	8.25	11.00	10.75	10.50						
41	08.10.19	Squaring and flowering	13.50	10.00	9.00	12.25	11.50	11.75						
41	12.10.19	Squaring and flowering	14.75	11.25	9.25	13.75	13.00	13.25						
42	16.10.19	Squaring and flowering	15.25	11.75	10.00	14.50	14.75	16.25						
42	20.10.19	Squaring and flowering	16.25	12.00	10.50	17.25	16.00	18.75						
43	24.10.19	Boll initiation	15.00	11.25	9.50	19.00	17.25	20.25						
43	28.10.19	Boll formation stage	14.25	9.00	8.00	21.25	19.25	23.25						
44	01.11.19	Boll formation stage	13.25	8.50	7.25	24.00	20.75	25.50	3.00					
45	05.11.19	Boll formation stage	11.75	6.25	6.50	26.25	22.00	31.50	4.25					
45	09.11.19	Boll development stage	9.50	5.00	5.00	29.75	26.50	34.25	6.50					
46	13.11.19	Boll development stage	7.00	4.25	2.50	30.25	31.00	40.50	8.50	1.50				
46	17.11.19	Boll development stage	4.25	2.25	1.00	33.00	36.25	42.25	10.00	2.00	1.00			

Table 1 Cont'd.

Table 1 Cont'd.

Std wk	Date of observation	Phenological stage	Per cent Disease Index (PDI)											
			Alternaria leaf spot			Corynespora leaf spot			Grey mildew			Rust		
			Jaadoo BG II	RCH 2 BG II	L 1060	Jaadoo BG II	RCH 2 BG II	L 1060	Jaadoo BG II	RCH 2 BG II	L 1060	Jaadoo BG II	RCH 2 BG II	L 1060
47	21.11.19	Boll maturity stage	0.50	0.50	0.50	34.75	39.00	46.75	13.75	2.50	1.25			
47	25.11.19	Boll maturity stage				37.25	42.50	48.00	17.00	3.25	2.00			
48	29.11.19	Boll maturity stage				39.25	46.00	49.75	21.25	4.00	2.25			
49	03.12.19	Boll bursting initiation				37.25	44.25	47.25	25.75	6.50	3.00	3.00	-	-
49	07.12.19	Boll bursting stage				36.00	43.00	46.50	27.50	9.00	3.75	4.75	1.25	-
50	11.12.19	Boll bursting stage				33.00	42.25	43.00	30.00	10.25	4.00	7.25	4.25	-
50	15.12.19	Boll bursting stage				30.25	40.00	40.25	32.50	12.75	4.25	11.25	6.50	2.25
51	19.12.19	Picking stage				29.00	41.75	43.75	33.00	13.00	4.75	14.75	10.50	3.50
51	23.12.19	Picking stage				30.50	38.00	40.25	30.75	11.75	5.00	18.00	12.50	8.25
52	27.12.19	Picking stage				31.75	36.25	37.50	26.50	10.00	5.25	22.75	15.00	12.75
52	31.12.19	Boll bursting and Picking stage				29.25	34.00	35.00	22.00	9.25	4.25	28.50	18.25	16.00
1	04.01.20	Picking stage				26.00	32.25	34.00	19.75	8.75	4.00	32.00	21.00	19.25
2	08.01.20	Picking stage				24.25	30.50	32.50	17.50	7.25	3.75	36.25	24.75	22.25
2	12.01.20	Picking stage				22.75	27.00	29.50	15.75	6.50	3.00	40.50	29.25	25.00
3	16.01.20	Boll bursting and Picking stage				19.00	26.25	27.00	13.25	5.00	2.50	38.50	32.50	27.25
3	20.01.20	Picking stage				17.25	23.00	25.50	14.50	6.75	2.00	32.00	28.25	28.25
4	24.01.20	Picking stage				15.00	20.50	23.25	12.00	6.00	2.25	27.25	25.00	24.00
4	28.01.20	Picking stage				12.25	16.00	21.00	10.25	5.50	1.00	25.00	20.25	22.25

Table 2. Correlation between fungal foliar diseases in cotton and weather factors during *kharif* 2019-20

Weather Factor	Alternaria leaf spot (ALS)			Corynespora leaf spot (CoLS)			Grey mildew (GM)			Rust		
	Jaadoo BG II	RCH 2 BG II	L 1060	Jaadoo BG II	RCH 2 BG II	L 1060	Jaadoo BG II	RCH 2 BG II	L 1060	Jaadoo BG II	RCH 2 BG II	L 1060
Maximum temperature (Tmax)	-0.175	-0.105	-0.107	-0.46**	-0.572**	-0.501**	-0.584**	-0.674**	-0.781**	-0.368	-0.197	-0.152
Minimum temperature (Tmin)	-0.540*	-0.506*	-0.540*	-0.510**	-0.697**	-0.620**	-0.673**	-0.857**	-0.809**	0.101	-0.026	0.021
Morning relative humidity (RH I)	0.584*	0.555*	0.583*	0.121	-0.042	0.049	-0.178	-0.429	-0.435*	-0.607*	-0.642*	-0.716**
Evening relative humidity (RH II)	0.579*	0.581*	0.582*	0.238	0.357*	0.262	0.691**	0.575**	0.675**	-0.248	-0.376	-0.408
Rainfall (Rf)	0.186	0.274	0.202	-0.677**	-0.725**	-0.724**	-0.357	-0.319	-0.286	0.361	0.195	0.222
Rainy days (RD)	0.460	0.540*	0.490*	-0.733**	-0.794**	-0.798**	-0.284	-0.170	-0.097	0.396	0.233	0.255
Sunshine hours (SSH)	-0.843**	-0.914**	-0.88**	0.341	0.358*	0.425*	-0.588**	-0.486*	-0.619**	0.205	0.380	0.385
Wind speed (WS)	-0.643**	-0.615**	-0.662**	-0.041	0.058	0.046	-0.141	-0.002	0.040	0.711**	0.785**	0.758**
Evaporation (Evap.)	0.026	-0.056	-0.002	0.590**	0.642**	0.669**	-0.415	-0.220	-0.268	0.634*	0.756**	0.758**

ALS: N = 18; CoLS: N=32; GM: N=21; Rust: N=13; ** Significant at 1% leve l; * Significant at 5% leve l; NS:Non-Significant

Table 3. Multiple regression equations for fungal foliar diseases in cotton during *kharif* 2019-20

Disease	Cultivar	Regression equation	Coefficient of determination (R2)
Alternaria leaf spot	Jaadoo BG II	Y = 20.93- 0.141(Tmin)* -1.687 (SSH)**	0.770
	RCH 2 BG II	Y= -13.156 +0.825 (RH I)** - 0.804 (RH II)** + 5.124 (RD)**	0.692
	L 1060	Y= 13.527- 1.281 (SSH)** - 0.595 (WS)**	0.850
Corynespora leaf spot	Jaadoo BG II	Y=-200.12 - 4.077 (Tmax)** + 1.812 (Tmin)** + 2.098 (RH I)** + 1.685 (RH II)** -7.333 (Rd)** +4.394 (SSH)** - 6.305 (WS)**	0.949
	RCH 2 BG II	Y= = -227.53 - 2.367 (Tmax)** + 2.261 (RH I)** + 2.022 (RH II)** - 9.704 (Rd)** + 4.197 (SSH)** -7.016 (WS)** -5.357 (Evap.)**	0.986
	L 1060	Y= -288.64 -4.459 (Tmax)** + 1.631 (Tmin)** + 2.832 (RH I)** + 2.239(RH II)** –9.886 (Rd)** + 5.862 (SSH)** -7.496 (WS)**	0.977
	Jaadoo BG II	Y= -159.70 -3.450 (Tmin)** + 1.971 (RH I)** +1.194 (RH II)** - 6.536 (WS)**	0.979
Grey mildew	RCH 2 BG II	Y =72.66- 1.775 (Tmin)** -0.556 (Rf)**+ 6.853 (Rd)** - 1.759 (WS)** – 5.713 (Evap.)**	0.946
	L 1060	Y = 5.820-0.530 (Tmax)* -0.703 (Tmin)* +0.354 (RH I)** - 0.160 (Rf)** + 3.149 (Rd)** -0.419 (SSH)** -0.669 (WS)**	0.990
Rust	Jaadoo BG II	Y = 1349.28 -24.605 (Tmin)** -2.833 (RH I)* -3.865 (RH II)**	0.85
	RCH 2 BG II	Y = 322.77-9.955 (Tmax)** -1.297 (RH II)** + 10.445 (Rd)* + 6.439 (WS)** + 19.218 (Evap.)**	0.997
	L 1060	Y = 426.99-6.336 (Tmax)** -1.234 (RH I)**-2.280 (RH II)** + 22.510 (Rd)** + 9.809 (WS)**	0.998

* Significant at p < 5% ; ** Significant at 1% level; NS :Non-Significant

hours was recorded in cotton variety, Narasimha (Venkatesh *et al.*, 2016).Minimum temperature, evening relative humidity, rain fall and number of rainy days were negatively correlated and significantly influenced the development of Alternaria leaf spot while number of sunshine hours and evaporation showed positive significant influence in Jaadoo BG II (Bhattiprolu and Monga, 2018a).

Heavy rainfall (833.2 mm) during June to September, minimum and maximum temperature in the ranges of 19.7 °C-23.7 °C and 29.4°C-30.9 °C, respectively, and relative humidity between 78%-85% in the morning hours and 45.5%-62.0% in the evening hours, contributed for grey mildew development in Maharashtra (Shivankar, 1989) while minimum and maximum temperatures in the ranges of 24-25 °C and 28-31 °C, respectively, relative humidity between 90-91% and cultivation of highly susceptible *G. arboreum* cultivar AKH 4 were responsible for grey mildew epidemics (Mukewar *et al*.,1994).Temperature regime of 20°C–30 °C with prolonged high humidity (>80%) and frequent rains though required for infection and development of grey mildew; cool weather coupled with prolonged dewy periods in the absence of rains were also found conducive for the development of grey mildew (Johnson *et al*., 2013). Grey mildew incidence could be predicted at lead week two in the initiation phase for varieties Laxmi (R2=0.74) and DCH-32 (R2=0.92); R2 reduced with decrease in lead time (Venkatesh *et al*., 2015). Maximum temperature, minimum temperature, evaporation and morning relative humidity were negatively correlated and significantly influenced the progress of grey mildew in Jaadoo BG II (Bhattiprolu and Monga, 2018).

Significant positive impact of evening relative humidity on the incidence of rust in thecotton crop was emphasized while developing adecision support system for cotton (Nesur, 2014). Bhattiprolu *et al.* (2016) observed that RH II and SSH played a major role in thedevelopment of rust in cotton varieties *viz*., Narasimha and L 604 and also in the hybrid NSPHH 5. RH I also contributed to the progress of rust in Bunny hybrid while SSH also favoureddisease in Bunny BG II. In case of Jaadoo BG II and RCH 2 BG II hybrids, SSH alone or in combination with evaporation encouraged the severity of disease, respectively. Maximum temperature (L 604), minimum temperature (NSPHH 5), RH I (Narasimha, L 604, Bunny) andevaporation (Bunny BG II) significantly contributed to the development of rust in respective cultivars indicating genotypic differences. Furthermore, Bhattiprolu and Monga (2018b) reported that minimum temperature, morning relative humidity and evening relative humidity are the critical parameters contributing to the development of cotton rust in BG II hybrids.

CONCLUSIONS

Sunshine hours, number of rainy days and wind speed are the critical parameters contributing to the development of Alternaria and Corynespora leaf spots; minimum temperature and wind speed in case of grey mildew; RH II for rust are favourable parametersin cotton and farmers are advised to take up preventive and/or protective measures with recommended fungicides *viz*., 0.25% propineb or 0.1% propiconazole against fungal leaf spots and rust; 0.3% wettable sulphuror 0.1% kresoxim methylfor

grey mildewunder favourable weather conditions as given under weekly advisories from the University.

REFERENCES

Bhattiprolu, S.L. 2015. Estimation of crop losses due to rust *Phakopsora gossypii* (Arth.) Hirat.f disease in Bt cotton hybrid. Journal of Cotton Research and Development. 29 (2): 301 – 304.

Bhattiprolu, S.L and Prasada Rao, M.P. 2009. Estimation of crop losses due to Alternaria leaf spot in cotton. Journal of the Indian Society for Cotton Improvement. 34 (3): 151 – 154.

Bhattiprolu, S.L and Monga, D. 2018. Effect of weather parameters on the development of Alternaria leaf spot and grey mildew in cotton. Journal of Agrometeorology. 20 (4): 315-318.

Bhattiprolu, S.L and Monga, D. 2018b. Progress and severity of cotton rust in relation to weather parameters in Andhra Pradesh. Journal of Agrometeorology. 20 (3): 259-261.

Bhattiprolu, S.L., Reddy, V.C and Narayana, E. 2016. Development of rust disease in cotton as influenced by weather parameters. Indian Phytopathology. 69 (4s): 260-265.

Chattannavar, S.N., Hosagoudar, G.N and Ashtaputre, S.A.2010. Crop loss estimation due to foliar diseases in cotton.Karnataka Journal of Agricultural Sciences. 23: 559 – 601.

Chattannavar, S.N., Prakash, H., Hiremath, S.V., Khadi, B.M and Narlula, A.M. 2002. Study on the relationship between climatic factors, incidence, development and progress of foliar diseases of cotton. Journal of Cotton Research and Development.16 (2): 233-234.

Conner, K.N., Hagan, A.K and Zhang, L. 2013. First report of *Corynespora cassiicola*-incited target spot on cotton in Alabama. Plant Disease. 97(10):1379. Doi: 10.1094/PDIS-02-13-0133-PDN.

Gowdar, S.B., Nargund, V.B., Amaresh, Y.S., Sreenivas, A.G and Patil, B.V. 2007. Correlation of cotton alternaria blight incidence with weather variables. Research on Crops. 8(2): 455-457.

Hagan, A.K., Bowen, K.L., Pegues, M and Jones, J. 2015. Relationship between target spot intensity and seed cotton yield. Phytopathology.105:4.

Hosagoudar, G.N. 2012. Epidemiology and management of leaf spot of cotton caused by *Alternaria* spp.Ph. D. Thesis submitted to University of Agricultural Sciences, Dharwad.

Johnson, I., Ramjegathesh, R., Karthikeyan, M and Chidambaram, P. 2013. Epidemiology of grey mildew and *Alternaria* blight of cotton. Archives of Phytopathology and Plant Protection. 46 (18): 2216-2223.

Monga, D., Sree Lakshmi, B and Prakash, A. H. 2013. Crop losses due to important cotton diseases. Central Institute for Cotton Research, Regional Station, Sirsa-125055, India, Technical Bulletin. pp. 1-23.

Mukewar, P.M., Raj, S., Chakrabarty, P.K.1994. Epidemic occurrence of grey mildew disease of cotton in Central India. Journal of the Indian Society for Cotton Improvement.19: 170-172.

Nesur, G. B. 2014. Development of decision support system for cotton and sugarcane. M. Sc. thesis submitted to University of Agricultural Sciences, Dharwad.

Shivankar, S.K.1989. Investigation on *Ramularia areola* causing Dahiya or Grey mildew of cotton in relation to physiological races, crop losses and control. Ph.D. Thesis submitted toPanjabrao Krishi Vidyapeeth, Akola.

Sumer Singh and Ratnoo R.S. 2013. Effect of different weather parameters on progress of alternaria leaf spot (*Alternaria gossypina*) of cotton. Journal Plant Disease Sciences.8(2): 221-224.

Venkatesh, H., Rajput, R.B., Chattannavar, S.N and Hiremath, J.R.2013. Weather based forecasting of Alternaria blight disease on cotton at Dharwad. Journal of Agrometeorology.15 (Special Issue-II): 20-24.

Venkatesh, H., Chattannavar, S.N., Rajput, R.B and Hiremath, J.R.2015. Weather in relation to Grey mildew disease in cotton at Dharwad, Karnataka. Environment and Ecology. 33(4A): 1667-1671.

Venkatesh, I., Bhattiprolu, S.L., Krishna Prasadji, J and Ramachandra Rao, G. 2016. Influence of weather parameters on the development of Alternaria leaf spot in cotton crop. Journal of Cotton Research and Development.30 (1): 127-130.

Wheeler, B. E.J. 1969. An Introduction to Plant Diseases. John Wiley and Sons Limited, London. pp. 301-302.

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SEASONAL INCIDENCE OF MAJOR INSECT PESTS OF RICE IN KRISHNA WESTERN DELTA REGION OF GUNTUR DISTRICT

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ABSTRACT

The seasonal occurrence of major insect pests of rice in Guntur district of Andhra Pradesh during *kharif* 2021-22 was studied in Krishna Western Delta area in 90 farmers fields of 10 mandals (Bapatla, Kakumanu, Ponnur, Tsunduru, Amruthaluru, Vemuru, Tenali, Duggirala, Repalle and Nagaram). Fortnightly observations on pest population in parallel relation with meteorological parameters revealed the highest leaf damage due to rice leaf folder *Marasmia medinalis* (Crambidae: Lepidoptera)during second fortnight of September (2.95%) when the crop was more succulent. The incidence of yellow stem borer *Scirpophaga incertulas* (Crambidae: Lepidoptera) begun appearing during first fortnight of August with highest percent damage during second fortnight of September causing 2.62 percent dead hearts. The peak population of brown planthopper *Nilaparvata lugens* (Delphacidae: Hemiptera) was observed during first fortnight of October (4.97 hoppers/hill) when the crop was in panicle initiation stage.

Keywords: Abiotic factors, Brown planthopper, Rice leaf folder, Seasonal occurrence and Yellow stem borer

INTRODUCTION

Rice is the most important cereal food crop and is the staple food in India, especially South India. One of the main reasons for the low productivity of rice is insect-pests, diseases and weeds. Many of the insect species has been reported to attack rice crop out of which approximately 20 species have been found to be major including brown plant hopper, white backed plant hopper, yellow stem borer, leaf folder, gall midge, rice hispa and some other insect pests**.** It was estimated that more than hundred species of insects feed on rice and cause severe damage (Muralidharan and Pasalu, 2006). Some insects significantly damage the rice growth and yield which were considered as major pests of rice and were predominantly important (Nathan, 2015).

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Approximately 52 percent of global rice production is lost each year due to biotic stress factors, of which 21 percent is attributed by the attack of major insect pests (Yarasi *et al.,* 2008). A critical examination of rice insect pests over the past 52 years (1965-2017) revealed a gradual increase in pest numbers, which showed that there was always an addition of insect pests every 5 or 10 years, with the previous pest still a source of concern (Jena *et al.,* 2018). Based on the report "integrated pest management package for rice" issued by National Centre for Integrated Pest Management (NCIPM) in 2014, yellow stem borer, planthoppers *viz.,* brown planthopper and white backed planthopper*,* leaf folder, gall midge and gundhi bug were considered as major insect pests of national significance in India. Thrips, panicle mite and black bug were the pests of regional importance in Andhra Pradesh (NCIPM, 2014).

Furthermore, climate change will have an impact on insect behaviour, distribution, and abundance, as indicated by an increase in the number of generations per year, higher winter survival rates, and the earlier appearance of the majority of insects (Patel and Singh, 2017 and Singh *et al.,* 2012). Meteorological factors influence seasonal abundance, distribution, and population growth of an insect as reported by Pandey *et al*. (2001). Plant hopper, armyworm and root weevil population build up was favoured under hot, dry and clear sky conditions. Whereas, leaf folder, stem borer and hispa population build up was favoured under wet, humid and cloudy weather conditions (Singh *et al.,* 2012).

MATERIALS AND METHODS

Sampling procedure

The study was carried out in Guntur district of Andhra Pradesh in Krishna Western Delta area in *kharif* 2021-2022. Guntur district located between 15°-16' and 16°-50' of the Northern Latitude and 70°-10' and 80°-55' of the Eastern Longitude, with significant area under rice cultivation. The data was collected at fortnightly intervals in 90 farmer fields from 30 villages representing 10 mandals *i.e.,* Bapatla, Kakumanu, Tenali, Vemuru, Duggirala, Nagaram, Repalle, Tsunduru, Ponnur and Amruthaluruof the study area. Random sampling was done in fixed plots to record the occurrence of various pests in rice ecosystem for the entire crop growth period *i.e.,* from sowing till harvest. For this, each field was hypothetically assumed and marked with X path for collection of data from ten random sampling spots (1 square metre each) using quadrant, and leaving 3 metres distance from the field borders. From each spot two hills were randomly selected and observed for recording infestation level.

Recording of Observations: In terms of SMWs, the observations were recorded from 21-52 SMWs of 2021 during the crop season.

Leaf Folder: The leaves that had damage symptoms viz., folded leaves and scratching of chlorophyll by larva were

$$\text{Percent damage (\%)} = \frac{\text{Number of damaged leaves per hill}}{\text{Total number of leaves per hill}} \times 100$$

$$\text{Percent damage (\%)} = \frac{\text{Number of dead hearts or white ears per hill}}{\text{Total number of tillers or panicles per hill}} \times 100$$

considered to record percent damage infestation. The extent of damage caused by leaf folder was calculated using the formula presented below.

Paddy Yellow Stem Borer (YSB): The incidence of YSB was recorded in terms of per cent damage by counting the damage done *i.e.,* dead hearts and white ears to total number of tillers and panicles per hill in vegetative and reproductive stages, respectively. The percent damage was calculated using the below mentioned formula.

Plant hoppers: The number of nymphs and adults per hill were counted to record the abundance of brown planthoppers (BPH) and white-backed plant hopper (WBPH) in the field and expressed as population per hill.

RESULTS AND DISCUSSION

Incidence of Leaf folder: The data on leaf folder incidence presented in Table 1 revealed the initial incidence was noticed from 1st FN of August (0.01%) and gradually increased causing highest percent leaf damage in the month of September during 2nd FN (2.95%). The finding discussed above was on par with the reports given by Shyamrao and Raghuraman (2019) who mentioned peak infestation of leaf folder during 2nd FN of September.

The correlation results of leaf folder damage with abiotic factors presented in Table 2 revealed non-significant positive correlation with maximum temperature (0.456), minimum temperature (0.496), evening relative humidity (0.148) and rainfall (0.063) unlike morning relative humidity (-0.042), which showed non-significant negative correlation. The above findings with respect to abiotic factors and pest infestation were in line with the reports of Appalanaidu *et al.* (2021) who stated that maximum and minimum temperature and rainfall showed non-significant positive correlation, Mishra *et al.* (2019) reported thatnon-significant negative correlation with morning relative humidity and Bumireddy *et al.* (2018) reported non-significant positive correlation with evening relative humidity.

Incidence of Yellow Stem Borer: Yellow stem borer caused damage to the tillers and panicles in vegetative and reproductive stages of the crop, respectively which were represented as percent dead hearts and percent white ears. The incidence of YSBstarted in tillering stage and continued till harvest.

Percent dead hearts: The dead hearts caused due to YSB incidence presented in Table 1 revealed the initial record of dead hearts was noticed from 1st FN of August (0.28%) and gradually increased reaching highest per cent of damage during 2nd FN of September (2.62%). Jasrotia *et al.* (2019) also reported the peak infestation of YSB (dead hearts) during 2nd FN of September.

The correlation results of dead hearts caused due to YSB with abiotic factors (Table 2) revealed non-significant positive correlation

Table 1. Seasonal incidence of insect pests of rice during *kharif* 2021-22 in Krishna Western Delta area of Guntur district

Month	Fortnight	Leaf folder (% leaf damage)	Yellow stem borer		Brown planthopper (hoppers/hill)
			% Dead hearts	% White ears	
1.July	1 FN (01 Jul - 15 Jul)	0.00	0.00	0.00	0.00
2. July	2 FN (15 Jul - 30 Jul)	0.00	0.00	0.00	0.00
3. August	1 FN (01 Aug - 15 Aug)	0.01	0.28	0.00	0.02
4. August	2 FN (16 Aug - 31 Aug)	0.55	1.82	0.00	0.45
5. September	1 FN (01 Sep - 15 Sep)	2.46	2.52	0.00	1.62
6. September	2 FN (15 Sep - 30 Sep)	2.95	2.62	0.00	4.66
7. October	1 FN (01 Oct - 15 Oct)	1.64	1.96	0.05	4.97
8. October	2 FN (16 Oct - 31 Oct)	0.50	1.57	0.47	2.51
9. November	1 FN (01 Nov - 15 Nov)	0.10	0.86	0.82	1.51
10.November	2 FN (16 Nov - 30 Nov)	0.00	0.19	0.34	0.34
11.December	1 FN (01 Dec - 15 Dec)	0.00	0.00	0.13	0.00
December	2 FN (16 Dec - 31 Dec)	0.00	0.00	0.06	0.00

Table 2. Correlation between incidence of insect pests of rice and weather parameters during *kharif* 2021-22 in Krishna Western Delta area

Insect pest	Correlation coefficient (r)					Coefficient of determination (R2)
	Temperature (^{O}C)		Relative humidity (%)		Rain fall (mm)	
	Maximum	Minimum	Morning	Evening		
1. Leaf folder	0.456	0.496	-0.042	0.148	0.063	0.584
2. Yellow stem borer (Dead hearts)	0.375	0.632	0.024	0.317	0.060	0.787
3. Yellow stem borer (White ears)	-0.492	-0.111	0.439	0.469	-0.112	0.341
4. Brown planthopper	0.422	0.450	0.184	0.323	0.123	0.916

** Correlation is significant at 0.01 level (2-tailed)

* Correlation is significant at 0.05 level (2-tailed)

with maximum temperature (0.375), minimum temperature (0.632), morning relative humidity (0.024) evening relative humidity (0.317) and rainfall (0.060). The above results were in conformity with the findings of Rana *et al.* (2017) who reported that maximum temperature, rainfall, morning and evening relative humidity showed non-significant positive correlation.

Percent White Ears: The incidence of white ears caused due to damage of panicles in rice crop by YSB presented in Table 1 revealed the occurrence of white ears noticed after emergence of panicles *i.e.,* from 1st FN of October (0.05 %) and reported until harvest *i.e.* 2nd FN of December (0.06 %). The highest percent of white ears were observed in 1st FN of November (0.82 %) when the crop in all the farmers' fields completed panicle emergence. Devi and Varma (2022) also reported the peak infestation of YSB (white ears) during 1st FN of November.

Incidence of Brown Planthopper: The initial incidence of BPH was noticed in 1st FN of August with 0.02 hoppers/hill and gradually increased where the highest number of hoppers/hill were observed during 1st FN of October (4.97 hoppers/hill) followed by 2nd FN of September (4.66 hoppers/hill) (Table 1). Kumar *et al.* (2020) also reported peak incidence of BPH during 1st FN of October which confirms the above findings of the study.

The results of correlation between BPH and abiotic factors (Table 2) revealed positive non-significant correlation with maximum temperature (0.422), minimum temperature (0.450), morning relative humidity (0.184), evening relative humidity (0.323) and rainfall (0.123). The above findings were in conformity with Kumar and Suri (2021) w.r.t morning relative humidity, Jadhao and Salwa (2021) w.r.t. Maximum temperature, Mohanta *et al.* (2020) w.r.t. minimum temperature and Chittibabu *et al.* (2020) w.r.t. rainfall and evening relative humidity.

CONCLUSIONS

The research revealed that,the initial occurrence of *M.medinalis* was observed during first fortnight of August (0.01%) reaching its peak activity in first fortnight of September (2.95%). The occurrence of *S. incertulas* with dead heart symptom noticed during vegetative stage and it reached peak percent damage during second fortnight of September (2.62%) and during reproductive stage of the crop white ear head occurs with maximum percent damage during first fortnight of November (0.82%). The initial occurrence of *N. lugens* was observed during first fortnight of August reaching highest population in the time of first fortnight of October (4.97 hoppers/hill). The results are benefitting to promote Economic Threshold Level (ETL) among farmers as a result of which unnecessary and irrational usage of pesticides can be reduced.

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REFERENCES

Appalanaidu, N., Kumar, D.A., Dhurua, S and Suresh, M. 2021. Studies on incidence of major lepidopteran pests in rice and its correlation with weather parameters. The Andhra Agricultural Journal. 68(2):195-199.

Bhumireddy, S., Simon, S and Nagar, S. 2018. Seasonal incidence of rice leaf folder, *Cnaphalocrocis medinalis* (Guen) in Allahabad region. Journal of Pharmacognosy and Phytochemistry. 7(4): 2528-2530.

Chitti Babu, G., Naidu, D.C., Rao, P.V and Kumar, N.R. 2020. Impact of climate change on brown plant hopper, *Nilaparvata lugens* (Stal) incidence and management in rice eco system in Srikakulam district of Andhra Pradesh. Journal of Entomology and Zoology Studies. 8(4): 1102-1105.

Devi, R.S and Varma, N.R.G. 2022. Seasonal incidence and effect of weather parameters on yellow stem borer, *Scirpophaga incertulas* (Walker) in rice. The Pharma Innovation Journal. 11(4): 1889-1895.

Jadhao, M., Salwe, F and Arti, A. 2021. Seasonal fluctuation of rice brown planthopper (Homoptera: Delphacidae), *Nilaparvata lugens* (Stal) - A major paddy pest in Central India. Journal of Scientific Research. 65: 6-8.

Jasrotia1, P., Khippal, A., Yadav, J., Kashyap P.L., Kumar, S and Singh, G.P. 2019. Effect of weather variables on the incidence of yellow stem borer (*Scirpophaga incertulas* W.) and leaf folder (*Cnaphalocrocis medinalis*G.) in rice. Journal of Cereal Research. 11(3): 247-251.

Jena, M., Pandi, G.G.P., Adak, T., Rath, P.C., Gowda, G.B., Patil, N.B., Prasanthi, G and Mohapatra, S.D. 2018. Paradigm shift of insect pests in rice ecosystem and their management. Oryza. 55: 82-89.

Kumar, R.K and Suri, K.S. 2021. Seasonal activity of rice brown planthopper, *Nilaparvata lugens* (Stal) (Homoptera: Delphacidae) in sub-mountainous region of Punjab. Agricultural Research Journal. 58(1): 82-87.

Kumar, S.T., Sudhakar, S.K., Moulya, M.R., Srinivas, K and Meena, R.S. 2020. Studies on incidence of major insect pests of rice (*Oryza sativa*) and its correlation with weather parameters. Journal of Entomology and Zoology Studies. 8(6):1717-1720.

Mishra, Y.K., Sharma, A.K., Bhowmick, A.K., Saxena,A.K and Anil, K. 2019. Seasonal incidence of insect pest species of paddy collected through light Trap. International Journal of Current Microbiology and Applied Sciences. 8(4): 381-393.

Mohanta, K., Raju, S.V.S and Giri, G.S. 2020. Influence of environmental factors on seasonal incidence of sucking pests of rice Pankaj. Journal of Pharmacognosy and Phytochemistry. 9(3): 822-825.

Muralidharan, K and Pasalu I.C. 2006 Assessments of crop losses in rice ecosystem due to stem borer damage (Lepidoptera: Pyralidae). Crop Protection. 25 (5): 409-417.

Nathan, S. 2015. A review of biopesticides and their mode of action against insect pests. Environmental Sustainability. Springer. pp. 49-63.

NCIPM. 2014. Integrated Pest Management Package for Rice. National Centre for Integrated Pest Management. New Delhi, India.

Pandey, V., Sharma, M.K and Singh, R.S., 2001. Effect of weather parameters on light trap catches of yellow stemborer, *Scirpophaga incertulus* Walker. Shashpa. 8: 55–57.

Patel, S and Singh, C.P. 2017. Seasonal incidence of rice stem borer, *Scirpophaga incertulas* (Walker) on different varieties of rice in relation to weather parameters. Journal of Entomology and Zoology Studies. 5(3): 80-83.

Rana, R., Singh, G., Tanwar, A.K and Kumar, R. 2017. Effect of weather parameters on the infestation of yellow stem borer, *Scirpophaga incertulas* Walker in basmati rice. Journal of Entomology and Zoology Studies. 5(3): 24-27.

Shyamrao, I.D and Raghuraman, M. 2019. Effect of abiotic factors on incidence of leaf folder, *Cnaphalocrocis medinalis* (Linnaeus) in rice ecosystem of Varanasi region. The Pharma Innovation Journal. 8(3): 31-34.

Singh, S., Kaur, P., Kumar and Singh, H. 2012. Incidence of insect pest damage in rice crop in relation to meteorological parameters in Punjab- A plant clinic data based case study. Journal of Agrometeorology. 14 (1): 50-50.

Yarasi, B., Sadumpati, V., Immanni, C.P., Vudem, D.R and Khareedu, V.R. 2008. Transgenic rice expressing *Allium sativum* leaf agglutinin (ASAL) exhibits high-level resistance against major sap-sucking pests. BMC Plant Biology. 8:102-115.

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GENETIC VARIABILITY STUDIES FOR YIELD, ITS ATTRIBUTES AND QUALITY TRAITS IN BLACKGRAM [*Vigna mungo* (L.)]

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ABSTRACT

The experiment was conducted involving 89 genotypes of blackgram for genetic variability of 18 quantitative and qualitative traits at S.V. Agricultural College, Tirupati during *Rabi*, 2015-16. The analysis of variance (ANOVA) revealed existence of significant differences among the genotypes for all the characters studied. Among the genetic parameters PCV was higher than GCV for all the traits indicates the role of environment in expression of the characters. Higher estimates of genotypic coefficient of variation was observed for the traits tryptophan content, lysine content, methionine content, number of primary branches per plant, seed yield per plant, number of pods per plant and number of clusters per plant. High heritability accompanied with high genetic advance was observed for methionine content, tryptophan content, lysine content, number of clusters per plant, number of primary branches per plant, seed yield per plant, harvest index, number of pods per plant, carbohydrate content and plant height specified dominance of additive gene action in appearance of these traits and selection for these characters will be effective.

Key Words: Blackgram, Genetic advance, GCV, Heritability, PCV, quality traits, yield

INTRODUCTION

Blackgram (*Vigna mungo* (L.) Hepper 2n=22) is popularly known as urd and self-pollinating grain legume belongs to the family Fabaceae, having the diploid chromosome number 2n=2x=22. Among the pulses, it is a highly priced pulse crop for its biological protein value and rich phosphoric acid content. It's seed contains about 22% to 24% protein, 60% carbohydrates, 1.3% fat, 0.43% lysine, 0.07% tryptophan and 0.09% methionine (Bressani and Elias, 1980). It is consumed in the form of split pulse as well as whole pulse, which is an essential supplement of cereal-based diet. It is also well suited for various cropping systems It also enriches the soil fertility, improves the soil structure and used as green fodder for cattle.

India is the largest producer as well as the consumer of pulses accounting for more than 70 percent of global production. Blackgram ranks

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fourth in position after bengalgram, redgram, greengram and cultivated in an area of about 4.14 M ha, with an annual production of 2.23 M t and with a productivity of 538 kg ha^{-1}. Andhra Pradesh is one of the major blackgram growing states of India with an area of 3.93 lakh ha, with a production of 3.65 lakh tons and a productivity of 929 kg ha^{-1} (GoI, 2021).

Though, India ranks first globally in terms of area and production of pulses, having superior nutritional quality over the cereals and being well adapted under local conditions, the production and productivity of pulse crops including blackgram have been slowing down, lessening food and nutritional security of millions of the population. The low production might be attributed due to several constraints such as non availability of location specific varieties suitable for cultivation round the year, poor harvest index and susceptibility to various biotic and abiotic stresses. Though, legumes are considered as the major source of dietary proteins but its protein quality however does not reach the dietary level by in animal products. This may be due to unbalanced amino acid composition in the protein (Norton *et al.*, 1985). Hence, there is a necessity to develop blackgram cultivars with high yield and improved amino acid profiles which enhances protein quality. Although intensive research work is going on to understand the genetic architecture of the yield and yield attributes in blackgram, but research on the nature of gene action conditioning the yield and yield related traits along with the quality traits is limited.

Development of new varieties in any crops requires information on nature and magnitude of genetic variability present in the available population. To develop blackgram cultivars with high yield and improved amino acid profiles, the genetic basis of yield, its attributes along with amino acid content should be explored thereby allowing for the selection of individual components conditioning improved protein quality along with high yield. The assessment of variation provides us a correct picture of the extent of variation, further helping us to improve the genotypes. In order to maintain, evaluate and utilize germplasm effectively, estimation of genetic variability in conjunction with heritability and genetic advance gives an idea of the possible improvement of the character through selection. Hence, the study was undertaken with the objective of evaluation of the germplasm lines with respect to variability in terms of physiological, quantitative and quality traits.

MATERIALS AND METHODS

Eighty-nine blackgram genotypes were sown in Randomized Block Design and replicated thrice during *rabi,* 2015-16 at dryland farm, S. V. Agricultural college, Tirupati and each genotype was grown in a single row of 3 m length, with a spacing of 30 cm X 10 cm. All the recommended crop production and protection practices were followed to raise a good and healthy crop. The observations for 13 yield and yield attributes days to 50% flowering, days to maturity, plant height, number of primaries per plant, number of clusters per plant, number of pods per plant, pod length, number of seeds per pod, 100–seed weight, seed yield per plant and harvest index were recorded on five randomly tagged competitive plants in each genotype in each replication except for days to 50 percent flowering and maturity for which the observations were recorded on plot basis. The mean of these five plants were used in the statistical analysis. Physiological parameters

such as SCMR and SLA were taken on the fully expanded, healthy third leaf from the apex of the main axis in each plant. Protein content was estimated by using the method of Lowry *et al.* (1951), whereas, carbohydrate, lysine, tryptophan and methionine contents were estimated by the method proposed by Sadasivam and Manickam (1996). The statistical analysis and variance due to different sources was worked out according to Panse and Sukhatme (1967). Phenotypic and genotypic coefficients of variation were calculated based on the method advocated by Burton (1952). Heritability and genetic advance as per cent of mean were estimated as per formula given by Johnson *et al.* (1955).

RESULTS AND DISCUSSION

In the present study, the analysis of variance (ANOVA) revealed highly significant mean sum of squares among genotypes for all the characters (Table 1). This indicates the existence of substantial genetic variability in the selected germplasm lines which ensures ample scope for improvement of the crop.

An insight into the magnitude of variability present in crop species is of utmost importance as it provides the basis for effective selection for the desired trait (Burt and Austin, 2000). Assessment of variability for yield and its component characters becomes absolutely essential before planning for an appropriate breeding strategy for genetic improvement. Genetic parameters *i.e.* genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h2) and Genetic advance as percent mean (GAM) were estimated for the 13 quantitative and qualitative traits (Table 2).

Genetic parameters such as genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) are useful in detecting the amount of variability present in germplasm. The GCV measures the magnitude of genetic variability present in the crop. Since, it reflects the heritable portion of variability, it is considered to be more useful than PCV. The estimates of phenotypic coefficient of variation (PCV) for all 18 characters were observed higher than the estimates of genotypic coefficient of variation (GCV), indicating the presence of variation is not only due to the genotypes but also due to the influence of environment. Moreover, the difference between GCV and PCV indicates the operation of environmental factors. The present findings are in accordance with the findings of Partap *et al*. (2019), Pallavi *et al.* 2021, and Chippy *et al*. (2022)

Higher estimates of PCV and GCV was recorded for the traits *viz.,* tryptophan content (32.23%,31.96%), lysine content (28.31%, 28.16%), methionine content (28.06%, 27.82%) number of primary branches per plant (25.80%, 24.81%), number of pods per plant (24.51%, 22.42%), seed yield per plant (24.94%, 22.72%) and number of clusters per plant (20.92%, 20.16%). Interestingly, the difference between PCV and GCV was very narrow for the traits *viz.,* lysine content, tryptophan content, methionine content and number of clusters per plant which suggests that environment components had relatively less influence on these characters. Whereas the difference was more for the traits *viz.,* number of primary branches per plant, seed yield per plant, number of pods per plant indicating the traits were much affected by environment, and selection on the basis of

phenotype independent of genotype could be effective for improvement of such traits. Similar pattern of the result was reported by Partap *et al*. (2019), Thirumalai and Murugan (2020), Gomathi *et al*. (2021) for seed yield per plant, number of pods per plant and number of primary branches per plant

Moderate estimates of PCV and GCV were observed by plant height (19.16%, 16.97%), followed by harvest index (18.63%, 16.74%), SLA (18.19%, 14.03%) and carbohydrate content (14.16%, 13.88%). Moderate PCV and GCV were also reported by Gomathi *et al*. (2021) and chippy *et al*. (2022) for plant height, Sushmitharaj *et al.* (2018) and Partap *et al*. (2019) for harvest index. In contrast, low estimates of co-efficient of variation was observed for the characters days to maturity (PCV: 3.94%; GCV: 3.64%), pod length (PCV: 7.93%; GCV: 5.57%), days to 50% flowering (PCV: 7.93%; GCV: 7.56%) and 100 seed weight (PCV: 8.60%; GCV: 7.40%) indicating the low range of variation for these characters in the genotypes, thus offering little scope for further improvement of these characters through simple selection. Similar kind of findings was also reported by Reddy *et al.* (2018), Thirumalai and Murugan (2020) and Roshani *et al.* (2022) for pod length ,100 seed weight days to 50% flowering and days to maturity.

The amount of genetic variation considered alone will not be of much use to the breeder unless supplemented with the information on heritability, which gives a measure of the heritable portion of the total variation. It is a superior index of transmission of traits from parents to their progeny and assists the breeder as a tool for selecting elite genotypes from the diverse population. Heritability in broad sense includes both additive and non-additive gene effects (Hanson *et al.,* 1956).

The highest heritability estimates was registered for lysine content (98.91%) followed by tryptophan content (98.33%), methionine content (98.32%), carbohydrate content (96.14%), protein content (93.55%), number of clusters per plant (92.85%), number of primary branches per plant (92.46%), days to 50% flowering (90.95%), days to maturity (85.37%), number of pods per plant (83.69%), seed yield per plant (83%), harvest index (80.70%), plant height (78.46%), SCMR (72.34%),100 seed weight (74.11%) and number of seeds per pod (63.10%) in the decreasing order of their magnitude and thus indicated the influence of additive genetic component for expression of these traits. It demonstrates that these traits could be successfully transferred to offspring, if selection for these characters is performed in the hybridization programme. This was in line with the studies by Thirumalai and Murugan (2020) reported high for seed yield per plant, number of pods per plant, number of pods per plant, plant height. Gomathi *et al.* (2021) reported high heritability for hundred seed weight, single plant yield, number of pods per plant, days to 50% flowering, plant height and number of primary branches per plant. Khan *et al.* (2020) days to 50% flowering, days to maturity, number of seeds per pod and pod length and Saran and sharma (2021) for days to maturity, number of primary branches per plant, number of seeds per pod and pod length.

The estimate of heritability (broad sense) alone is not used in predicting the resultant effect for selecting the best individuals or genotypes

Table 1. Analysis of variance for 18 quantitative and qualitative traits in 89 blackgram genotypes

S. No	Characters	Mean sum of squares		
		Replications	Treatments	Error
		(df = 2)	(df = 88)	(df = 176)
1	Days to 50% flowering	84.31	30.67**	0.98
2	Days to maturity	0.55	25.12**	1.35
3	SPAD chlorophyll meter reading (SCMR)	5.24	54.96**	6.21
4	Specific leaf area (cm^2 g^{-1})	1699.19	1864.57**	345.48
5	Plant Height (cm)	15.71	128.72**	10.79
6	Number of primaries per plant	0.33	1.93**	0.05
7	Number of clusters/plant	0.34	17.21**	0.43
8	Number of pods/plant	8.66	112.54**	6.86
9	Pod length (cm)	0.02	0.30**	0.07
10	Number of seeds/pod	0.08	1.10**	0.18
11	100 seed weight (g)	0.14	0.46**	0.04
12	Seed Yield per plant (g)	0.14	10.19**	0.65
13	Harvest Index	0.01	90.27**	6.66
14	Protein content (mg/g)	2.12	1453.48**	32.65
15	Carbohydrate content (mg/g)	109.44	14177.38**	187.28
16	Lysine content(mg/g)	0.01	0.72**	0.004
17	Tryptophan content (mg/g)	0.015	1.33**	0.007
18	Methonine content (mg/g)	0.09	13.09**	0.04

*: Significant at 5% level; ** : Significant at 1% level

Table 2. Estimates of genetic parameters for quantitative and qualitative traits in 89 blackgram genotypes

S. No.	Character	Mean	Range		Variance		Coefficient of Variation		Heritability (Broad sense) (%)	Genetic advance (GA)	Genetic advance as percent of mean (%)
			Min.	Max.	Genotypic	Phenotypic	Genotypic	Phenotypic			
1.	Days to 50% flowering	41.56	35.33	48.66	9.89	10.88	7.56	7.93	90.25	6.18	14.87
2	Days to maturity	77.14	69.66	83.00	7.92	9.27	3.64	3.94	85.37	5.35	6.94
3.	SPAD chlorophyll meter reading (SCMR)	42.25	34.17	55.22	16.25	22.46	9.54	11.21	72.34	7.06	16.71
4	Specific leaf area ($cm^2 g^{-1}$)	160.38	101.98	235.23	506.36	851.85	14.03	18.19	59.44	35.73	22.28
5.	Plant Height (cm)	36.98	23.60	51.60	39.31	50.10	16.97	19.16	78.46	11.44	30.97
6.	Number of primaries per plant	3.19	1.66	5.40	0.62	0.67	24.81	25.80	92.46	1.56	49.14
7.	Number of clusters/plants	11.73	5.80	18.46	5.59	6.02	20.16	20.92	92.85	4.69	40.01
8.	Number of pods/plants	26.46	15.93	41.33	35.22	42.09	22.42	24.51	83.69	11.18	42.26
9.	Pod length (cm)	4.90	4.13	5.84	0.07	0.15	5.57	7.93	49.41	0.39	8.07
10.	Number of seeds/pods	6.37	4.46	7.40	0.30	0.48	8.71	10.96	63.10	0.90	14.25
11.	100 seed weight (g)	5.01	4.20	6.19	0.13	0.18	7.40	8.60	74.11	0.65	13.13
12.	Seed Yield per plant (g)	7.84	5.37	13.16	3.18	3.83	22.72	24.94	83.00	3.34	42.64
13.	Harvest Index	31.52	20.10	43.99	27.86	34.53	16.74	18.63	80.70	9.76	30.98
14.	Protein content (mg/g)	220.15	169.83	268.88	473.61	506.26	9.88	10.22	93.55	43.36	19.69
15.	Carbohydrate content (mg/g)	491.85	318.93	604.64	4663.36	4850.64	13.88	14.16	96.14	137.93	28.04
16.	Lysine content(mg/g)	1.76	1.01	2.86	0.24	0.24	27.82	28.06	98.32	1.00	56.83
17	Tryptophan content (mg/g)	2.07	1.07	3.87	0.44	0.44	31.96	32.23	98.33	1.35	65.29
18	Methionine content (mg/g)	7.40	3.48	12.85	4.34	4.39	28.16	28.31	98.91	4.27	57.70

because it includes additive and non-additive gene effects. High genetic advance occurs only due to additive gene action. Hence, heritability estimates coupled with the genetic advance would be more useful than heritability alone. High heritability (h2) coupled with high genetic advance indicates the predominance of additive gene action and greater response to phenotypic selection and improvements of such traits could be anticipated.

High genetic advance as percent of mean was registered for tryptophan content (65.29%) followed by lysine content (57.70%), methionine content (56.83%), number of primary branches per plant (49.14%) seed yield per plant (42.64%), number of plants per plant (42.26%), number of clusters per plant (40.01%), harvest index (30.98%), plant height (30.97%), carbohydrate content (28.04%) and SLA (22.28%). The traits, protein (19.69%), SCMR (16.71%), days to 50% flowering (14.87%), number of seeds per pod (14.25%) and 100 seed weight (13.13%) recorded moderate genetic advance as per cent of mean. These findings were in contradiction with Priya *et al.* (2018), in this current study, the traits *viz.,* pod length (8.07%) and days to maturity (6.94%) showed low genetic advance as percent of mean (Table 2). Similar results were reported by Kumar *et al*. (2015), Gowsalya *et al.* (2016), Priyanka *et al.* (2016) and Sushmitharaj *et al.* (2018) .

In the study, high heritability and high GAM was observed by methionine content (98.91%, 57.70%), tryptophan content (98.33%,65.29%), lysine content (98.32%, 56.83%), carbohydrate content (96.14% , 28.04%), number of clusters per plant (92.85%, 40.01%), number of primary branches per plant (92.46%, 49.14%), seed yield per plant (83%, 42.64%), harvest index (80.70%, 30.98%), number of pods per plant (92.46%, 49.14%) and plant height (78.46%, 30.97%). This indicates the preponderance of additive gene action for appearance these characters and hence phenotypic selection would be more effective for these characters. Similar outcome were reported by Thirumalai and Murugan (2020), Sidramappa *et al.* (2020) for number of clusters per plant, number of primary branches per plant, seed yield per plant, number of pods per plant and plant height.

The traits days to 50% flowering (90.25%,14.87%) SCMR (72.34%, 16.71%), number of seeds per pod (63.10%,14.25%) 100 seed weight (74.11%, 13.13%) and protein (93.55%,19.69) exhibited high heritability and moderate genetic advance indicating that these characters were governed by additive gene effects and may express consistently in succeeding generations, leading to greater efficiency of breeding programme.

High heritability coupled with low genetic advance as per cent of mean was recorded for days to maturity (85.37%, 6.94%) indicating the influence of non- additive gene effects (dominance) in the inheritance of this trait and selection for such traits become difficult as the high heritability for this trait is being exhibited due to favourable influence of the environment rather than genotypes. Hence, selection may not be effective for this trait. The finding corroborates Harish *et al.* (2018) Gowsalya *et al.* (2016) and Sushmitharaj *et al.* (2018) and Susmitha and Gabrial (2021).

CONCLUSIONS

High to moderate GCV estimates and high heritability coupled with high genetic advance as

percent of mean were observed for methionine content, tryptophan content , lysine content , number of clusters per plant , number of primary branches per plant , seed yield per plant , harvest index , number of pods per plant carbohydrate content and plant height indicating that the variation in the above characters most likely due to additive gene effects, hence, simple directional selection may be effective to improve these characters.

REFERENCES

Bressani, R and Elias, L.G. 1980. Nutritional value of legume crops for humans and animals. In: Summerfield, R. J and Bunting, A.H. (Editors). Advances in Legume Science. Kew, Richmond, London: Royal Botanical Gardens. pp. 135-155.

Burt and Austin. 2000. Perspective sex, recombination and the efficacy of selection-Was Weismann Right. International Journal of Organic Evolution. 54(2): 337-35.

Burton, G.W. 1952. Quantitative inheritance in grasses. Proceedings of 6th International Grassland Congress. 1: 277-283.

Chippy A. K. , Andrew, P. L .M. A. S. T., Rengasamy K., Shoba D., Shunmugavel S., Jeshima Khan, Y and Arumugampillai M. 2022. Genetic diversity analysis in blackgram (*Vigna mungo*) genotypes using microsatellite markers for resistance to Yellow mosaic virus (YMV). Plant Protection Science. 58(2): 110–124.

GoI. 2021.Directorate of Economics and Statistics. Department of Agriculture and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, New Delhi.

Gomathi D., Shoba D., Ramamoorthy V and Arumugampillai, M.2021. Studies on variability, heritability, correlation and path analysis in segregating population of black gram [*Vigna mungo* (L.) Hepper]. Legume Research - An International Journal. DOI :10.18805/LR-4411.

Gowsalya,P. Kumaresan, D. Packiaraj, D and Kannan Bapu, J.R. 2016. Genetic variability and character association for biometrical traits in Blackgram (*Vigna mung*o (L.) Hepper) Electronic Journal of Plant Breeding. 7 (2) :317-324.

Hanson, G.H., Robinson, H.F and Comstock, R.E. 1956. Biometrical studies of yield in segregating populations of Korean Lespedeza. Agronomy Journal. 8: 267-282.

Harish, K T., Sharma, P.P., Nagar, K.K., Bairwa L.L and Meghawal. 2018. Genetic variability and heritability studies in blackgram [*Vigna mungo* (L.) hepper]. International Journal of Chemical Studies. 6(6): 642-646.

Hemalatha K., Lal, S.S and Lal, G.M. 2017. Study on genetic variability and correlation in blackgram (*Vigna mungo* L. Hepper). Journal of Pharmacognosy and Phytochemistry. 6:674-676.

Johnson, H.W., Robinson, H.F and Comstock, R.E. 1955a. Estimates of genetic and environmental variability in soybean. Agronomy Journal. 47: 314-318.

Khan, T., Dubey, R.B., Nagar, K.K and Bairwa, L.L. 2020. Studies on genetic variability in genotypes of blackgram [*Vigna mungo* (L.) Hepper]. International Journal of Current

Microbiology and Applied Sciences. 9(3): 2736-2741.

Kumar, V.G., Vanaja, M., Abrahum, B., Anitha, Y., Jyothi Laxmi, N., Maheshwari, M. 2015. Variability, heritability and genetic advance for quantitative traits in blackgram. International Journal of Current Sciences. 17:37-42.

Lowry, O.H., Rosebrough, N.J., Farr, A.L and Randall, R.J. 1951. Protein measurement with the Folin phenol reagent. The Journal of Biological Chemistry. 193: 265-275.

Norton, G., Bliss, F.A and Bressani, R. 1985. Biochemical and nutritional attributes of grain legumes. In*:* Summer field, R.J., Roberts, E.H (Editors), Grain legume crops. London: Collins. pp. 73–114.

Pallavi Y., Rakshe, M.B and Ujjainkar, V.V 2021. Genetic variability analysis in blackgram [*Vigna mungo* (L.) Hepper]. The Pharma Innovation Journal. 10(9): 1447-1451.

Panse, V.G and Sukhatme, P.V. 1961. Statistical method for research workers. 2nd Edition. ICAR, New Delhi. pp. 351.

Partap B., Mukesh Kumar., Vipin Kumar and Arvind Kumar. 2019. Genetic variability and correlation studies of seed yield and its components in black gram (*Vigna mungo* (L.) Hepper). Journal of Pharmacognosy and Phytochemistry. 8(3): 2035-2040.

Priya, L., Arumugam Pillai, M., Shoba, D., Merina Prem Kumari, S. and Aananthi, N. 2018. Genetic variability and correlation studies in black-gram [*Vigna mungo* (L.) Hepper]. Electronic Journal of Plant Breeding. 9(4): 1583-1587.

Priyanka S., Rangaiah, S and Showkathbabu, B.M. 2016. Genetic variability estimates of quantitative and qualitative traits in blackgram. International Journal of Agriculture Sciences.; 40:1821-1824.

Reddy, A.K., Priya, M.S., Reddy, D.M and Reddy, B.R. 2018. Genetic divergence studies in blackgram (*Vigna mungo* (L.) Hepper). International Journal of Pure and Applied Bioscience, 6(5): 232–237. DOI: http://dx.doi.org/10.18782/2320-7051.6957.

Roshani, B., Niranjan P., Nav Raj, A and Ankur, P. 2022. Genetic variability for growth, yield, and yield-related traits in blackgram (*Vigna mungo* (L.) Hepper) genotypes. Russian Journal of Agricultural and Socio-economic Sciences. 4(124). DoI: http://dx.doi.org/10.18551/rjoas.2022-04.12.

Sadasivam, S and Manickam, A. 1996. Bio-Chemical Methods. New age International (P) Ltd., New Delhi. pp. 8-9.

Sai Deekshith, K., Venkanna V., Rukmini Devi, K., Saida Naik, D and Sameerkumar, C.V 2022. Genetic variability, heritability and genetic advance in blackgram (*Vigna mungo* L.). Biological Forum – An International Journal. 14(2a): 583-588(2022).

Saran, R and Sharma, P.P. 2021. Estimation of genetic variability in blackgram [*Vigna mungo* (L.) Hepper]. Electronic Journal of Plant Breeding. 12(2): 602-605.

Sidramappa, P. H., Kuchanur, M., Shobharani, B., Arunkumar, S. A., Kulkarni, H. C., Sowmya Sheela, D., Laxman and Bharati, S. 2020. Genetic variability, heritability and genetic

advance studies in blackgram [*Vigna mungo* (L.) Hepper] across seasons. International Journal of Current Microbiology and Applied Sciences. 9(10): 2319-7706.

Sushmitharaj, D.V., Shoba, D and Arumugam Pillai, M. 2018.Genetic Variability and Correlation Studies in Blackgram (*Vigna mungo* [L.] hepper) with reference to YMV Resistance. International Journal of Current Microbiology and Applied Sciences. pp. 2849-2856.

Susmita B and Gaibriyal L.M. 2021. Study on genetic variability and selection strategy for enhancing productivity in Urdbean [*Vigna mungo* (L.) Hepper]. International Journal of Plant and Environment. 7 (2): 6-11. DOI: 10.18811/ijpen.v7i02.

Thirumalai, R and Murugan,S. 2020. Variability studies on blackgram (*Vigna mungo* (l.) Hepper) genotypes for mungbean yellow mosaic virus (mymv) resistance. Plant Archives. 20(1): 2535-2539.

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STUDIES ON INHERITANCE OF BACTERIAL WILT RESISTANCE IN TOMATO CROP CAUSED BY *Ralstonia solanacearum* (E.F. SMITH)

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ABSTRACT

The study aimed at the inheritance of bacterial wilt resistance in tomato with six different generations (P_1, P_2, F_1, F_2, BC_1 and BC_2) obtained by 4 crosses (Susceptible X Resistant). Two susceptible cultivars (Arka Meghali and Arka Vikas) and two resistant lines (H-7996 and H-7997) of tomato were crossed during *kharif* , 2020 in four possible combinations to generate the experimental material. The P_1, P_2, F_1, F_2 BC_1 and BC_2 generations of 4 crosses were screened for bacterial wilt caused by *Ralstonia solanacearum* (E.F. Smith) in tomato research fields of Monsanto Holdings Private Ltd., Kallinayakana Halli village, Gauribidanuru Taluka, Chikkaballapura District, Karnataka to understand the mode of inheritance. Single dominant gene controlling the resistance to bacterial wilt was observed in two crosses between Arka Meghali x H-7996 and Arka Vikas x H-7997. *Chi*-square test for goodness of fit indicated that the F_2 is segregating in the ratio 3 resistant to 1 susceptible in the single gene model. Resistant to susceptible ratio in BC_2 was 1:1. While, in the crosses between Arka Vikas x H-7996 and Arka Meghali x H-7997 the complimentary gene interaction was observed with the F_2 expected ratio of 9:7 indicating duplicate recessive epistasis.

Key words: Bacterial wilt, Inheritance, Resistant, Susceptible, Tomato

INTRODUCTION

Tomato *(Lycopersicon esculentum* Mill.) belongs to family *Solanaceae*, is one of the most popular and widely grown fruits around the world. The wild species of tomato originated in the Andes Mountains of South America, probably mainly in Peru, and is thought to have been domesticated in pre-Columbian Mexico. In 2020, the worldwide production of tomatoes was 186.66 million tons and average productivity around 37.2 t ha^{-1}. The leading producer, China accounted for 34.7 percent of the total world production. India produces 20.57 million tonnes of tomato from 8.1 m ha area with a productivity of 25.3 t ha^{-1}. India contributes 11.39 percent of the world tomato production (FAO, 2020). The production and productivity of tomato in India is constrained by increased incidence of various biotic and abiotic stresses.

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Bacterial wilt of tomato incited by *Ralstonia solanacearum* (E.F. Smith) is the most important and widespread disease of tomato (Aslam *et al.,*2017). *Ralstonia solanacearum* has impact on all stages of plant growth and reports confirm that maximum infections are at flowering and fruiting stages (Acharya *et al.,*2018). The symptoms of bacterial wilt initially start with drooping of the lower leaves of infected plants, in some cases plant may appear stunted before wilting occurs. Affected plants rapidly die through wilting without yellowing of the leaves. As the disease advances, decay of pith region is observed with a clear brown discoloration and hollowness of the stem (Aslam *et al*., 2017).

The use of resistant hybrids is the most economic and efficient way of controlling the losses due to diseases. Hence, the knowledge of inheritance is of paramount important for disease resistance breeding since this information increases the efficiency of breeding programme. The inheritance and genetic control of bacterial wilt resistance was reported to be monogenic (Mane *et al.,* 2013), oligogenic (Costa *et al.,* 2019), and polygenic (Wang *et. al.,* 2013). The available literature suggested that genetic control of resistance to bacterial wilt disease varied with source of resistance, genetic background, and the environmental conditions as well (Acharya *et al.*, 2018). This background information indicates the necessity to investigate on inheritance of bacterial wilt resistance in tomato and to develop bacterial wilt resistant hybrids with higher yield for commercial cultivation.

MATERIALS AND METHODS

The study was conducted in the tomato research fields of Monsanto Holdings Private Limited, Kallinayakana Halli village, Gauribidanuru Taluka, Chikkaballapura District, Karnataka. This study was conducted in August 2020, to determine the mode of inheritance of bacterial wilt resistance of tomato (*Ralstonia solanacearum)* in selected cultivars *viz.,* Arka Meghali and Arka Vikas were used as susceptible cultivars while H-7996 and H-7997 (Hawaii selections) as resistant donors. The Hawaii -7996 and Hawaii -7997 selections bred by J.C. Gilbert in 1970 are stable source of resistance to bacterial wilt, released from Hawaii University. Two major QTLs *Bwr-6* and *Bwr-12* were identified and mapped on chromosome 6 and 12, respectively (Wang *et al.,* 2013). The susceptible cultivars used for screening resistance to *R.solanacearum* were varieties released by Indian Institute of Horticultural Research (IIHR), Bangalore. The crossing to produce F_1s was done between susceptible and resistant parents as Arka Meghali x H-7996, Arka Vikas x H-7996, Arka Meghali x H-7997 and Arka Vikas x H-7997 (Table 1). The crossing was carried out during *kharif* 2020 using susceptible x resistant and crossing programme was conducted as given in Table 2. The experiment for inheritance study of bacterial wilt resistance with parents F_1s, F_2s, BC_1 and BC_2 was presented in Table 3.

Preparation of tomato seedlings for bacterial wilt disease screening

Twenty-five seeds each of genotype were sown in a fifty cavity seedling trays filled with sterilized commercially supplied cocopeat. The seeds of F_1s, F_2s, BC_1s and BC_2s were sown uniformly at 1 cm depth in the cocopeat and drenched with basal fungicide to avoid any fungal or bacterial contamination infections coming from soil or cocopeat or seed handling. The seedlings were maintained in the insect

proof nursery until the plants grown enough for the inoculation stage.

Preparation of Inoculum and seedling inoculation to study the inheritance of resistance

Drenching method of inoculation was followed for inoculation of bacterial culture. At least twenty-five plants each genotype in two replications were used for the bioassay. The seedlings were drenched in two different stages of the crop at 14 and 21 days of seedling using bacterial culture grown in the nutrient agar plate. Seedlings were raised in green house using 50 cavity seedling trays with standard sterile pot mixture, soil: sand: farmyard manure at 2:1:1 ratio. Watering was stopped for the seedlings one day prior to inoculation. Five plants of each genotype were kept uninoculated as mock inoculated checks. Bacterial suspensions were adjusted to a concentration between 0.2 – 0.3 OD at 600 nm. These suspensions were diluted in non-sterilized RO water for further dilution and inoculations. Before inoculation, a small 'L' shaped incision was made using the scalpel blade, near the root zone of all the seedlings to facilitate the uniform bacterial entry into the seedlings. Immediately after the cut, culture with the respective concentration were poured on to root zone at volume of 10ml/ seedling (Figure 1). Disease incidence (DI) was taken one week after inoculation and at one week interval of time up to 3 to 4 weeks post inoculation.

Statistical analysis

To test whether the observed ratio is fitting to the expected ratio, *Chi*-square test for goodness of fit was used. The test statistic for comparing observed and expected frequencies is $\chi 2$, defined as:

$$\chi 2 = \frac{(O - E)^2}{E}$$

Where, O = observed value; E = expected value.

RESULTS AND DISCUSSION

The experiment to study the inheritance of resistance to bacterial wilt in tomato cultivars Arka Meghali, Arka Vikas and lines H-7996, H-7997 was laid out between *kharif* 2020 and *kharif* 2022 by artificial inoculation. Bacterial suspensions were adjusted to a concentration between 0.2 – 0.3 OD at 600 nm.

Set 1: Arka Meghali x H-7996

Screening of both the parents and their F_1 hybrid during *kharif* 2021 revealed that H-7996 and F_1 hybrids were resistant to bacterial wilt. The total number of wilted plants and survived plant population in both the parents (SP1 and RP1), F_1 and the segregating families (F_2, BC_1 and BC_2) were mentioned in table 5. Among the 303 F2 progenies screened, 231 were resistant while 72 were susceptible. Of the 104 BC_1 progenies screened, only six were susceptible and 98 were resistant (Table 6). Among 77 BC_2 progenies screened, 43 were resistant while 34 of them were susceptible to bacterial wilt (Table 7).

As per the results obtained the observed ratio fits good with expected 3:1 ratio indicating single dominant gene action. BC segregation ratios also supports the hypothesis.

As per the data it can be a single gene governing the trait and observed segregation ratio fits good with the predictable ratio of 3:1 for F_2, also 1:0 for BC_1 and 1:1 for BC_2 in the single gene model of *Chi*-square analysis. As

per the results of C*hi*-square analysis there is no significant difference between expected and observed ratio in the segregating families (F_2 , BC_1 and BC_2).

Similar results for segregation pattern of 3:1 for BW resistant were reported by Ajjappalavara *et al*. (2008), Mane (2013) and Acharya *et al*. (2018). Investigation on F2 population and back cross generations of Arka Meghali x H-7996 observed segregation ratio which fits well with the expected ratio of 3:1 for F2 generation, 1:0 for BC_1 and 1:1 for BC_2 through *Chi*-square analysis. This finding indicated that single dominant gene is controlling the inheritance of the bacterial wilt resistance in H-7996. Hence, the cultivars Arka Meghali and the resistance source can be utilized conveniently in the bacterial wilt resistant hybrid development program by incorporating the resistance from one of the parents *viz.,* H-7996.

Set 2: Arka Vikas x H-7996

The parents, F_1 population and segregating progenies of set 2 crosses were screened for bacterial wilt resistance. All the plants were survived in the resistant parent while in the susceptible parent, 38 out of 41 plants showed the wilting. During the F1 generation artificial screening, three plants showed wilting while all the remaining 38 plants showed resistance to bacterial wilt. The 222 F_2 plants from the cross artificially inoculated with bacterial wilt yielded 127 resistant and 95 susceptible plants. While in BC generation it was observed that out of 131 BC_1 and 140 BC_2 plants, 121 and 41 survived, respectively, while 10 BC_1 and 99 BC_2 plants were found susceptible.

The result obtained from these cross supports two gene model for resistance to bacterial wilt resistance and segregation ratio of 9:7 in F_2 population, 1:0 in BC_1 and 1:3 in BC_2 generation (Tables 6 & 7). The observed ratio is fitting to expected 9:7 ratio indicating duplicate recessive epistasis or complementary gene action. This is also supported by segregation pattern of BC populations.

Resistant to susceptible ratio of 9:7 was observed in this cross in F2, 1:0 in BC_1 and 1:3 in BC_2 generation of Arka Vikas x H-7996. As per *Chi*-square test this ratio fits well with the expected ratio. This ratio indicates that the resistance to bacterial wilt is governed by two genes which are interdependent for expression. Similar results were also reported by Sharma *et al.* (2006), Prasanna (2012) and Costa *et al*. (2019) in inheritance study of bacterial wilt resistance of tomato. This reveals the two genes working together in conferring resistance in Arka Vikas and H-7996 cross and the gene action is complementary gene action. Also, from this investigation allelic nature of these two genes can be possible in Arka Vikas and H-7996.

Table 1. Crossing sequence and generation of material of tomato crop

S. No.	Cross	Susceptible Parent	Resistant Parent	F_1	F_2	BC_1	BC_2
1	Set-1	Arka Meghali (SP1)	H-7996 (RP1)	SP1 x RP1	F1 Self	F1 x RP1	F1 x SP1
2	Set-2	Arka Vikas (SP2)	H-7996 (RP1)	SP2 x RP1	F1 Self	F1 x RP1	F1 x SP2
3	Set-3	Arka Meghali (SP1)	H-7997 (RP2)	SP1 x RP2	F1 Self	F1 x RP2	F1 x SP1
4	Set-4	Arka Vikas (SP2)	H-7997 (RP2)	SP2 x RP2	F1 Self	F1 x RP2	F1 x SP2

Table 2. Programme for inheritance study of tomato

S. No.	Season/ Year	Details
1.	*Kharif,* 2020	Crosses between susceptible x resistant genotypes were attempted
2.	*Rabi,* 2020-2021	Evaluation of $F_{1,}$ harvested F_2 seeds and BC generated
3.	*Kharif,* 2022	Scoring of P_1, P_2, F_1, F_2, BC_1 and BC_2 generation was done to study mode of inheritance of BW resistance

Table 3. Experiment details to study the bacterial wilt inheritance pattern in tomato crop

S. No.	Experiment details	
1	Number of generations	6 (P_1, P_2, BC_1, BC_2, F_1 and F_2)
2	Crosses	4
3	Row to Row spacing	120 cm
4	Plant to Plant spacing	45 cm

Table 4. Total plants screened from each generation for 4 set of crosses in tomato crop

S. No.	Sets	Resistant parent	Susceptible parent	F_1	F_2	BC_1	BC_2
1	Set 1: (SP1 x RP1)	35	35	35	303	104	77
2	Set 2: (SP2 x RP1)	41	41	41	222	131	140
3	Set 3: (SP1 x RP2)	42	42	42	266	134	120
4	Set 4: (SP2 x RP2)	48	48	48	234	120	73

Table 5. Segregation pattern of bacterial wilt disease through artificial inoculation in F_2 generations of four crosses in tomato crop

S. No.	Cross	Total Plants in F_2	BW resistant plants	BW susceptible plants	Test ratio	*Chi*-Square Value	
						Calculated	P Value (5%)
1	Arka Meghali x H-7996	303	231	72	3:10	0.61	0.26 (NS)
2	Arka Vikas x H-7996	222	127	95	9:7	0.77	0.32 (NS)
3	Arka Meghali x H-7997	266	148	118	9:7	0.84	0.32 (NS)
4	Arka Vikas x H-7997	234	174	60	3:1	0.82	0.33 (NS)

Table 6. Segregation pattern of bacterial wilt disease through artificial inoculation in BC_1 generations of four crosses in tomato crop

S.No.	Cross	Total Plants in BC1	BW resis-tant plants	BW susce-ptible plants	Test ratio	*Chi*-Square Value	
						Calcul-ated	P Value (5%)
1	Arka Meghali x H-7996	104	98	6	1:00	0.56	0.24 (NS)
2	Arka Vikas x H-7996	131	121	10	1:00	0.38	0.17 (NS)
3	Arka Meghali x H-7997	134	127	7	1:00	0.55	0.24 (NS)
4	Arka Vikas x H-7997	120	116	4	1:00	0.72	0.30 (NS)

Table 7. Segregation pattern of bacterial wilt disease through artificial inoculation in BC_2 generations of four crosses in tomato crop

S.No.	Cross	Total Plants in BC2	BW resis-tant plants	BW susce-ptible plants	Test ratio	*Chi*-Square Value	
						Calcul-ated	P Value (5%)
1	Arka Meghali x H-7996	77	43	34	1:01	0.31	0.14 (NS)
2	Arka Vikas x H-7996	140	41	99	1:03	0.24	0.11 (NS)
3	Arka Meghali x H-7997	120	32	88	1:03	0.67	0.29 (NS)
4	Arka Vikas x H-7997	73	38	35	1:01	0.73	0.30 (NS)

A) Pouring of Ralstonia inoculum


B) Preparation of Ralstonia inoculum


C) Damaging seedling root zone for bacterial entry

d) Screening of tomato genotypes panel for inheritance of resistance

Fig. 1. Screening of tomato seedlings for inheritance of resistance for bacterial wilt

Set 3: Arka Meghali x H-7997

In resistant parent only wilting of one plant was observed out of 42 plants while the susceptible parent showed 100 percent wilt. Out of 42 F_1 plants screened against bacterial wilt, three exhibited wilt symptoms. Among 266 F_2 progenies, 148 were resistant. Seven BC_1 plants out of 134 exhibited wilt symptoms and 127 were resistant. Of the 120 BC_2 progenies, 88 plants were susceptible to bacterial wilt (Table 4) while 32 plants were resistant. *Chi*-square test for goodness of fit indicates that the F_2 is segregating in the ratio 9 resistant to 7 susceptible in the digenic model. Resistant to susceptible ratio in BC_2 was 1:3. Seven out of 134 BC_1 progenies expressed wilt symptoms and the fitness was good for 1:0 resistant by susceptible expected ratio.

The results are in conformity with Sharma *et al.* (2006), Prasanna (2012) and Costa *et al*. (2019) in inheritance study of bacterial wilt resistance of tomato crop.

Set 4: Arka Vikas x H-7997

In resistant parent wilting was observed only in 4 plants out of 48 plants while the susceptible parent showed wilting in 45 plants. Out of 48 F_1 plants screened against bacterial wilt, 2 exhibited wilt symptoms. Among 234 F_2 progenies, 174 were resistant. Four BC_1 plants out of 120 exhibited wilt symptoms and 116 were resistant. Of the 73 BC_2 progenies, 35 plants were susceptible to bacterial wilt while 38 plants were resistant. *Chi*-square test for goodness of fit indicates that the F_2 is segregating in the ratio 3 resistant to 1 susceptible in the single gene model. Resistant to susceptible ratio in BC_2 was 1:1.

Similar results for segregation pattern of 3:1 for BW resistant were reported by Ajjappalavara *et al*. (2008), Mane (2013) and Acharya *et al*. (2018). This indicates single dominant gene is governing the trait. This type of inheritance is very useful to develop the

hybrids which are resistant to bacterial wilt by backcross breeding program.

CONCLUSIONS

The Hawaiian genotypes, H-7996 and H-7997 have good resistance for bacterial wilt, and this is controlled by single dominant gene. This gene is also showing complementary gene action and can be said as genotype dependent inheritance. Hence, both the lines can be utilized conveniently in the bacterial wilt resistant hybrid development program by incorporating resistance from one of the parents. Also, these can be used to develop bacterial wilt resistant lines to utilize in further breeding programs.

REFERENCES

Acharya, B., Ghorai, A.K., Dutta, S., Maurya, P.K., Dutta, S., Mandal, A.K., Chattopadhyay, A and Hazra, P. 2018. Genetics of tolerance to bacterial wilt disease in tomato (*Solanum lycopersicum* L.). Australasian Plant Pathology. 47 (6):591-600.

Ajjappalavara, P.S., Dharmatti, P.R., Salimath, P.M., Patil, R.V., Patil, M.S and Krishnaraj, P.U. 2008. Genetics of bacterial wilt resistance in brinjal. Karnataka Journal of Agricultural Sciences. 21 (3):424-427.

Aslam, M.N., Mukhtar, T., Ashfaq, M and Hussain, M.A. 2017. Evaluation of chili germplasm for resistance to bacterial wilt caused by *Ralstonia solanacearum*. Australasian Plant Pathology. 46 (3): 289-292.

Costa, K.D.S., Dos Santos, P.R., Dos Santos, A.M.M., Silva, A.M.F., Chagas, J.T.B., De Carvalho Filho, J.L.S., Pereira, J.D.L., Silva, M.D.O., Da Silva, J.R and Menezes, D. 2019. Genetic control of tomato resistant to *Ralstonia solanacearum*. Euphytica. 215 (7): 1-11.

Mane, R.S. 2013. Genetic studies of yield and its component traits and identification of molecular markers linked to bacterial wilt resistance in tomato crop (*Solanum lycopersicum* L.). Ph.D. thesis submitted to University of Agricultural Sciences, Dharwad.

Prasanna, K.M. 2012. Development of bacterial wilt resistant F_1 hybrids with long shelf life in tomato crop (*Solanum lycopersicum* L.). Ph.D. thesis submitted to University of Agricultural Sciences, Bangalore.

Sharma, J.P., Jha, A.K., Singh, A.K., Pan, R.S., Rai, M and Kumar, S. 2006. Evaluation of tomato against bacterial wilt (*Ralstonia solanacearum*) in Jharkhand. Indian Phytopathology. 59(4): 405-409.

Wang, J.F., Ho, F.I., Truong, H.T.H., Huang, S.M., Balatero, C.H., Dittapongpitch, V and Hidayati, N. 2013. Identification of major QTLs associated with stable resistance of tomato cultivar 'Hawaii 7996' to *Ralstonia solanacearum*. Euphytica. 190 (2): 241-252.

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PHYSICO-CHEMICAL AND FUNCTIONAL PROPERTIES OF JACKFRUIT (*Artocarpus heterophyllus*) SEED FLOUR

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ABSTRACT

Jackfruit seeds are under-utilized waste products in many tropical countries. The study was conducted in the Department of Food and Nutrition, College of Community Science, ANGRAU, Guntur in the year 2022 to study the physico-chemical and functional properties of jackfruit seed flour (JSF).The seeds were lye peeled, dried, and milled into flour. Physical characteristics of the seeds including linear dimensions namely length, breadth and thickness of seeds were recorded as 3.32± 0.44 cm, 1.72±0.40 cm and 1.61±0.26 cm, respectively. Geometric mean diameter was 2.03±0.34 cm. Surface area, Sphericity, aspect ratio were estimated as 12.57 cm^2, 0.63, 57.04%, respectively. Chemical characteristics such as total sugar and reducing sugar were estimated as 1.84% and 1.62 %, respectively and soluble solids as 30.4^0 Brix. Functional properties of jackfruit seed flour including water absorption capacity (184.27 ± 1.82 ml/100 g), oil absorption capacity (87.65 ± 2.63 ml/100 g), bulk density (0.73 ± 0.11 g/ml) and flour dispersibility (32± 0.95 %) were recorded for the JSF. The values for swelling power and solubility were 12.46 ± 0.80% and 1.46 ± 0.15%, respectively. Jackfruit seed flour acquire good functional property and hence can be used for domestic, commercial, and industrial purposes.

Keywords: Jackfruit seed flour, lye peeling, Physio-chemical and functional properties

INTRODUCTION

Jackfruit is scientifically as known *Artocarpus heterophyllus* belonging to family, Moraceae which is the world's largest fruit bearing tree. It is an essential underutilized fruit and often called as poor man's fruit as it is easily affordable and abundantly accessible in large numbers during the season (Sivaranjini *et al.,* 2020). Wild or locally available harvested jackfruits provides livelihood to the poor people and it has a great potential in increasing local income by growing them in agroforestry and home garden systems (Lakshminarayan, 2017).

The by-product seeds are a significant source of phenolics, which have a variety of

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actions, including antiviral, antibacterial, cardio-protective, and anti-mutagenic properties, as well as sugars, minerals, organic acids, dietary fibre, and phenolics. Seed has a strong antioxidant capacity.One distinguishing aspect of some tropical exotic fruit byproducts, such as jackfruit seeds, is that they contain significant levels of soluble dietary fibre, which is thought to provide additional health benefits. In addition to its well-known health benefits, dietary fibre demonstrates some functional properties as food additives, such as the ability to hold water, swell, increase viscosity, or form gels, all of which are crucial in the formulation of some food products. (Mani, 2018).

Jackfruit seeds are less recognized by people, but they have substantialnutritional benefits and constitute about 10% to 15% of the fruit weight (Waghmare *et al.,* 2019). Jackfruit seeds are rich in carbohydrate (60–80% based on dry matter), protein, vitamins and minerals, which may be eaten in boiled or roasted form or syrup like chestnuts (Anaya-Esparza *et al*., 2018). The jackfruit seeds are suitable for eating and its flour can be used in bakeryindustries. In addition, the seeds are widely consumed in desserts or as an ingredient in Asian culinary preparations (Zang *et al*., 2021).

However, despite its high nutritional value and health benefits, jackfruit is still underutilized perishable fruit due to insufficient processing knowledge and resources in the regions where it is grown. **(**Ngwere and Mongi, 2021; Ranasinghe *et al*., 2019). According to Adan *et al*. (2020) and Banarjee and Datta (2015), the seeds may be processed into flour and incorporated into wheat flour to produce composite bakery products and confectionery like cake, bread, and buns. Composite flour technology has been used to improve the nutritional and functional properties of flour and its processed products in an economical way (Oke *et al*., 2019; Hasmadi *et al*., 2020).

MATERIALS AND METHODS

The study was carried out in the Department of Food and Nutrition, College of Community Science, ANGRAU, Lam, Guntur in the year 2022. Jackfruit seed used in the study was obtained from Krishi Vigyan Kendra, (KVK), Amadalavasa, Srikakulam district, Andhra Pradesh, India. Physical properties of ten seeds from 10 fruits each *i.e*. total of hundred seeds were selected randomly and the three linear dimensions namely length, width, and thickness, and the related properties based on linear dimensions were determined. Chemical properties such as total sugars, reducing sugars, soluble solids and functional properties which includes water absorption capacity, swelling power, oil absorption capacities, percent solubility, flour dispersibility and bulk density were analysed.

Physico-chemical characteristics of jackfruit seeds

Physical composition of fruit: Physical parameters of randomly selected ripe fruits were studied and observations were recorded on the following characters.

Weight of the fruit, fleshy bulbs and seeds in the fruit: Ripened fruits were collected randomly and weighed using an electronic balance from each replication separately and observations were recorded.

Bulb seeds separated from bulbs were weighed in replica and observations were recorded.

Weight of non-edible waste: The weight of non-edible waste was weighed separately and themean value of fruits in each replication was recorded.

Pulp: seed ratio : Pulp:seed ratio was calculated by dividing the weight of pulp by the weight of seed.

Number of seeds per fruit: Seeds were collected from randomly selected jackfruits. Number of seeds per fruit was counted and the same process was repeated in replications.

Number of seeds per 100 g: Hundred grams jackfruit seeds were weighed and number of seeds were counted and recorded**.**

Flour yield per 100 g: Hundred grams of jackfruitseed was considered for yield calculation. After the processing steps, the total flour was weighed and expressed as percentage.

Physical properties of jackfruit seeds: Physical parameters of randomly selected ripe fruits were studied and observations were recorded on the following characters. To determine the size of jackfruit seeds, a random sample of 10 seeds were collected from 10 fruits each.

Linear dimensions: Linear Dimensions including Length, Width, and Thickness of jackfruits were recorded. These parameters were observed using digital Vernier Callipers. Where, L = length of the jackfruit seed in cm; W = width of the jackfruitseed in cm and T = thickness of the jackfruit in cm.

Volume of the jackfruit Seed: The length, width and thickness of jackfruit seeds were measured assuming perpendicular axis along its largest dimension. The volume of the jackfruit seed was calculated by using the formula: Volume = (L×W×T).

Geometric mean diameter (GMD): The shape of the jackfruit seed was determined with the help of GMD. By using linear dimensions, Geometric mean diameter of the seeds was denoted by Dg was calculated by using the formula Geometric mean diameter (Dg) = (LWT) 1/3.

Sphericity (ϕ): The sphericity (Sp) was used to describe the shape of seed. The sphericity was accordingly computed as per formulae :Sp (ϕ) = Dg / L ; where, Dg = Geometric mean diameter.

Surface area :The surface area (S) of the seed sample was calculated by the following equation **,** Surface area (S) = πDg^2 **;**Where, Dg is Geometric Mean Diameter.

Aspect ratio : The aspect ratio (R) of the jackfruit seeds were calculated with the equation.

Aspect ratio (R) = Length of seed / Width of seed x 100.

Preparation of jackfruit seed flour

The jackfruit seeds were cleaned manually and white arils (seed coat) were manually peeled off. Seedswere lye peeled, soaking in 3% sodium hydroxide solution for 20 minutes to remove the thin brown spermoderm which covers the cotyledons. The spermoderm layer was removed by rubbing the seeds between the hands and washing

thoroughly under running water. The lye peeled seeds were sliced into thin chips and dried at 50- 60 °C to a constant moisture. The dried chips were powdered into flour.

Functional properties of jackfruit seed flour

Water absorption capacity (WAC): One gram sample was weighed into 25 ml graduated conical centrifuge tubes and about 10 ml of water added. The suspensions were allowed to stand at room temperature (30±2 °C) for 1 h. The suspension was centrifuged at 200 x g (2000 rpm) for 30 minutes. The volume of water on the sediment was measured and the water absorbed is expressed as per cent water absorption .

Oil absorption capacity (OAC): One gram sample was weighed into 25 ml graduated conical centrifuge tubes and about 10 ml of refined vegetable oil added. The suspension was centrifuge at 200 x g (2000 rpm) for 30 minutes. The volume of oil on the sediment was measured and the oil absorbed expressed as per cent oil absorption.

Swelling power and percent solubility: Swelling power and percent solubility of seed flour was determined**.** About 250 mg (W1) of jack seed flour was taken in a centrifuge tube. The weight of the centrifuge tube with sample (W2) and 10ml (VE) of distilled water was added. Then it was allowed for 30min in a boiling water bath at 100^{o} C. The contents were cooled and centrifuged at 5000rpm for 10min.The supernatant was carefully decanted in a test tube. The water adhering to the sides of centrifuge tube was wiped well and weight of the centrifuge tube was taken with swollen material (W3). The swelling power of seed flour per gram was calculated by the formula:Swelling power (g/g) = W3—W2 / W1.

In which, W1=Weight of seed flour sample, W2=Weight of the centrifuge tube with seed flour sample and W3=Weight of the centrifuge tube with swollen material.

For percent solubility of seed flour, the dried petriplate was weighed (W4) and 10ml of supernatant (VA) was pipetted into the petriplate. Then it was dried at 105°C in a hot air oven till constant weight was attained and cooled in a descicator and again weighed the petriplate with dry solids (W5). The per cent solubility of the supernatant was calculated by, % solubility= W5-W4 **/** VAX 100 **/** W1.

W1 = Weight of seed flour, W4 = Weight of the Petri plate; W5 = Weight of the Petri plate with dry solids; VE = Volume of water added; VA = Volume of supernatant taken.

Flour dispersability: Flour dispersability was measured by adding 10g of seed flour sample to 100 ml measuring cylinder. Distilled water was added to the volume of 100ml, stirred vigorously and allowed to settle for three hours. The volume of settled particles was subtracted from 100 and the difference was reported as dispersibility.

Bulk density: A graduated cylinder tubes were weighed and flour sample filled to 5 ml by constant tapping until there was no further change in volume. The contents were weighed and the difference in weight determined. The bulk density was computed as grams per milliliter of the sample.

Chemical propertiesof jackfruit seed flour

Reducing Sugars,total sugars and total soluble solids content of the sample were

determined using method of Ranganna (2009). Reducing Sugars and Total Sugars content of the sample was expressed as g/100 g. Ten grams of sample was transferred to 250 ml volumetric flask using a little amount of distilled water and 2 ml of lead acetate. Solution was added to the flask for precipitation of colloidal matter and kept aside for 10 minutes. Then 2 ml of potassium oxalate solution was added to this solution to precipitate the lead and then the volume was made up to 250ml using distilled water. The contents were then filtered through Whatman No.1 filter paper. Reducing Sugars in the lead free solution were then estimated by taking this solution in burette and titrating against 10 ml of standard Fehling's solution mix of A and B (1:1), using methylene blue as an indicator and formation of brick red precipitate as an end point. Keeping the Fehling's solution boiling on the heating mantle carried out the titration. Thirty-nine Total Sugars (percent) for inversion at room temperature, a 50 ml aliquot of clarified deleaded solution was transferred to 250 ml volumetric flask, to which, 10 ml of 50 percent HCl was added and then allowed to stand at room temperature for 24 h. It was then neutralized with 40 percent NaOH solution. The volume of neutralized aliquot was made to 250 ml with distilled water. This aliquot was used for determination of total sugars by titrating it against the boiling mixture of Fehling 'A' and Fehling 'B' (5 ml each) using methylene blue as indicator to a brick red end point. The results were expressed on percent basis.

$$\text{Total sugars percent} = \frac{\text{Factor} \times \text{Dilution}}{\text{Titre reading} \times \text{Weight of the sample}} \times 100$$

Soluble Solids: The percentage of soluble solids was determined using ERMA hand refractometer by placing a drop of the filtered juice on the refractometer prism. Before taking the reading, the refractometer was tested for error with distilled water.

RESULTS AND DISCUSSION

Physical composition of jackfruit seeds

Weight of the Fruit: Table 1 data revealed the weight of the fruits ranging from 4.22 kg to 14.10 kg. Themean weight of the fruits was 6.92 kg which broadly varied from the results of Xess (2021) who reported 11.4 kg of average jackfruit weight.

Weight of the fleshy bulbs in the fruit It was observed that although the total fruit was quite good, bulb quantity was less in some fruits due to less size of fleshy bulbs and more flakes and non-edible weights and vice versa. Present study results showed that the mean bulb weight of fruit was 2.6 kg which greatly differs from the values of 4.7 kg and when calculated in percentages from a total fruit it was 7.6% which is 39.86% reported by Xess (2021).

Weight of seeds in the fruit: Greater variation of weight of seeds was observed from fruit to fruit and this could be due to smaller seed size although the total number of seeds were more. The average seed weight of all the fruits was calculated to be 1.03 kg which is in conformity with Xess (2021) who reported 1.32 kg of average seed weight.

Weight of non-edible waste: Jackfruit consists of an edible (pulp and seed) and nonedible (rind and rachis) parts (Suzihaque

et al., 2022). Non-edible weight contributes about 47.5% of the total fruit weight which was interpreted from this study which is in on par with the values of 48.86% and by Xess (2021).

Pulp-seed ratio: The calculated value was 2.61 which was lower compared to Xess (2021**)** who recorded a ratio of 3.51.

Number of seeds per fruit and per 100g: The average total number of seeds in fruit was 161.6 per fruit and the total number of seeds for 100 g was calculated as 17.92 per 100 g.

Flour yield per 100g: Observations in the preparation of jackfruit seed flour data is presented in Fig.1**,** it was observed that 100 g of jackfruit seeds contain eighteen fresh seeds. The weight of the seeds reduced by 2.2 percent to 97.8 g after removal of white arils from seeds. The weight of the brown spermoderma was recorded as 6.4 g, thus the seed weight was decreased to 91.4 g. The flour was made from lye peeled and dried seeds, which weighed 46.9 g. Our results are in conformity with the result of 46% yield reported by Chowdhury *et al.* (2012) and 48.25% by Hossain *et al*. (2014), which was lower than the findings of Islam *et al*. (2015) and Afroza (2013) with the flour weight of 75 g and 68 g, respectively.

Physical properties of jackfruit seed

Table 2 represents the results for Physical properties of jackfruit seed.

Linear dimensions: Seed size determination was done by random sampling of jackfruits and their seeds. Jackfruit seeds were brown in colour, oval in shape and comparatively smaller in size with an average length and breadth of 3.32±0.44 and 1. 72 ± 0.40 cm. The values were in comparison with results reported by Suzihaque *et al*. (2022), Boris and Bharathi (2020), Kushwaha *et al*. (2019), Islam *et al.* (2015) and Butool and Butool (2013) who recorded 2.0 to 4.0 cm and 1.70 cm, 3.52±0.18 and 1.77±0.15, 2.77 cm and 1.93 cm and 3.30 and 1.71 cm, respectively. Slightly lower values of length (2-3 cm) and width (1-1.5 cm) were mentioned by Abraham and Jayamuthunagai (2014). The variations in physical dimensions of the seeds were attributed to differences in variety of the fruit, maturity index, location and climatic conditions of cultivation. An average seed weighed 5.75 ± 1.35 g, had a volume of 8.30 ± 0.32 ml and a bulk density of 1.04 ± 0.05 g/ml (Table 2).

Geometric mean diameter: Geometric Mean Diameter was calculated using the three principal dimensions. The geometric mean diameter of jackfruit seeds significantly ranged from 1.69 – 2.04 cm and the mean score was 2.03cm being higher than the width and thickness; lower than the length. This is in line with the findings of Kushwaha *et al*. (2019) and Deshmukh (2014) who reported 1.72 to 2.04 cm and 1.4- 1.78cm, respectively (Table 2).

Surface area, sphericity, aspect ratio: The Average surface area of the seeds was obtained as 12.57, which lies within the range of value 9.26 to 13.19 cm reported by Kushwaha *et al*. (2019). Sphericity of seeds average mean score was obtained as 0.58±0.08 which differed from the values of 0.63 reported by Deshmukh (2014). The sphericity of jackfruit seeds increases with an increase in moisture content (Deshmukh,

2014).This property is important in manufacturing dehuller design and hopper for seeds though the seeds were plane-shaped.

Aspect ratio is also very important for the handling operation of seeds like sphericity. The present study showed that the jackfruit seeds contain an aspect ratio of 57.06% which is within the range of 49.36 to 82.45% reported by Kushwaha *et al*. (2019). Higher the length of the seed lowers the aspect ratios.

Functional properties of jack seed flour

The functional properties play a significant role in the food systems in creating new products. The jackfruit seeds are very essential to get the characteristics of various properties. The flour obtained from jack fruit seed is evaluated for its quality parameters such as water absorption capacity, swelling power, oil absorption capacities, percent solubility, flour dispersibility and viscosity of the seed flour (Table 3)**.**

Water absorption capacity in JSF was (184.27±0.03%). These results are in agreement with those for raw JFSF, reported by Boris and Bharathi (2020), Ejiofor *et al*. (2014). Our results are lower than those reported by Nabubuya *et al.* (2022) who obtained 341.3 ± 9. Water absorption capacity varies with the molecular structure of flour sample, concentration of protein, interaction with water, hydrophilic groups, configuration properties, degree of grinding, husk presence, damaged starch, protein and carbohydrate contents. (Kaushal *et al*., 2012). The ability of the product in withholding water when processing dough and pastes is an indicator of WAC.

Oil absorption capacity is attributed mainly to the physical entrapment of oils. It indicates the rate at which protein binds to fat in food formulations. In the study, the oil absorption capacity of seed flour was 87.65 ± 0.20 percent. OAC was associated with Abraham and Jayamuthunagai (2014); Akubor and Obiegbuna (2014) and Ejiofor *et al*. (2014). Nabubya *et al.* (2022) reported higher OAC of 129.5 ± 14.2. Oil absorption capacity increased in processed flours which may be due to denaturing and separation of protein molecule when subjected to heat which unmasks the non-polar residues from the interior of the protein molecule.

Emulsifying and foaming properties of proteins increases in greater dispersibility conditions which was observed during food preparation of bread, macaroni, and cookies (Ali *et al.,* 2012). In the present investigation, the dispersibility of the flour was determined as 32±0.09, similar to the value of 33% stated by Deshmukh (2014) and higher value *i.e*. 80.50±0.60 by Eke-Ejiofor *et al*. (2014).

Food quality is associated with retaining water in the swollen starch granules. The swelling power of the flour was 12.46% and 12.75% for jackfruit seed flour and refined wheat flour,respectively. The gelatinization and swelling power tests were used to identify the baked quality of the flour. The high swelling power of the flours and starches may be due to the formation of protein amylase complexes. The extent of swelling depends on water absorption, temperature, availability of water and water absorption. It is regarded as a quality criterion in good food formulations such as

bakery products. (Osungbaro *et al*., 2010). The solubility **o**f flour was recorded as 14.60 ± 0.05%. Similar values were documented by Ejiofor *et al*. (2014) (Table 3).

Bulk density: Bulk density depends on the size of the particles in the samples and measures the heaviness of the flour. In the food processing industry, bulk density is important in determining to package and handling materials and used in the application of wet processes in the food industry. The value found in the study was 0.73 g/ml (Table3). A similar observation was made by Nabubuya *et al*.(2022). Odoemelan (2005) reported 0.61g/ml of bulk density and the values of 0.55 – 0.62 g/ml for tigernut flours was documented by Oladele and Aina (2007). Akubor and Badifu (2004) observed higher value of 0.54 g/cm^3 for breadfruit kernel flour and 0.71 g/ml for wheat flour. The higher bulk density flours useful in food product as thickening agents, the Jackfruit seed powder might be used as a thickener as flour with extreme bulk density was used in food product preparations like soups, gravies,etc.,

Chemical properties of jackfruit seed flour

Total sugars: Total sugars in jackfruit seed flour were determined as 1.84% which is in contrast with Xess (2021) who reported 5.50%, at the time of preparation which was found to increase significantly to 5.22% after 180 days of storage and 7.32±0.33 was reported by Baruah (2014) (Table 4).

Reducing sugars: Reducing sugars in jackfruit seed flour was observed as 1.62% which agreed with the findings of Xess (2021) who reported 1.72% at the time of preparation which was found to increase significantly to 1.85% after 180 days of storage (Table 4).

Soluble solids: Soluble solids of jackfruit seed powder were determined as 30.4 ^{0}Brix. This was in close proximity to the result of Xess (2021) who reported TSS as 32.53^0 Brix which was found to increase significantly to 40.86 ^{0} Brix after 180 days of storage (Table 4).

CONCLUSIONS

Processed jackfruit seed flour has strong functional properties, making it useful for

Table 1. Physical composition of jackfruit

S.No.	Parameters	Mean Values
1	Weight of the fruit (kg)	6.92
2	Weight of the bulbs (kg)	2.60
3	Weight of the seeds (kg)	1.03
4	Weight of the non-edible part (kg)	3.29
5	Pulp : Seed ratio	2.61
6	Total number of seeds in a fruit	161.6
7	Total number of seeds per 100g	17.92

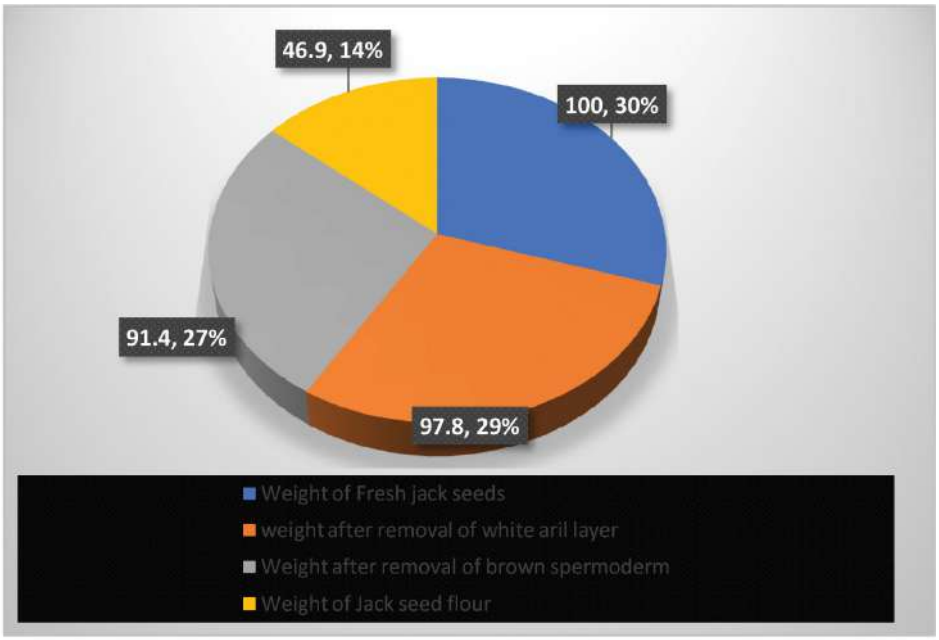

Figure 1. Flour yield percentage

Table 2. Linear dimensions of jackfruit seed

S.No.	Parameters	Mean Values
1	Length (cm)	3.32±0.44
2	Breadth (cm)	1. 72 ± 0.40
3	Thickness (cm)	1.61±0.26
4	Volume (ml)	8.30 ± 0.32
5	Geometric mean	2.03±0.34
6	Surface Area (cm^2)	12.57
7	Sphericity	0.58±0.08
8	Aspect Ratio	57.04

Table 3. Functional properties of jackfruit seed flour

S.No.	Parameters	Mean Values
1	Water absorption capacity (ml/100g)	184.27 ±1.82
2	Oil absorption capacity (ml/100g)	87.65 ±2.63
3	Dispersibility (%)	32 ±0.95
4	Swelling power (%)	12.46±0.80
5	Percent solubility (%)	1.46 ±0.15
6	Bulk Density (g/cm^3)	0.73±0.11

Table 4. Chemical properties of jackfruit seed

Chemical parameters	Quantity / 100 g
Total Sugar (%)	1.84
Reducing Sugar (%)	1.64
Soluble Sugar (%)	
Glucose	0.51
Fructose	0.18
Sucrose	1.15
Soluble Solids (^{0}Brix)	30.4^0

adding value at the residential, commercial, and industrial levels by replacing cereal flours in established goods or creating new ones.

REFERENCES

Abraham, A and Jayamuthunagai, J. 2014. An analytical study on jackfruit seed flour and its incorporation in pasta. Research Journal of Pharmaceutical, Biological and Chemical Sciences. 5(2):1597-1610.

Adan, A. A., Ojwang, R. A., Muge, E. K., Mwanza, B. K and Nyaboga, E. N. 2020. Phytochemical composition and essential mineral profile, antioxidant and antimicrobial potential of unutilized parts of jackfruit. Food Research. 4(4): 1125-1134.

Afroza, S., 2013. Physico-chemical and functional properties of jackfruit seed flour and quality enrichment of chapattis using composite flour. Ph.D. Thesis submitted to Bangladesh Agricultural University, Mymensingh.

Akubor P. I and Badifu, G. I. O. 2004. Chemical composition, functional properties and baking potential of African breadfruit kernel and wheat flour blends. International Journal of Food Science Technology. 39: 223–229.

Akubor, P. I and Obiegbuna, J. E. 2014. Effect of processing methods on the quality of flour and bread from African breadfruit kernel flour. Food Science and Quality Management. 24: 32-42.

Ali, J., Bantte, K and Feyissa, T. 2017. Protocol optimization for in vitro shoot multiplication of Jackfruit (*Artocarpus heterophyllus* L.). African Journal of Biotechnology. 16(2): 87-90.

Anaya-Esparza, L. M., González-Aguilar, G. A., Domínguez-Ávila, J. A., Olmos-Cornejo, J. E., Pérez-Larios, A and Montalvo-González, E. 2018. Effects of minimal processing technologies on jackfruit (*Artocarpus heterophyllus* L..) quality parameters. Food and Bioprocess Technology. 11(9): 1761-1774.

Banerjee, S and Datta, S. 2015. Effect of dry heat-treated jackfruit seed powder on growth of experimental animals. IOSR Journal of Pharmacy and Biological Sciences. 10: 42-46.

Boris. S and Bharati. P. 2020. Processing characteristics and acceptability of Jackfruit (*Artocarpus heterophyllus L.*) seeds, physical and functional properties of its flour. EPRA International Journal of Research and Development (IJRD). 5(10): 2455-7838.

Butool. S and Butool. M. 2015. Nutritional quality on value addition to jack fruit seed flour. International Journal of Science and Research. 4(4):2406-2411.

Chowdhury, A. R., Bhattacharyya, A. K and Chattopadhyay, P. 2012. Study on functional properties of raw and blended jackfruit seed flour (a non-conventional source) for food application. Indian Journal of Natural Products and Resources. 3 (3): 347-353.

Deshmukh, P. S. 2014. Development of Jackfruit seed flour by different methods. Ph.D. Thesis submitted to Dr.BalasahebSawant Konkan Krishi Vidyapeeth. Maharashtra.

Eke-Ejiofor, J., Beleya, E and Onyenorah, N. I. 2014. The effect of processing methods on the functional and compositional properties of jackfruit seed flour. Internationl Journal of Nutrional Food Science. 3(3): 166-173.

Hasmadi, M., Noor farahzilah, M., Noraidah, H., Zainol, M. K and Jahurul, M.H.A. 2020. Functional properties of composite flour: A review.Journal of Food Research. 4(6): 1820-1831.

Hossain, M.T., Hossain, M. M., Sarker, M., Shuvo, A. N., Alam, M. M and Rahman, M. S. 2014. Development and quality evaluation of bread supplemented with jackfruit seed flour. International Journal of Nutrition and Food Sciences. 3(5): 484.

Islam, M. S., Begum, R., Khatun, M and Dey, K. C. 2015. A study on nutritional and functional properties analysis of jackfruit seed flour and value addition to biscuits. International Journal Engineering Research Technology. 4 (12):139-147.

Kaushal, P., Kumar, V and Sharma, H. K. 2012. Comparative study of physico-chemical, functional, anti-nutritional and pasting properties of taro (*Colocasia esculenta*), rice (*Oryza sativa*), pigeon pea (*Cajanus cajan*) flour and their blends. Food Science and Technology. 48(1): 59–68.

Kushwala, R.,Vinti Singh, V., Singh, M and Kaur, D. 2019. Variation in physical and physico-chemical properties of different cultivars of Jackfruit seeds harvested from the northern region of India. International Journey of Advance and Innovative Research. 2(6): 2394-7780.

Lakshminarayan, N.G. 2017. Jackfruit based value added products. Retrieved from the website (https: //www.linkedin.com/pulse/jackfruit-based-value-added-products-n-glakshminarayan)on 02-09-2022.

Mani, S. 2018. Development of vegetable seeds incorporated cookies: Nutrient composition, functional properties, mineral analysis and sensory evaluation. International Journal of Environment, Agriculture and Biotechnology.3 (3): 916-927.

Nabubuya, A., Mugabi, R., Kaggwa, A., Ainebyona, P and Nalugya, R., 2022. Influence of roasting on the proximate,

functional and sensory properties of Jackfruit seeds and amaranth grain composite complementary flours. Tanzania Journal of Science. 48(1): 156-169.

Ngwere, S. S and Mongi, R. J. 2021. Nutritional composition, sensory profile and consumer acceptability of wheat-jackfruit seed composite buns. Tanzania Journal of Science. 47(3): 1154-1164.

Odoemelan, S. A. 2005. Functional Properties of raw and heat processed jackfruit (*Artocarpus heterophyllus*) flour. Pakistan Journal of Nutrition. 4 (6): 366 – 370

Oladele, A.K and Aina, J.O., 2007. Chemical composition and functional properties of flour produced from two varieties of tigernut (*Cyperus esculentus*). African Journal of Biotechnology.6(21):2473-2476.

Oke, E. K; Idowu, M. A.,Sobukola, O. P and Bakare, H. A. 2019. Quality attributes and storage stability of bread from wheat–tigernut composite flour. Journal of Culinary Science and Technology. 17(1): 75-88.

Osungbaro, T.O; Jimoh, D andOsundeyi, E. 2010. Functional and pasting properties of composite cassava- sorghum Flour Meal. Agriculture and Biology Journal of North America. 1(4):715-720.

Ranganna, S. 2009. Handbook of analysis and quality control for fruit and vegetable products. Tata McGraw Hill, New Delhi. pp:112.

Ranasinghe, R.A.S.N., Maduwanthi, S.D.T and Marapana, R.A.U.J. 2019. Nutritional and health benefits of jackfruit (*Artocarpus heterophyllus L.*): A review. International Journal of Food Science.Article ID 4327183. pp. 1- 12. https://doi.org/10.1155/2019/4327183.

Sivaranjini, Uthira, L and Abarajitha. K. 2020. Proximate analysis of jack fruit seed flour (non germinated and germinated) and value addition to bread. International Journal of Applied Research. 6(5): 293-299.

Suzihaque, M.U.H., Zaki, N.A.M., Alwi, H., Ibrahim, U.K., Abd Karim, S. F and Anuar, N.K. 2022. Jackfruit seed as an alternative replacement for starch flour. Materials Today: Proceedings.

Waghmare, R., Memon, N., Gat, Y., Gandhi, S., Kumar, V and Panghal, A. 2019. Jackfruit seed: An accompaniment to functional foods. Brazilian Journal of Food Technology. 22: 1-9.

Xess. R. 2021. Processing and by-product utilization of Jackfruit (*Artocarpus heterophyllus*) for the development of value addedproducts and their quality evaluation. Ph.D thesis submitted to Indira Gandhi Krishi Vishwavidyalaya, Raipur.

Zhang, Y., Li, B., Xu, F., He, S., Zhang, Y., Sun, L., Zhu, K., Li, S., Wu, G and Tan, L. 2021. Jackfruit starch: Composition, structure, functional properties, modifications and applications. Trends in Food Science & Technology. 107:268-283.

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PHYSICO-CHEMICAL AND COOKING QUALITY TRAITS OF SELECTED BLACK RICE (*Oryza sativa* L.) VARIETIES

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ABSTRACT

In this research, six black rice varieties cultivated in *Kharif* 2021 namely BPT 2841, BPT 2848, BPT 3136, BPT 3137, BPT 3145 and Burma Black (control) were studied for different quality traits such as physical, chemical and cooking quality traits. All the parameters showed significant variance. Thousand grains weight showed positive correlation with hulling per cent (r=0.748), milling percent (r=0.981), head rice recovery (r=0.594), kernel length (r=0.947) and kernel breadth(r=0.932). In terms of physical quality, 1000 grain weight of Burma black showed greater value due to its large grain size which is treated as undesirable. In terms of chemical quality traits, all the rice varieties except control had intermediate amylose content (20-25%) and intermediate alkali spreading value (4-5). These were considered as key characteristics to improve rice grain quality.

Keywords: Black rice, Burma black, Correlation, Physical-chemical traits and Cooking quality traits

INTRODUCTION

Black rice is a super functional variety of the *Oryza sativa* (L.) rice species. It has a high level of nutrients, a sticky, nutty flavour, and a black hue. Purple rice, forbidden rice, heaven rice, imperial rice, king's rice, and treasured rice are additional names for black rice. Indonesian black rice varieties plays a lot of emphasis on the grain's potential as a functional diet (Thanuja *et al*., 2018). Rice variants with black colour of grains were formed as a result of pigment known as anthocyanin, which is found in many parts of Asia. This colour change is caused due to rearrangement of promoter region in Kala4 gene (Oikawa *et al*., 2015).

Superfoods are defined as foods with exceptionally high nutritional values. Black rice is a nutrient-dense variety of rice that is rich in antioxidants, fibre, vitamins B and E, iron, thiamine, magnesium, phosphorus, and niacin (Saha, 2016). Black rice is a collection of several health promoting factors that includes prevention of skin cancer (Han *et al*., 2018),

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reduction of memory loss (Hwang *et al*., 2018) and promotion of gut health by probiotic action (Zhu *et al*., 2018).

In order to assess the grain quality, uniform grain weight is critical. In worldwide marketing, grain appearance, which includes 1000 grain weight, length, breadth, shape, and thickness, plays an essential role for both customers and sellers. Hence, it is important to investigate physicochemical and cooking quality of different black rice varieties.

MATERIALS AND METHODS

The experimental material comprised six black rice varieties such as BPT 2841, BPT 2848, BPT 3136, BPT 3137, BPT 3145 and Burma Black (control). Those were procured from Agricultural Research Station (ARS), Bapatla District, Andhra Pradesh. (Table 1) in the year 2021 and studied. After harvesting, threshing and cleaning, the seeds from individual black rice varieties were dried under shade till the grains reached moisture content of 14%. The paddy obtained were dehusked and analyzed for 15 quality traits.

Physical quality traits: The physical quality characteristics of black rice were determined according to Ghosh *et al*. (1971).

Table 1. List of black rice varieties

S.No.	Black rice varieties	Grain type
1.	Burma black	Long Bold
2.	BPT 2841	Medium Slender
3.	BPT 2848	Medium Slender
4.	BPT 3136	Long Bold
5.	BPT 3137	Medium Slender
6.	BPT 3145	Long Bold

Hulling percentage: A weight of one hundred grams from each variety of paddy grain samples were dehusked in Satake Dehuller and final weight of dehusked kernels were recorded for each replication. The hulling percentage can be calculated by dividing the weight of dehusked grain or black rice by weight of the paddy and multiplied with 100.

Milling percentage: The dehusked black rice was polished through Satake grain testing mill for 20sec to obtain 1% polish. Total weight of dehusked kernels was recorded. The milling percentage can be calculated by dividing the weight of milled kernels by weight of the paddy and multiplied with 100.

Head rice recovery (HRR) percentage: The dehusked samples were sieved to separate whole kernels from the broken ones. Whole kernels and three fourth kernels were considered and weighed. The HRR is calculated by dividing the weight of whole dehusked kernels by weight of the paddy and multiplied with 100.

Kernel length (mm) and Kernel breadth (mm): Ten grains at random from each sample from each replication were dehusked. The length and breadth in millimeter were recorded using Dial micrometer.

Kernel length/breadth (L/B) ratio: The kernel L/B ratio was computed by using the formula of Murthy and Govindaswamy (1967). The mean length of grain in millimetres is divided by mean breadth of grain in millimetres gives L/B ratio. Based on L/B ratio, grains were classified into long slender (LS), short slender (SS), medium slender (MS), long bold (LB) and short bold (SB). Classification

of grain length and shape of milled rice was carried out as per Ramaiah (1985).

Thousand grain weight (g): Thousand grains at 14 % moisture were randomly picked from 10 panicles were weighed in Digital electronic balance and recorded to nearest milligrams.

CHEMICAL QUALITY TRAITS

Amylose content (AC) (g %): Amylose content in the rice samples was estimated as per the procedure given by Juliano (1971). To 100mg of powdered sample add 1 ml of distilled ethanol, mix well and add 10 ml of 1N NaOH. Leave it overnight and make up the volume to 100 ml. Mix 2.5 ml of extract with 20ml of water and three drops of phenolphthalein indicator. Add 0.1N HCl drop by drop until the pink colour just disappears. Add 1ml of iodine reagent and make up the volume to 50ml and read the absorbance at 590nm. Calculate the amount of amylose in the sample using the standard curve prepared from amylose (range 0.2-1 mg) against a blank for which dilute 1ml of iodine reagent to 50 ml with water.

Calculation

Absorbance corresponds to 2.5 ml of test solution = 'x' mg amylose in test solution.

$$100 \text{ ml contains} = \frac{x}{25} \times 100 = \% \text{ amylose}$$

Gel consistency (GC) (mm): The gel consistency test was estimated according to Cagampang *et al.* (1973). 100mg of rice sample taken in 13 x 100 mm test tubes and wetted with 0.2 ml 95% ethanol containing 0.025 % thymol blue. The tubes were shaken to suspend the starch, 2.0 ml of 0.2 N KOH was added and the mixture was vortex and kept in hot water bath. The samples removed from the water bath were set at room temperature for 5 min, and then cooled in an ice-water bath for 15 minutes. The tubes were then laid horizontally over graph paper graduated in millimetres and the length of the gel was measured from the bottom of the test tube to the gel front 60 min later.

Alkali spreading value (ASV): Six milled grains per replication were spread evenly in transparent plastic boxes containing 10 ml of 1.7 percent KOH. These boxes were kept undisturbed in an incubator at 23-30°C for 23 h. The alkali spreading of kernels noted on a seven-point scale following the protocol of Little *et al.* (1958).

COOKING QUALITY TRAITS

The kernel length after cooking, kernel breadth after cooking and elongation ratio were calculated according to Juliano *et al.* (1965).

Kernel length after cooking (KLAC) (mm) and Kernel breadth after cooking (KLBC) (mm): Five grams of whole grain milled rice was soaked in 15 ml of water for 10 minutes in a 50 ml centrifuge tube and heated in water for 20 minutes. Then the cooked rice was shifted to a petridish. Ten cooked kernels are randomly selected and average lengths and average breadths were measured on a graph sheet to nearest millimeter.

Kernel elongation ratio (KER) (mm): The kernel elongation ratio was computed according to Verghese (1950) method. The

KER is calculated by dividing the mean length of cooked kernels by mean length of raw kernels in millimeter.

Volume expansion ratio (VER): Volume expansion ratio was determined as suggested by Verghese (1950). In a 50ml graduated centrifuge tubes 15ml of water and five grams of rice sample was soaked for 5 minutes. The initial water volume after adding rice samples (Y-15) was recorded. In a 100ml measuring cylinder (X) containing 50ml water add 20 minutes cooked rice. The volume raised recorded (X-50) and was calculated by dividing the increase in volume after cooking (X-50) with increase in volume before cooking (Y-15).

Water uptake (WU) (ml): Two grams of each rice sample was kept in 10 ml water and soaked for 30 minutes and boiled for 45 minutes at 77 °C - 80 °C in a constant temperature water bath. After boiling, the tubes were taken out cooled and the supernatant water was poured into a graduated cylinder to note the water level. The actual amount of water absorbed during cooking was calculated by subtracting the supernatant water from the water used for cooking after considering the evaporation loss. Water uptake was computed according to Beachell and Stansel, (1963) by using the formula mentioned below.

$$\text{Water uptake (ml)} = \frac{100\text{ g}}{2\text{ g}} \times \text{Actual water absorbed during cooking}$$

RESULTS AND DISCUSSION

The quality of rice is mainly influenced by numerous physical and chemical quality parameters that indicate the cooked rice texture and cooking characteristics. The results are presented in Table 2.

PHYSICAL QUALITY TRAITS

Hulling percentage: The hulling per cent among six black rice varieties ranged from 73.63% (BPT 2848) to 77.57% (BPT 3145), which on par with the results of Pal *et al.* (2019) who reported the range as 72.47-76.00%. The observed mean was 75.58% which was in conformity with the mean values 76.67% (Bassuony. 2016) and 76.65% (Singh and Devi., 2020). The maximum hulling per cent was observed in BPT 3145 (77.57) and minimum in BPT 2848 (73.63). In terms of milling quality, the rice with high hulling percentage is desirable because the hulling percentage is positively correlated with the milling percentage (Ojha *et al.,* 2018).

Milling percentage: Among all the six black rice varieties, the maximum milling per cent was observed in Burma Black (71.00%) and minimum in BPT 2841 (68.10%). The milling per cent ranged from 68.10% to 71.00% with mean value 69.22%. The values were in comparison with the recorded values 64.6%, 65.77%, 62.64±0.05% and 60.00%-62.00% which were reported by Bassuony. (2016), Ponnappan *et al.* (2017) and Pal *et al.* (2019).

Head rice recovery (HRR) (%): The head rice recovery was found highest for BPT 3145 (65.30%) and lowest for BPT 2841 (60.07%) with a mean value of 63.63%. The values resulted were higher than the values 58.91% (Bassuony. 2016), 57.34±0.04% (Ponnappan *et al.,* 2017), 33.00-52.00% (Pal *et al.,* 2019), 44.12±1.34% (Singh and Devi

2020) and 56.5% (Singh *et al.,* 2020) from different studies. Village rice mills have reported 30 per cent head rice, whereas commercial rice mills have reported 55 per cent of head rice recovery. The increase detected in head rice recovery may be due to the variation in milling conditions (Dhankhar, 2014).

Kernel length (mm) : Depending on grain length, grains were classified into long (>6mm), Medium (5mm-6mm) and Short (<5mm). The highest kernel length was recorded by Burma Black (6.18mm) and lowest by BPT 2841 (5.60 mm) with a mean value 5.91 mm. The obtained results were similar with results of Ponnappan *et al.* (2017) (5.62 mm) and Rajendran and Chandran (2020) (5.1mm to 6.3mm).

Kernel breadth (mm): Among the varieties, the highest kernel breadth recorded for Burma black (2.51mm) and the lowest value for BPT 2841 (1.93mm). The obtained results were on par with results of Ponnappan *et al.* (2017) (2.15mm) and Rajendran and Chandran (2020) (2.5-3 mm).

Length/Breadth (L/B) ratio : In the present study, Length/Breadth ratio ranged between 2.46 to 2.94 and the mean value was 2.82. The highest length/breadth ratio recorded for BPT 3136 and BPT 3137 (2.92) and the lowest value for Burma black (2.46). The obtained results were in conformity with results of Ponnappan *et al.* (2017) (2.61±0.04) and Rajendran and Chandran (2020) (1.88-2.52). Depending on L/B ratio, Burma black, BPT 3136 and BPT 3145 were classified as long bold grains. BPT 2841, BPT 2848 and BPT 3137 were categorized as medium slender grains.

Thousand grain weight (g) : In this study, thousand grain weight recorded highest value for Burma black (27.23g) and the lowest value for BPT 2841 (13.53g) with the mean value 19.20g. Ponnappan *et al.* (2017) observed it as 17.50±0.04 for black rice that was on par with the result obtained in the present study. The increase in kernel weight may be related to their larger kernel size.

CHEMICAL QUALITY TRAITS

Amylose content (AC) (g%): In the present study, the highest amylose content was recorded for BPT 3136 (24.37g%), whereas, lowest for Burma black (5.40g%) with a mean value 20.05 g%. Pakuwal and Manandhar (2021) observed the amylose content in black rice as 5.28g% while Masniawati *et al.* (2018) recorded between 2.51 g% to 18.29 g% which showed contrary with present obtained result. All the varieties except control are classified under intermediate amylose content.

Gel consistency (GC) (mm): Gel consistency determines the potential of cooked rice to become harder upon cooling. Rice eating quality is correlated with the gel consistency. The rice is categorized according to gel consistency based on gel length as hard (26-40mm), medium (41-60 mm) and soft (61-100 mm). In the study, the highest gel consistency was recorded for Burma black (85mm), lowest for BPT 3145 (71mm) and with a mean value of 77.88mm. The obtained result showed similarity with the value 66.00 to 77.33mm and 76 ± 0.72mm reported by Pal

et al. (2019) and Krishnan *et al.* (2020) respectively. A high value of gel consistency indicates soft texture and lower values of gel consistency indicate harder texture.

Alkali spreading value (ASV): The desirable rice genotypes should have intermediate alkali spreading value (4-5). The black rice genotypes studied in the present research were observed to have an ASV ranging from 3.67 (Burma black) to 6.67 (BPT 3136) with mean value 4.61. According to Singh *et al.* (2020), ASV of black rice pericarp genotypes ranged from 2.50 to 7.00, which showed similar results with the present study. BPT 2841, BPT 2848, BPT 3137 and BPT 3145 rice varieties were classified under intermediate ASV. The rice varieties with intermediate alkali spreading value showed medium disintegration and classified under intermediate gelatinization temperature which were the desired quality characters (Madhubabu *et al.,* 2017).

CHEMICAL QUALITY TRAITS

Kernel length after cooking (KLAC) (mm) Kernel length after cooking ranged from 8.06 mm (BPT 2841) to 8.81 mm (BPT 3137), with a mean value of 8.47 mm. The results were on par with studies of Nath *et al.* (2022) and Pal *et al.* (2019) with values 8.46±0.31 and 8.10-10.10, respectively. When rice elongates, it appears more palatable and when rice enlarges in circumference, it appears coarse. Most often, people choose rice with long cooked grains which give a satisfactory appearance (Pathak *et al.,* 2016).

Kernel breadth after cooking (KBAC) (mm): The highest mean value for Kernel breadth after cooking was recorded for BPT 3136 (3.88 mm) and lowest value for BPT 2841 (3.06 mm) with a mean value of 3.60 mm. According to Nath *et al.* (2022) KBAC was 2.63±0.09 which is lower than this study result.

Kernel elongation ratio (KER): The mean value of kernel elongation ratio is 1.43. The highest mean value was recorded for BPT 3136 (1.46) and lowest value for Burma black (1.38). These obtained values were on par with the results of Pal *et al.* (2019) (1.68-1.87) and Singh and Devi (2020) (1.35±0.032). Kernel elongation was influenced by several genetic and physicochemical factors such as genotype, ageing temperature, ageing time, water uptake, amylose content and gelatinization temperature.

Volume expansion ratio (VER): The mean value of volume expansion ratio was 3.72. The highest mean value was recorded for Burma black (4.07) and lowest value for BPT 3137 (3.37). The values showed similarity with results of Pal *et al.* (2019) (3.75-4.00) and Singh and Devi (2020) (4.15±0.024). Higher elongation ratio (ER) of the cooked rice is preferred over lower ER, and customers liked to accept lower VER than higher VER.

Water uptake (WU) (ml) : The highest mean value for water uptake was recorded for Burma black (461.67 ml) and lowest value for BPT 3136 (405 ml) with a mean value 421.94 ml. The obtained results were higher than the values of Pal *et al.* (2019) (156.00-273.33 ml) and Singh and Devi (2020) (297.97±0.718 ml). Water uptake by the rice grains was mostly influenced by their surface area *i.e.*, size and shape. The large and round varieties took long

time to cook and absorb less water than the small and slender varieties.

Analysis of variance (ANOVA) : Analysis of variance was done for 15 grain quality traits, namely physical quality traits, chemical quality traits and cooking quality traits data (Table 3). The F-CI values of the varieties have statistically displayed significant differences ($p<0.05$) for all traits. This shows that there is ample space for choosing desirable lines from the existing gene pool for desirable traits. Wide variations are common, which can be ascribed to different treatments used and environmental factors influencing phenotypes.

Correlation between quality traits of black rice: The pair-wise correlations between physical quality, chemical quality and cooking quality traits of the grains are displayed in Table 4. In the present study, hulling per cent showed positive significant correlation with milling per cent (r = 0.751) and head rice recovery per cent (r = 0.861). Hulling percent (r = 0.719), milling percent (r = 0.868) and head rice recovery percent (r = 0.627) showed positive correlation with kernel length. Thousand grains weight showed positive correlation with hulling percent (r = 0.748), milling per cent (r = 0.981), head rice recovery per cent (r = 0.594), kernel length (r = 0.947), kernel breadth (r = 0.932) and negative correlation with L/B ratio (r = -0.747). L/B ratio showed significant positive correlation with amylose content (r = 0.960) and significant negative correlation with Alkali spreading value (r = -0.926). Hulling percent and milling percent showed positive correlation with head rice recovery percentage (r = 0.861, r = 0.567) and Alkali spreading value (r = 0.502, r = 0.738) whereas negative correlation was found with L/B ratio (r = -0.661, r = -0.858) and amylose content (r = -0.524, r = -0.809). Kernel length (r = -0.509) and kernel breadth (r = -0.936) showed negative correlation with L/B ratio and these are similar to findings of Basri *et al.* (2015) and Shijagurumayum *et al.* (2018).

Amylose content showed negative correlation with Alkali spreading value (r = -0.991) and Gel consistency (r = -0.761) which was in accordance with studies of Pathak *et al.* (2016) and Shijagurumayum *et al.* (2018), whereas, amylose content showed positive correlation with volume expansion ratio (r = 0.723). The amylose content is negatively correlated to tenderness and stickiness of rice. Amylose and amylopectin were two kinds of starches present in rice grains are responsible for many cooking and eating qualities of rice. High amylose grains shows higher volume expansion ratio. A significant negative correlation was observed between amylose and water uptake (r = -0.982). Low amylose waxy rice absorbs more water than intermediate and amylose rice and becomes moist and sticky. Rice with high amylose content cooked dry, less tender and become harder upon cooling, whereas, low-amylose varieties cooked moist and sticky. A highly positive significant correlation is observed between gel consistency and alkali spreading value (r = 0.832) showed similarity with studies of Pathak *et al.* (2016) and Shijagurumayum *et al.* (2018).

In the context of cooking quality traits, kernel length after cooking is one of the critical quality attributes. Grain shape and visual

Table 2. Mean performance of quality traits of black rice varieties

S .No.	Varieties	Physical traits							Chemical traits			Cooking quality traits				
		H (%)	M (%)	HRR (%)	KL (mm)	KB (mm)	L/B	TGW (g)	AC (g%)	GC (mm)	ASV	KLAC (mm)	KBAC (mm)	KER	VER	WU (ml)
1.	Burma Black	77.53	71.00	65.17	6.18	2.51	2.46	27.23	5.40	85.00	6.67	8.55	3.84	1.38	3.37	461.67
2.	BPT 2841	74.67	68.10	63.47	5.60	1.93	2.90	13.53	21.21	83.00	4.67	8.06	3.06	1.44	3.42	425.00
3.	BPT 2848	73.63	68.23	60.07	5.63	1.96	2.88	14.31	22.48	78.00	4.33	8.07	3.10	1.43	3.73	416.67
4.	BPT 3136	74.53	69.23	62.80	6.09	2.07	2.94	21.20	24.37	71.00	3.67	8.81	3.88	1.46	4.07	405.00
5.	BPT 3137	75.57	68.87	64.97	5.91	2.01	2.94	18.40	22.94	76.30	4.33	8.56	3.83	1.44	3.77	415.00
6.	BPT 3145	77.57	69.23	65.30	6.05	2.14	2.83	20.52	23.92	74.00	4.00	8.79	3.86	1.45	3.97	408.33
7.	Mean	75.58	69.22	63.63	5.91	2.10	2.82	19.20	20.05	77.88	4.61	8.47	3.60	1.43	3.72	421.94
8.	S.D	1.90	1.41	2.07	0.24	0.21	0.17	4.74	6.82	5.10	1.09	0.33	0.42	0.03	0.28	24.01
9.	C.V	2.28	1.08	1.58	0.01	0.01	0.01	0.75	0.05	1.91	6.02	0.15	1.58	0.03	0.40	67.14
10.	S.E	1.07	0.70	0.82	0.02	0.01	0.01	0.31	0.08	0.99	0.43	0.09	0.19	0.01	0.10	13.74
11.	Range lowest	73.63	68.10	60.07	5.60	1.93	2.46	13.53	5.40	71.00	3.67	8.06	3.06	1.38	3.37	405.00
12.	Range highest	77.57	71.00	65.30	6.18	2.51	2.94	27.23	24.37	85.00	6.67	8.81	3.88	1.46	4.07	461.67

H- Hulling percent, M- Milling percent, HRR- Head rice recovery, KL- Kernel length, KB- Kernel breadth, L/B- Length/Breadth ratio, TGW- Thousand grain weight, AC-Amylose content, GC- Gel consistency, ASV- Alkali spreading value, KLAC- Kernel length after cooking, KBAC- Kernel breadth after cooking, KER- Kernel elongation ratio, VER- Volume expansion ratio, WU- Water uptake

Table 3. Analysis of variance for quality traits of black rice varieties

Physical quality traits						
Source of Variation	**Df**	**S.S.**	**MSS**	**F-Cl**	**F-tab**	**Interpretation**
1. Physical traits	6	123071.22	20511.87	38446.83	2.21	Significant
2. Rice varieties	5	179.61	35.92	67.33	2.32	Significant
3. Physical traits X Rice varieties	30	321.44	10.71	20.08	1.59	Significant
4. Error	84	44.82	0.53			
5. Total	125	123617.09				
Chemical quality traits						
Source of Variation	**Df**	**S.S.**	**MSS**	**F-Cl**	**F-tab**	**Interpretation**
1. Chemical traits	2	53709.26	26854.63	45150.55	3.25	Significant
2. Rice varieties	5	88.98	17.80	29.92	2.47	Significant
3. Chemical traits X Rice varieties	10	1144.66	114.47	192.45	2.1	Significant
4. Error	36	21.41	0.59			
5. Total	53	54964.31				
Cooking quality traits						
Source of Variation	**Df**	**S.S.**	**MSS**	**F-Cl**	**F-tab**	**Interpretation**
1. Cooking traits	4	2512154.76	628038.69	11079.70	2.52	Significant
2. Rice varieties	5	1244.16	248.83	4.39	2.36	Significant
3. Cooking traits X Rice varieties	20	5168.07	258.40	4.56	1.74	Significant
4. Error	60	3401.02	56.68			
5. Total	89	2521968.02				

Note: Df- Degree of freedom; S.S.- Sum of Squares; MSS- Mean Sum of Squares; F-Cl: F calculated value, F-tab: F table value

Table 4. Correlation coefficients for 15 quality characteristics among black rice varieties

Parameter	H	M	HRR	KL	KB	L/B	TGW	AC	GC	ASV	KLAC	KLBC	KER	VER	WU
H	1.000														
M	0.751	1.000													
HRR	0.861*	0.567	1.000												
KL	0.719	0.868*	0.627	1.000											
KB	0.766	0.982**	0.525	0.778	1.000										
L/B	-0.661	-0.858*	-0.368	-0.509	-0.936**	1.000									
TGW	0.748	0.981**	0.594	0.947**	0.932**	-0.747	1.000								
AC	-0.524	-0.809	-0.336	-0.413	-0.875*	0.960**	-0.681	1.000							
GC	0.246	0.271	0.162	-0.211	0.409	-0.670	0.086	-0.761	1.000						
ASV	0.502	0.738	0.309	0.308	0.823*	-0.926**	0.593	-0.991**	0.832*	1.000					
KLAC	0.578	0.558	0.589	0.895*	0.429	-0.093	0.706	0.029	-0.573	-0.136	1.000				
KLBC	0.657	0.693	0.682	0.938**	0.566	-0.252	0.809	-0.170	-0.400	0.071	0.956**	1.000			
KER	-0.391	-0.624	-0.195	-0.155	-0.725	0.898*	-0.460	0.957**	-0.881*	-0.985**	0.289	0.071	1.000		
VER	-0.129	-0.207	-0.116	0.271	-0.328	0.588	-0.024	0.723	-0.985**	-0.792	0.622	0.438	0.849*	1.000	
WU	0.447	0.691	0.295	0.249	0.776	-0.914*	0.540	-0.982**	0.866*	0.997**	-0.194	0.015	-0.985**	-0.840*	1.000

*Correlation is significant at the 0.05 level, **Correlation is significant at the 0.01 level.

H- Hulling percent, M- Milling percent, HRR- Head rice recovery, KL- Kernel length, KB- Kernel breadth, L/B- Length/Breadth ratio, TGW- Thousand grain weight, AC-Amylose content, GC- Gel consistency, ASV- Alkali spreading value, KLAC- Kernel length after cooking, KBAC- Kernel breadth after cooking, KER- Kernel elongation ratio, VER- Volume expansion ratio, WU- Water uptake.

appearance of rice before and after cooking are essential to determine acceptance of a rice variety. Head rice recovery was found to be positively correlated with kernel length after cooking (r = 0.589). A positive correlation was observed between Kernel length after cooking and kernel elongation ratio (r = 0.289) which was similar to the result reported by Shijagurumayum *et al.* (2018). A significant positive correlation was observed between water uptake and alkali spreading value (r = 0.997). The retrogradation behaviour of the starch particles in the rice grains absorbed water and increased in volume during cooking should be regarded as reason for positive correlation of more water uptake.

The data obtained on primary quality traits such as hulling percentage, milling percentage, head rice recovery percentage, intermediate amylose, intermediate alkali spreading value, soft gel consistency and higher volume expansion can be given to the breeders for varied application in future breeding projects.

CONCLUSIONS

The physico-chemical and cooking quality parameters among the black rice varieties were investigated in the study. All the physical, chemical and cooking quality traits showed significant differences. All the black rice varieties except control (Burma black) showed intermediate amylose content and intermediate alkali spreading value, which were considered as desired quality traits because the cooked rice shows flakiness and high kernel elongation ratio and good volume expansion ratio.

REFERENCES

Basri, F., Sharma, H.P., Jain, P and Mohato, G. 2015. Grain quality and starch evaluation of local varieties of rice (*Oryza sativa* L.) growing in Jharkhand state, India. International Journal of Current Research. 7(1): 11895-11900.

Bassuony, N.N. 2016. Cooking qualities evaluation for white and black rice mixture. Journal of Plant Production. 7(2): 197-202.

Beachell, H.M and Stansel, J.W. 1963. Selecting rice for cooking characteristics in breeding programme. International Rice Commission Newsletter. pp. 25-40.

Cagampang, G.B., Perez, C.M and Juliano, B.O. 1973. A gel consistency test for eating quality of rice. Journal of the Science of Food and Agriculture. 24: 1589-1594.

Dhankhar, P. 2014. Rice milling. International Organisation of Science Research Journal of Engineering. 4(5): 34-42.

Ghosh, A.K., Nanda, B.B., Govindaswami, S and Nayak, B.B. 1971. Influence of nitrogen on the physico-chemical characteristics of rice grain. Oryza. 8(1): 87-97.

Han, M., Bae, J., Ban, J., Shin, H., Lee, D and Chung, J. 2018. Black rice (*Oryza sativa* L.) extract modulates ultraviolet-induced expression of matrix metalloproteinases and procollagen in a skin cell model. International Journal of Molecular Medicine. 41: 3073-3080.

Hwang, S.N., Kim, J.C., Bhuiyan, M.I.H., Kim, J.Y., Yang, J.S., Yoon, S.H., Yoon, K.D

and Kim, S.Y. 2018. Black rice (*Oryza sativa* L.) extract reduces hippocampal neuronal cell death induced by transient global cerebral ischemia in mice. Experimental Neurobiology. 27(2): 129.

Juliano, B.O. 1965. Relation of starch composition, protein content, and gelatinization temperature to cooking and eating qualities of milled rice. Food Technology. 19: 1006-1011.

Juliano, B.O. 1971. A simplified assay for milled rice amylose. Cereal Science Today. 16: 334-360.

Krishnan, V., Awana, M., Raja Rani, A.P., Bansal, N., Bollinedi, H., Srivastava, S., Sharma, S.K., Singh, A.K., Singh, A and Praveen, S. 2021. Quality matrix reveals the potential of Chak-hao as a nutritional supplement: a comparative study of matrix components, antioxidants and physicochemical attributes. Journal of Food Measurement and Characterization. 15(1): 826-840.

Little, R.R. 1958. Differential effect of dilute alkali on 25 varieties of milled white rice. Cereal Chemistry. 35: 111-126.

Madhu Babu, P., Suman, K., Rathod, R., Fiyaz, R.A., Rao, D.S., Sudhakar, P., Satya, A.K., Babu, V.R and Neeraja, C.N. 2017. Evaluation of grain yield, quality and nutrients content in four rice (O*ryza sativa* L.) Genotypes. Current Journal of Applied Science and Technology. 22(1): 1-12.

Masniawati, A., Asrul, N.A.M., Johannes, E. and Asnady, M. 2018. Characterization of rice physicochemical properties local rice germplasm from Tana Toraja regency of South Sulawesi. Journal of Physics: Conference Series. IOP Publishing. 979 (1): 012005.

Murthy, P.S.N and Govindaswamy, S. 1967. Inheritance of grain size and its correlation with the hulling and cooking qualities. Oryza. 4(1): 12-21.

Nath, S., Bhattacharjee, P., Bhattacharjee, S., Datta, J and Dolai, A.K. 2022. Grain characteristics, proximate composition, phytochemical capacity, and mineral content of selected aromatic and non-aromatic rice accessions commonly cultivated in the North-East Indian plain belt. Applied Food Research. 2(1): 100067.

Oikawa, T., Maeda, H., Oguchi, T., Yamaguchi, T., Tanabe, N., Ebana, K., Yano, M., Ebitani, T and Izawa, T. 2015. The birth of a black rice gene and its local spread by introgression. The Plant Cell. 27 (9): 2401-2414.

Ojha, P., Chaudhary, O., Subedi, U., Karki, R and Dongol, D.M.S. 2018. Milling, nutritional, physical and cooking properties of four Basmati rice varieties. Journal of Nepal Agricultural Research Council. 4: 18-24.

Pakuwal, E and Manandhar, P. 2021. Comparative study of nutritional profile of rice varieties in Nepal. Nepal Journal of Biotechnology. 9(1): 42-49.

Pal, S., Bagchi, T.B., Dhali, K., Kar, A., Sanghamitra, P., Sarkar, S., Samaddar, M and Majumder, J. 2019. Evaluation of sensory, physico-chemical properties and Consumer preference of black rice

and their products. Journal of food science and technology. 56(3): 1484-1494.

Pathak, K., Rathi, S., Sarma, R.N and Baishya, S. 2016. Assessment of physical, chemical and antioxidant properties of few pigmented glutinous rice grown in Northeast India. Indian Journal of Plant Physiology. 21(3): 287-299.

Ponnappan, S., Thangavel, A and Sahu, O. 2017. Milling and physical characteristics of pigmented rice varieties. International Journal of Food Chemistry. 1(1): 24-29.

Rajendran, M and Chandran, K.R. 2020. Grain Dimension, nutrition and nutraceutical properties of black and red varieties of rice in India. Current Research in Nutrition and Food Science. 8(3): 903.

Ramaiah, K. 1985. Grain classification. Rice Research in India, ICAR Publication. 629.

Saha, S. 2016. Black rice: the new age super food (an extensive review). American International Journal of Research in Formal, Applied and Natural Sciences. 16(1): 51-55.

Shijagurumayum, S., Shantibala Devi, G.A and Singh, C.B. 2018. Grain quality evaluation of some aromatic rice varieties of Manipur, India. Research on Crops. 19(2):19-21.

Singh, K.S and Devi, G.A.S. 2020. Nutritional analysis and cooking quality parameter of white, red and black rice cultivar of manipur by using scanning electron microscope and EDAX. International Journal of Scientific and Technology Research. 9(2): 1443-1446.

Singh, K.S., Suneetha, Y., Kumar, G.V., Rao, V.S., Raja, D.S and Srinivas, T. 2020. Evaluation of coloured and white rice genotypes for yield and quality. International Journal of Current Microbiology and Applied Sciences. 9(7): 2454-2466.

Thanuja, B and Parimalavalli, R. 2018. Role of black rice in health and diseases. International Journal of Health Sciences and Research. 8: 241-248.

Verghese, E.J. 1950. A standard process for cooking rice for experimental purpose. Madras Agriculture Journal. 37:2 17-221.

Zhu, Y., Sun, H., He, S., Lou, Q., Yu, M., Tang, M and Tu, L. 2018. Metabolism and prebiotics activity of anthocyanins from black rice (*Oryza sativa* L.) i*n vitro.* Public Library of Science. 13(4): e0195754.

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ASSESSMENT OF POST-COVID SYNDROME MANIFESTATIONS AMONG COVID-19 PATIENTS IN ERNAKULAM DISTRICT

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ABSTRACT

The study was conducted between 2021 and 2022 among the post-COVID patients in Ernakulam district of Kerala by assessing Dietary Diversity Score (DDS), comorbidities, symptoms during COVID and post-COVID, fatigue, stress, and insomnia. The research was a six-month community-based prospective cohort study comprising 250 patients.Out of the 250 patients, 41.6% were male and 58.4% were female. Among the patients, 26% had a high Dietary Diversity Score. The most common comorbidities observed were hypertension (24%), followed by obesity (20.8%), diabetes mellitus (19.2%), and cardiovascular disease (16.8%), respectively. During the period of infection, the most common symptom among patients was tiredness (89.2%), followed by fever (83.2%), headache (78.8%), dry cough (67.6%), and loss of taste or smell (56.4%). Breathlessness (30%), chest pain (26%), and diarrhea (9.2%) were the other significant symptoms. The most prevalent post-COVID symptoms in various systems among patients were loss of appetite (89%), weakness (62.4%), sore throat (51.6%), dry cough (40.4%), joint pain (26.8%), and pain/burning in the chest (14.8%). During COVID, 42.4% of the patients were severely fatigued, 61.2% of the patients had a moderate level of perceived stress, and 44.4% of the patients had subthreshold insomnia. During post-COVID, 80.4% were severely fatigued; moderate stress was found in 40%, of the subjects; and 22.8 % of the study subjects had subthreshold insomnia. The Pearson's coefficient of correlation, 'r', between stress and insomnia among study subjects was 0.37. The obtained t-value for stress (7.14 > 2.58), fatigue (8.31> 2.58), and insomnia (10.97 > 2.58) were significant. Post-COVID is associated with comorbidities and disease severity. The prevalence of new-onset fatigue, perceived stress, and insomnia was significant among COVID-19 survivors.

Key Words: Comorbidities, COVID-19, Diabetes, Fatigue, Insomnia, Post-COVID syndrome

INTRODUCTION

Infection with a novel coronavirus strain (SARS CoV-2) causes coronavirus disease (COVID-19), a serious respiratory condition. Most persons reported experiencing chest discomfort, diarrhea, loss of taste or smell, exhaustion, sore throat, headache, shortness of breath, loss of speech or movement, or disorientation. Some of the less frequent

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symptoms include skin rash, finger or toe discoloration, red or itchy eyes, and skin irritation.Post acute COVID-19 is defined as a condition where manifestations of COVID-19 are extending beyond three weeks from the onset of symptoms and chronic COVID 19 as extending beyond 12 weeks (Anjana *et al.*, 2021). The fact is that fatigue, stress, and sleep are affected by COVID, and certain factors such as good prior nutritional status and good dietary diversity will help to reduce the intensity of symptoms during the infection. Little research about COVID or post-COVID had been conducted in Kerala, particularly in the Ernakulam district. This study envisaged obtaining information regarding the socio-demographic profile, assessing the nutritional status, and obtaining an insight into health-related problems during COVID and post-COVID among the patients.

MATERIALS AND METHODS

A total of 250 respondents between the age of 18 and 60 were chosen from the Ernakulam district of Kerala between July 2021 and January 2022. Based on the information available from the Primary Health Centre, the participants were selected from the study locale. An interview schedule was used to gather data about the sociodemographic profile, anthropometry and dietary assessment, assessment of comorbidities, symptoms during and after COVID, stress, fatigue, and sleep. WHO (1998) defined underweight, normal weight, overweight, and obesity based on BMI. Individuals with BMI < 18.5 were considered underweight, 18.5 to 24.9- normal, 25.0 to 29.9-overweight and > 30.0 as obese. The Indian consensus indicated BMI classification of 18-22.9, 23-24.9, 25-29.9 and 30-34.9 for normal, overweight, obesity grade I and Grade II, respectively (Misra *et al.,* 2009). The post-COVID symptoms in various systems are pain/burning in the chest, weakness, joint pain, sore throat, dry cough, and loss of appetite were assessed between 0 and 6 months after the primary infection. A 4-point Likert scale was utilized for each symptom during COVID described as absent, mild, moderate, or severe, and participants responded to it to the best of their knowledge. In patients with the modest disease, COVID-19 is expected to substantially impact physical, cognitive, mental, and social health status and dietary status.

Personal stress was assessed using the Perceived Stress Scale (PSS-10-C). The scale includes several direct questions about the current levels of stress experienced. In each case, the respondents were asked how many times they felt a particular condition. The PSS-10-C comprises 10 items, each of which offers five response options: never, rarely, occasionally, almost always, and always. Items 1, 2, 3, 6, 9, and 10 are scored directly from 0 to 4, and items 4, 5, 7, and 8, conversely, from 4 to 0 (Campo-Arias *et al.*, 2020). PSS score correlates with the severity of stress. A person with a score of 0–13 was considered to be having low stress. A score of 14-26 indicated moderate stress, while a score of 27-40 indicated high–perceived stress.

The Chalder Fatigue Scale (CFQ-11) was used to measure fatigue or tiredness. It has 11 items on an ordinal 0–3 scale. The CFQ-11 has a different scoring system bimodal scoring technique, in which each item answer is

dichotomized as 0 (0 to 1) or 1 (2–3), resulting in a 0–11 scale (Stavem *et al.*, 2021). The CFQ 11 allows the user to distinguish between 'cases' and 'non-cases' of fatigue. The physical and mental fatigue subscales are not employed in this study; instead, the responder is given a global binary fatigue score ranging from 0 to 11. Those who are not exhausted have a global binary fatigue score of 3 or less, while those who have a score of 4 or more have severe fatigue (Jackson, 2015).

The Insomnia Severity Index (ISI) assesses the subjective complaints, effects, and degree of dysfunction brought on by these sleep disruptions. The ISI consists of seven domains, including (a) the severity of sleep onset (initial), (b) sleep maintenance (middle), (c) early morning awakening (terminal) problems, and (d) the degree to which the patient was satisfied with current sleep pattern, (e) impact on daily activities, (f) observed by others/interfering with the quality of life, and (g) the level of distress level caused by the sleep problem.Interpretation of the results is as follows: absence of insomnia (0–7); subthreshold insomnia (8–14); moderate insomnia (15–21); and severe insomnia (22–28) (El Sayed *et al*., 2021).

DDS makes a list of everything they ate or drank in the past two days (meals and snacks), both during the day and at night. The IDDS (Individual Dietary Diversity Score) is made up of the following steps: new food group variables for those food groups that need to

Table 1. Socio-demographic status of study subjects (n=250)

S. No.	Socio-demographic Characteristics	Frequency (n)	Percentage (%)
	Gender		
1.	Male	104	41.6
2.	Female	146	58.4
	Age (Years)		
1.	18 – 29	95	38
2.	30 – 39	31	12.4
3.	40 – 49	48	19.2
4.	50 – 59	49	19.6
5.	Above 60	27	10.8
	Educational Status		
1.	P.G. and above	65	26
2.	Graduation	85	34
3.	Higher Secondary	66	26.4
4.	Secondary	34	13.6

Table 2. Anthropometric assessment of the subjects by BMI classification (n=250)

S.No.	BMI	WHO (BMI)	Percentage (%)	Asia-Pacific (BMI)	Percentage (%)
1.	Underweight	< 18.5	9.6	< 18.5	9.6
2.	Normal	18.5 – 24.9	61.2	18.5 – 22.9	60
3.	Overweight	25.0 – 29.9	23.6	23.0 – 24.9	14.8
4.	Obese	> 30.0	5.6	> 25.0	15.6

be aggregated were created to form a total of nine food groups. In the IDDS, for example, the food group "Starchy basics'' is made up of "Cereals" and "White roots and tubers." By merging the answers to "Cereals'' and "White roots and tubers," a new variable called "Starchy staples'' was formed. A person with a high dietary variety score has fewer DDS < 4 was considered as having poor dietary diversity. A score between 6 and 9 represents good diversity. Each food group was only counted once when calculating DDS.

RESULTS AND DISCUSSION

The study comprised 250 patients, with 104 (41.6%) men and 146 (58.4%) women. On studying the age-wise distribution of the subjects, 95 (38%) were in the 18-29 age group, 31 (12.4%) in the 30-39 age group, 48 (19.2%) in the 40-49 age group, 49 (19.6%) in the 50-59 age group, and 27 (10.8%) in the above 60 age group. According to the educational status of the study subjects, 65 (26%) had attained post-graduation, 85 (34%) were graduates, 66 (26.4%) had attained higher secondary education, and 34 (13.6%) had secondary education (Table 1).

The BMI categories of the patients, with (9.6%) subjects being underweight, (61.2%) being normal, (23.6%) being overweight, and (5.6%) being obese. By the Asia-Pacific BMI classification, with (9.6%) subjects being underweight, (60%) being normal, (14.8%) being overweight, and (15.6%) being obese (Table 2).

The Dietary Diversity Score (DDS) is a proxy tool that is based on the idea that "dietary diversity is a fundamental part of diet quality, and a diverse diet helps provide appropriate intakes of vital nutrients that promote health" (FAO, 2018). Among the patients, 26% had a high dietary diversity with a score of 6-9, 59.2% had a medium dietary diversity with a score of 4-6, and 14.8% had a low dietary diversity with a score of 1-3 (Table 3).

The different systems of medicines adopted to treat COVID-19 infection were

Table 3. Dietary diversity score among patients(n=250)

S. No.	Score	Interpretation	Frequency(n)	Percentage(%)
1.	6-9	High	65	26
2.	4-6	Medium	148	59.2
3.	1-3	Low	37	14.8

Table 4. System of medicine adopted to treat COVID – 19 infection (n=250)

S.No.	System of Medicine	Frequency(n)	Percentage (%)
1.	Ayurveda	2	0.8
2.	Allopathy	225	90
3.	Homeopathy	21	8.4
4.	Other	2	0.8

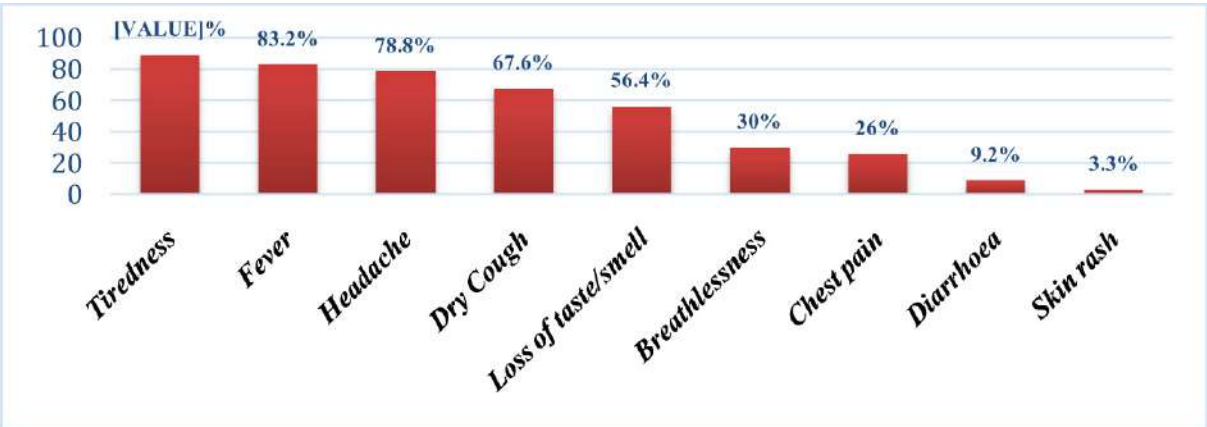

Fig 1. Assessment of symptoms during COVID-19 infection period

studied, with 2 (0.8%) of subjects adopting Ayurveda, 225 (90%) adopted Allopathy, 21 (8.4%) adopted Homeopathy and about 2 (0.8%) adopted other modes of treatment(Table 4).

The most common comorbidity among patients was hypertension 60 (24%), followed by obesity 52 (20.8%), diabetes mellitus 48 (19.2%), and cardiovascular disease 42 (16.8%). The least observed comorbidities were kidney disease 13 (5.2%), lung disease 11 (4.4%), and cancer 8 (3.2%). The study observed that hypertension 60 (24%) is the most prevalent comorbidity(Table 5).

Table 5. Assessment of comorbidities among patients (n=250)

S.No.	Comorbidity	Frequency(n)	Percentage (%)
1.	Hypertension	60	24
2.	Diabetes Mellitus	48	19.2
3.	Cardiovascular Disease	42	16.8
4.	Obesity	52	20.8
5.	Chronic Lung Disease	11	4.4
6.	Kidney Disease	13	5.2
7.	Liver Disease	7	2.8
8.	Cancer	8	3.2

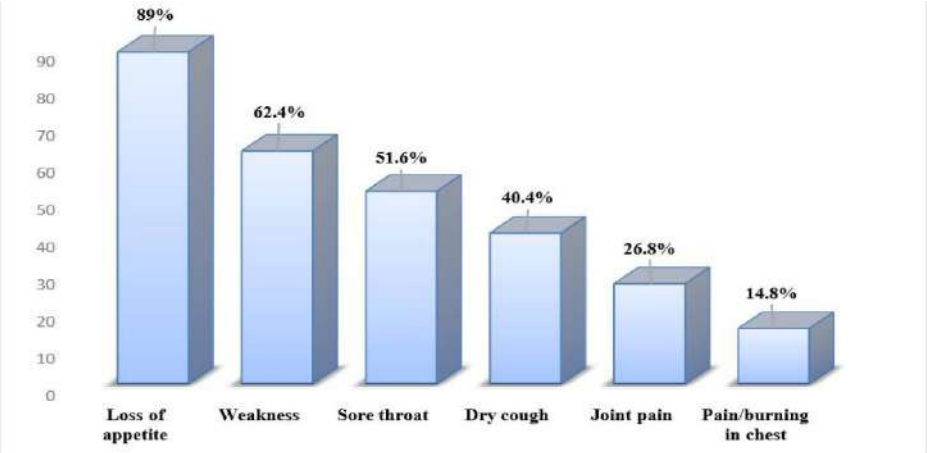

Fig. 2. Assessment of post-COVID symptoms during infection period

It can be observed that tiredness 223 (89.2%) was the most prevalent symptom among the COVID patients, followed by fever 208 (83.2%), headache 197 (78.8%), dry cough 169 (67.6%), and loss of taste/ smell141(56.4%). Breathlessness 75 (30%), chest pain 65 (26%), and diarrhea 23 (9.2%) were the other significant symptoms. The least prevalent symptom was skin rash 8 (3.2%). In a study conducted by Amin *et al.,* conducted among 439 people in Bangladesh who recovered from COVID-19 the most common symptoms reported by the study subjects were fever (93.60 percent), tiredness (88.80 percent), and cough (70.80 percent) (Fig 1).

The most common cardiovascular symptom among the subjects was pain/burning in the chest (14.8%), systemic symptom among the subjects was weakness 156 (62.4%), joint pain 67 (26.8%) was the most prevalent musculoskeletal symptom among the participants, sore throat 129 (51.6%) was the most prevalent HEENT(Head, Ears, Eyes, Neck and Throat) symptom among the participants,pulmonary symptom among the participants was dry cough 101 (40.4%),gastrointestinal symptom among the participants was loss of appetite (89%)(Fig 2).

Fatigue is common in individuals with a variety of chronic health conditions and can have significant negative effects on quality of life including feelings of weariness, tiredness, a lack of energy, or decreased motivation to continue on a task. During COVID, only (42.4%) of the patients were severely fatigued,

Table 6. Assessment of Fatigue using CFQ 11 scale among patients (n=250)

S.No.	Score	Interpre-tation	During COVID		Post COVID	
			Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)
1.	0-3	Not Severe	144	57.6	49	19.6
2.	4-11	Severe	106	42.4	201	80.4

Table 7. Assessment of perceived stress using PSS-10-C scale among patients (n=250)

S.No.	Score	Interpretation	During COVID		Post COVID	
			Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)
1.	0-13	Low Stress	82	32.8	145	58
2.	14-26	Moderate Stress	153	61.2	100	40
3.	27-40	High Stress	15	6	5	2

while 201 (80.4%) were severely fatigued during Long COVID. Those who had fatigue symptoms for more than 6 months following SARS were more likely to suffer psychological illnesses (Table 6).

During COVID, 153 (61.2%) of the subjects had a moderate level of perceived stress, 82 (32.8%) had a low level of stress, and 15 (6%) had a high level of stress (Table7). On analyzing the results of Post COVID, low stress was found in 145 (58%) of the subjects, moderate stress in 100 (40%), and high stress in 5 (2%) of the subjects (Table 8). Laxmi *et al* (2021),conducted a cross-sectional web-based survey among dental faculties of all the five Government Dental Colleges across Kerala and a total of 162 faculties reported, some level of perceived stress exhibited by all the members of the this study group. 67.3% of the total respondents were having moderate levels and 6.8% of them were having high levels of perceived stress. There is little data on psychiatric ill-health in adults recovering from COVID-19, especially in those with symptoms weeks to months after their initial infection or "Long COVID" (Callard *et al.*, 2021).

During the infection period, 54 (21.6%) of the subjects had no clinically significant insomnia, 111 (44.4%) had subthreshold insomnia, 75 (30%) had moderate insomnia and 10 (4%) had severe insomnia (Table 8). In the Post-COVID period, 22.8 percent of subjects had subthreshold insomnia. El Sayed *et al.* (2021), conducted a case series and reported that three out of four patients had worsening in subjective sleep quality and sleep problems, including changes in subjective sleep quality, sleep latency, and daytime

Table 8. Insomnia severity index (ISI) to assess sleep among patients (n=250)

S.No.	Score	Interpretation	During COVID		Post COVID	
			Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)
1.	0-7	Absence of insomnia	54	21.6	175	70
2.	8-14	Subthreshold insomnia	111	44.4	57	22.8
3.	15-21	Moderate insomnia	75	30	14	5.6
4.	22-28	Severe insomnia	10	4	4	1.6

Table 9. Correlation between stress and insomnia among the patients (n=250)

S.No.	Category	r	Fisher's 't'
1.	Stress	0.37**	6.28
2.	Insomnia		

Note** indicates 'r' is significant at 0.01 level.

Table 10. Significance of difference in the mean scores of stress among thepatients during COVID and Post COVID (n=250)

S.No.	Category	Mean Stressscore	S.D	t value	Level of significance
1.	During COVID	24	± 7.07	7.14*	P<0.01
2.	Post-COVID	20	± 5.25		

*Significant at 0.01 level

function, were observed in (85%) of patients who recovered from COVID-19 infection and were evaluated again 8 weeks after discharge gain 8 weeks after discharge. This study concluded that the post-COVID-19 patients showed impairment of different subdomains of quality of life including physical and mental aspects.

Pearson's coefficient of correlation 'r' between Stress and Insomnia among study subjects for the sample is 0.37 (Table 9). This shows that there is a positive relationship between stress and insomnia.The quality of life was diminished in post-COVID-19 patients, and stress triggered sleep abnormalities that result in insomnia.

Table 10 indicates the mean scores of stress among patients during COVID and post-COVID are 24 and 20, respectively. Obtained t-value (7.14) is greater than 2.58 which is the value required for significance at a 0.01 level of significance. Hence, the difference between the two sets of scores is significant.Being isolated from family and friends during the period of infection and fear of the consequences of infection was more stressful than the period subsequent to the infection.

Table 11 depicts that the mean scores of fatigue among patients during COVID and post-COVID are 28.23 and 33.47, respectively. Obtained t-value (8.31) is greater than 2.58 which is the value required for significance at a 0.01 level of significance. Hence, the difference between the two sets of scores is significant. Although the exact causes of lasting fatigue in post-COVID-19 is not elucidated, it is suggested that the body's natural response may be thrown off after it comes in contact with certain types of infection.

Table 12 depicts the mean scores of insomnia among subjects during COVID and long COVID as 37.25 and 29.02, respectively. Obtained t-value (10.97) is greater than 2.58

Table 11. Significance of difference in the mean scores of fatigue among patients during COVID and Post COVID (n=250)

S.No.	Category	Mean Stressscore	S.D	t value	Level of significance
1.	During COVID	28.23	±7.82	8.31*	P<0.01
2.	Post-COVID	33.47	±6.36		

*Significant at 0.01 level

Table 12. Significance of difference in the mean scores of insomnia among patients during COVID and post COVID (n=250)

S.No.	Category	Mean Stressscore	S.D	t value	Level of significance
1.	During COVID	37.25	±9.41	10.97*	P<0.01
2.	Post-COVID	29.02	±7.29		

*Significant at 0.01 level

which is the value required for significance at a 0.01 level of significance. Insomnia during COVID than long COVID can be a result of varying circumstances like self-isolation and quarantine at home, social media information and excessiveworryabout one's own health.

CONCLUSIONS

The researcher explored the persisting symptoms of post-COVID. Hypertension has been reported as the highest pre-existing comorbidity (24%), followed by obesity (20.8%). Tiredness has been reported as the most prevalent symptom 89.2%, followed by fever 83.2%, headache 78.8%, dry cough 67.6%, and loss of taste/smell 56.4%. Breathlessness 30%, chest pain 26%, and diarrhea 9.2% were the other significant symptoms. During COVID, (42.4%) of the patients were severely fatigued, 61.2% of the study subjects had a moderate level of perceived stress, and 44.4% of the patients had subthreshold insomnia. During post-COVID, 80.4% were severely fatigued, low stress was found in 58% of the subjects, moderate stress in 40%, and 22.8% of the study subjects had subthreshold insomnia. Pearson's coefficient of correlation 'r' between stress and insomnia among study subjects was 0.37. Obtained t-value for stress (7.14 > 2.58), fatigue (8.31> 2.58) and insomnia (10.97 > 2.58) were significant. Post-COVID is associated with comorbidities and disease severity. The prevalence of fatigue, perceived stress, and insomnia was significant among COVID-19 survivors. Given that COVID-19 affects several systems and has an effect on health and well-being, understanding its long-term effects is just as crucial as resolving its immediate symptoms.

REFERENCES

Amin, M.T., Hasan, M and Bhuiya, N.M.M.A. 2021. Prevalence of COVID-19 associated symptoms their onset and duration and variations among different groups of patients in Bangladesh. Frontiers in Public Health. 9 (738352):1–13.

Anjana, N., Annie, T.T., Siba, S.,Meenu, M.S., Chintha, S and Anish, T. 2021. Manifestations and risk factors of the post-COVID syndrome among COVID-19 patients presented with minimal symptoms - A study from Kerala, India. Journal of Family Medicine and Primary Care.10 (11):4023–4029.

Callard, F and Perego, E. 2021. How and why patients made Long Covid. Social Science and Medicine. 268:113426.

Campo-Arias A., Pedrozo-Cortés M.J and Pedrozo-Pupo JC. Pandemic-related perceived stress scale of COVID-19: An exploration of online psychometric performance. 2020 Rev Colomb Psiquia tr. 49(4):229-230.

El Sayed, S., Gomaa, S., Shokry, D., Kabil, A and Eissa, A. 2021. Sleep in post-COVID-19 recovery period and its impact on different domains of quality of life The Egyptian journal of neurology psychiatry and neurosurgery. 57(1):172.

Food and Agriculture Organization. 2018. Dietary assessment: A resource guide to method selection and application in low resource settings. Rome: FAO. pp. 52-56.

Jackson, C. 2015. The Chalder Fatigue Scale (CFQ 11) Occupational Medicine (Oxford, England). 65(1):86-87.

Laxmi Suresh Babu., M Janarthanan Pillai and K. A. Janardhanan, Marco Tommasi. 2021. Prevalence of perceived stress due to COVID-19 among faculties of government dental colleges in Kerala,India. Cogent Psychology. 8:1.

Misra, A., Chowbey, P., Makkar, B.M., Vikram, N.K., Wasir, J.S., Chadha, D., Joshi, S.R., Sadikot, S., Gupta, R. Gulati, S and Munjal, Y.P. 2009. Consensus statement for diagnosis of obesity, abdominal obesity and the metabolic syndrome for Asian Indians and recommendations for physical activity, Medical and Surgical Management. Journal of the Association of Physicians of India. 57:163-170

Stavem, K., Ghanima, W., Olsen, M. K., Gilboe, H. M and Einvik, G. 2021. Prevalence and determinants of fatigue after COVID-19 in non-hospitalized subjects a population-based study. International Journal of Environmental Research and Public Health. 18(4):20-30.

World Health Organization. 1998. Obesity, prevention and managing the global epidemic. Report of a WHO consultation on obesity Geneva: World Health Organization. pp. 67-74.

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PREVAILING SANITARY CONDITIONS OF OUTDOOR CATERING UNITS IN KOTTAYAM DISTRICT, KERALA

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ABSTRACT

The study was conducted between September 2019 and February 2020 to find the general hygiene and sanitary conditions followed in outdoor catering units in Kottayam district of Kerala state. Data was collected from 126 outdoor catering units using an observation checklist. Forty-two percent of the premises of catering units were used for residential purpose. Stray animals and birds were observed in 14.3 percent units. Majority (71.4 percent) of the catering units had concrete floors; roofing sheets (87.3 percent) were used as the construction material for ceiling and weld mesh (91.3 percent) instead of windows. Statistically, significant relation was found between manufacturer's who has more than 10 years of experience with location of the outdoor catering units as well as the cleanliness of the atmosphere. Outdoor catering for mass events is a high-risk activity and always carries with it the possibility of food poisoning. Therefore, utmost care must be taken not only in food handling but also inthe maintenance of premises and infrastructural facilities, proper waste disposal and cleaning for the production of safe food.

Keywords: Food poisoning, Food safety, Hygiene, Outdoor catering, Sanitation

INTRODUCTION

According to Oyarzabal and Van Renterghem (2020), food safety is a scientific discipline describing the safe processes and practices to grow, harvest, store, transport, handle, prepare and serve food and food ingredients to prevent food-borne illness. It is an important goal to be achieved for global health, as food-borne diseases pause great threat to people around (Velusamy *et al*., 2010). It is an important cause for morbidity and mortality and is a growing global concern (Chan and Chan, 2008). Food-borne diseases affect the most vulnerable sections of the society. One in every ten person falls ill after consuming contaminated food and 4,20,000 people die, including 1,25,000 children under five each year (FAO/WHO, 2020). In India, most of the food-borne diseases go unreported. Very few cases are reported by the media and that too, if the morbidity or mortality rate is high, especially in urban areas.

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Around the world, it is evident that the life style pattern and food consumption behaviour has been changed. The number of meals taken from home has decreased and people increasingly depend on outdoor catering establishments (Hülya *et al*., 2015). This might be due to rapid urbanization, increased industrialization and increased number of women in the workforce. These changes in food pattern have led to the tremendous growth of a wide variety of food and beverage industries all over the globe. Outdoor catering provides the provision for food and drink at social events like marriages, parties and conventions. The food will be served at any selected venue and necessary arrangements at the venue will be made by the caterers itself (Roday, 2011).

Celebrations have become the part and parcel of life, and in order to rejoice, even for small occasions people are increasingly depending on outdoor catering units. Catering to a mass is a high-risk activity and will always have the possibility of causing food poisoning to a large number of people. However, provision of safe food is necessary for the continued patronage of any establishment. Careless practices on the part of food handlers can lead to multiplication of pathogenic bacteria in food and can cause illness in consumers (Olson *et al*., 2000). Inorder to produce food in the most hygienic manner, the preparation area and storages have to be taken care of,along with thegeneral cleanliness of the entire catering unit which include both the premises and the infrastructure (Bhat and Rao, 1997). Hence, this study was conducted to find out the sanitary conditions prevailing in various outdoor catering units in Kottayam district in the state of Kerala. The major objectives were to collect information regarding the surroundings of the catering units and to study the infrastructure facilities such as layout of the kitchen, the water supply and plumbing system, the waste disposal mechanism employed, the cleaning and disinfection mechanism and the pest control measures adopted.

MATERIALS AND METHODS

The study was carried out in Kottayam district of Kerala state, between September 2019 and February 2020. Kottayam is a city located in Central Kerala. The state is known for its literacy rate. It has many tourist destinations and tourists round the globe are attracted every year towards this wonderful land. Studies on food safety in outdoor catering units have not been done in the state of Kerala and since Kottayam district is known for its tourist destinations, many catering establishments has flourished here. Therefore, this locale has been chosen for the study. There were approximately 404 outdoor catering units, big and small, in Kottayam district, out of which 165 units were enrolled in caterers association.

The association maintained a directory, from which obtained the lists of outdoor catering units. The following inclusion criteria were considered a) Only registered outdoor catering units were chosen for the study purpose b) Those units from which consent was obtained were only considered. Before commencing the study, permission was obtained from the President of the Catering Association.

Kottayam district was divided into five zones. Based on the location of outdoor catering units, it has been grouped into each of these five zones. Thus, from the enrolled 165 outdoor catering units, only 126 units showed willingness to participate in the study and they constituted the study population. Prior permission was obtained from the owners of each catering unit telephonically, followed by the visit on the fixed date. Informed consent has been obtained from them which showed their willingness to participate in the study. Consent letter were prepared in both English and vernacular language. It was explained to them and then signatures of both the owner and investigator were done and a copy of the consent was retained by both.

Data was collected using a direct observational check list and to collect general information regarding the catering units, personal interview method was employed. The details regarding infrastructure of each outdoor catering unit which included the presence of kitchen, the type of doors, windows, ceiling, flooring done, water supply system, waste disposal methods and pest control measures employed were studied. Data collected was compiled and statistically analysed.

Table 1. General hygiene of the premises (n=126)

S.No.	Particulars	Frequency	
		Yes	No
1.	Units located far away from industries and environmental pollution	125(99.2) *	1(0.8)
2.	Atmosphere was free from obnoxious odor, soot, smoke and dust	125(99.2)	1(0.8)
3.	Premise was neither used for residential purpose nor it does have any access to it	73(57.9)	53(42.1)
4.	Adequate space in the surroundings for the food business	120(95.6)	6(4.8)
5.	Area was not subjected to flooding	114(90.5)	6(9.5)
6.	Location was free from water stagnation	112(88.9)	14(11.1)
7.	Absence of garbage dumps in the vicinity	94(74.6)	32(25.4)
8.	No unnecessary movement of personnel not connected with food handling	111(88.1)	15(11.9)
9.	Absence of stray animals, birds or pests in the premises	108(85.7)	18(14.3)
10.	Absence of any cage or barn to keep domestic or pet animals	119(94.4)	7(5.6)

*** Figures in parenthesis shows percentages**

RESULTS AND DISCUSSION

Socio-economic profile of food manufacturers

The socio-economic profile of food manufacturer's or owners of the outdoor catering units were studied, and it was reported that 77 percent of outdoor catering business was run by single ownership. It was reported to be a male dominant sector as, 97.6 percent of the units were run by males. A similar study of food handlers by Prabhu and Shah (2014), showed that 78.66 percent of food handlers were males and this indicates that in India, food processing in public eating places is predominantly an occupation of the males. Forty-six percent of the catering units have covered 10-25 years of business and 88.9 percent served both vegetarian and non-vegetarian food. Out of the 126 units,79.4 percent of the outdoor catering units were located in the panchayat. It was found that 27 percent of the food manufacturer's holds a degree or diploma in catering management while 35.7 percentage has acquired higher secondary education.More than 20 years of work experience in the field of catering was asserted by 32.5 percentage of food manufacturer's or owners. Catering was the main source of income for 92.1 percent of the owners. Other sources of income include hiring utensils and shamiana for events. In case of 68.3 percent owners the monthly income ranged between Rs.2.5 and Rs.5 lakhs.

General hygiene of the premises

The general hygiene of the premises was studied and it was reported that 99 percent of the units were located away from industries and environmental pollution and their atmosphere was found to be free from smoke and dust (Table 1). Among the 126 outdoor catering units, 42.1 percent used the premise for residential purposes. These outdoor catering units had direct access to their homes. Almost 95.6 percent units were spacious for food business. The area in which the units were located was not subjected to flooding (90.5

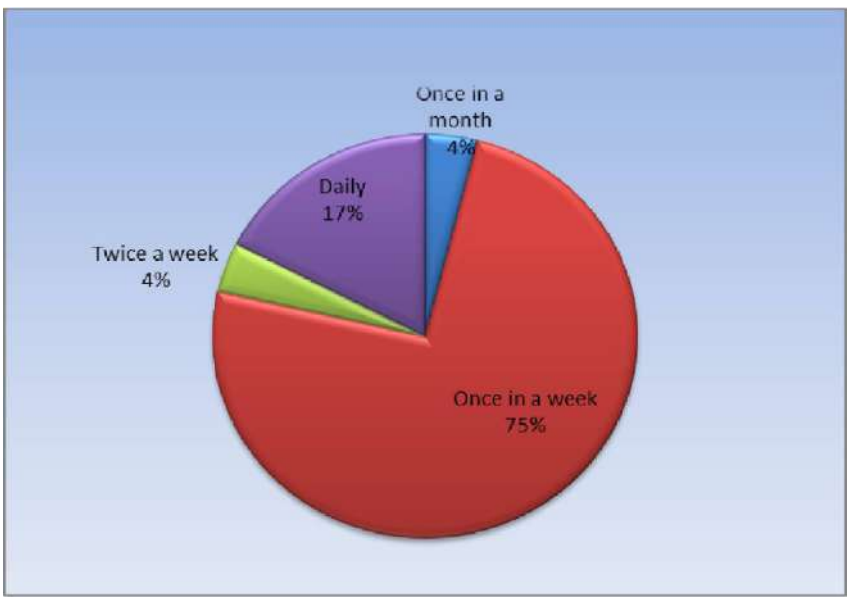

Fig.1. Frequency of cleaning the floor in different catering units

percent). Presence of garbage was visible in about 25.4 percent of the units. Stray animals such as dogs and pets such as cats were observed in 14.3 percent of the units. Presence of birds was also sighted, where garbage dumps such as disposable water bottles and waste materials were seen.The World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO) published the Codex Alimentarius, in 2003 which serves all the required guidelines to food safety (Chaudhuri, 2015).

Layout and design

A. Floor

The layout and design of the outdoor catering units were studied and it was reported that all the 126 units had separate kitchen. Unidirectional work flow was observed in only 7 (5.5 percent) units. In about majority of the units (51.5 percent) concrete flooring were done, 19.8 percent were cemented and the rest were marbled and tiled. The frequency of cleaning the floor is represented in Figure 1.

Table 2. Construction and maintenance of walls of the catering units (n=126)

S.No.	Walls	Frequency	Percentage (%)
1.	Construction of walls:		
	Built with wire mesh	74	58.7
	Brick built	9	7.1
	Plastered	5	4
	Tiled	38	30.2
2.	i) Maintenance: Painted		
	Yes	117	92.9
	No	9	7.1
	ii) Clean/ washable/ non-toxic and non-absorbent material		
	Yes	117	92.9
	No	9	7.1
	iii) Absence of flaking paints/ cobwebs and mould growth		
	Yes	40	31.7
	No	86	68.3
3.	Frequency of cleaning		
	Once in a month	115	91.3
	Once in a week	4	3.2
	Twice in a week	7	5.6

B. Walls

The walls were constructed in such a manner that, half of the wall was brick built and wired meshes (58.7 percent) were raised over it (Table 2). This was employed to provide adequate lighting and ventilation. It could provide protection against birds and rodents also. Tiled walls were observed in 30.2 percent catering units. The walls were painted in 92.9 percent units and it was made with washable, non-toxic and non-absorbent material. The presence of flaking paints and spider webs (68.3 percent) shows the lack of regular cleaning and also inspection from health authorities.

A. Ceiling/ Roofing

Among the 126 catering units, roofing sheets (86.5 percent) were used as the construction material for ceiling by majority. Ninety-six percent of the ceiling was painted and cleaned without any cobwebs (Table 3). Mold growth and condensation particles were absent in 81 percent of the units. Majority of the units (91.3 percent) cleaned the ceiling once in a month.

B. Doors and windows

Manually closing doors were present in all the 126 units andonly 5.6 percent units have doors with fly proof screens. Proper maintenance of the doors such as cleaning and dusting were done by 31.7 percent units. The frequency of cleaning the doors once in a month was conducted in 94.4 percent units.

Among the 126 outdoor catering units windows were present in 84.9 percent units. It was covered with fly proof screens and wired mesh in 66.7 percent and 33.3 percent units, respectively. The windows were dusted and found clean in 55.6 percent units. The frequency of cleaning once in a month was adopted by 94.4 percent units. Window and door fly-proof

Table 3. Construction and maintenance of ceiling or roof of the catering units (n=126)

S.No.	Ceiling or Roof	Frequency	Percentage (%)
1.	Construction of ceiling /roof:		
	Roofing sheet	109	86.5
	Concrete and plastered	12	9.5
	Polythene sheet	5	4
2.	Maintenance:		
	i) Painted/ clean without any cobwebs		
	Yes	121	96
	No	5	4
	ii) Absence ofmold growth and condensation particles		
	Yes	102	81
	No	24	19
3.	Frequency of cleaning		
	Once in a month	119	91.3
	Once in a week	7	3.2

Table 4. Water supply and plumbing system (n=126)

S. No.	Water supply and plumbing	Frequency	Percentage (%)
1.	Presence of hot water and cold water in the kitchen		
	Yes	7	5.6
	No	119	94.4
2.	Source of potable water		
	i) Open well	21	16.7
	ii) Open well and bore well	48	38.1
	iii) Open well, bore well and corporation water	52	41.3
	iv) Open well, bore well and rivers	5	4
3.	Source of water for catering at distant venue		
	i) Potable water is brought for preparation	7	5.6
	ii) Whatever available at the venue	5	4
	iii) Both i and ii	114	90.5
4.	Presence of storage tanks	126	100
5.	Tanks are covered	126	100
6.	Absence of suspended particles	126	100
7.	Absence of turbidity	126	100
8.	Periodic cleaning of water tank	126	100
9.	Maintenance of register	126	100
10.	Presence of water purification system in kitchen		
	Yes	54	42.9
	No	72	57.1
	i) Purification system is in good working condition		
	Yes	54	42.9
	No	72	57.1
11.	Maintenance of record	54	42.9
12.	Periodic water quality check	126	100
13.	Leakage in the plumbing system		
	Yes	107	84.9
	No	19	15.1
14.	No cross contamination between potable and non-potable water	126	100
15.	Presence of adequate number of taps in good working condition	126	100

screening is essential to prevent food-borne diseases but it is missing in most of the establishments. A study conducted in food establishments of rural Maharashtra showedlower (16 percent) proportion of fly-proof doors and windows (Deshpande and Phalke, 2013).

Water supply and plumbing

Kibret and Abera (2012) opined that lack of basic infrastructure, lack of potable water, inadequate facilities for garbage disposal etc. can create an atmosphere in which bacteria and other microorganisms can multiply and easily be transmitted. The data collected from all the 126 outdoor catering units regarding water supply and plumbing is furnished in Table 4.

Ample supply of potable water was available round the clock in all the 126 units. Hot and cold water supply was present only in 5.6 percent units. The major source of potable water supply available to almost 41.3 percent units were open well, bore well and corporation water. Only 5.6 percent caterers brought potable water for catering at distant venue, which would be safe for food preparation whereas 90.5 percent depend on both water from their own units and water available at the venue. Sufficient number water storage tanks were available in all the 126 units and the tanks were properly covered. The water in the storage tanks were neither turbid nor have any suspended particles. The water tanks were periodically cleaned in all the 126 units and all of them maintained a register for that. Frequency of cleaning the tank is illustrated in Figure 2.

On contrary to this study, a research conducted in food establishments of Ethiopia by Girmay *et al*. (2021) stated that the type of drinking water storage used in 31.7 percent of the food outlets were rough and untidy and 34 percent of the food outlets' drinking water storage had no lid/cover in place at the time of the visit.

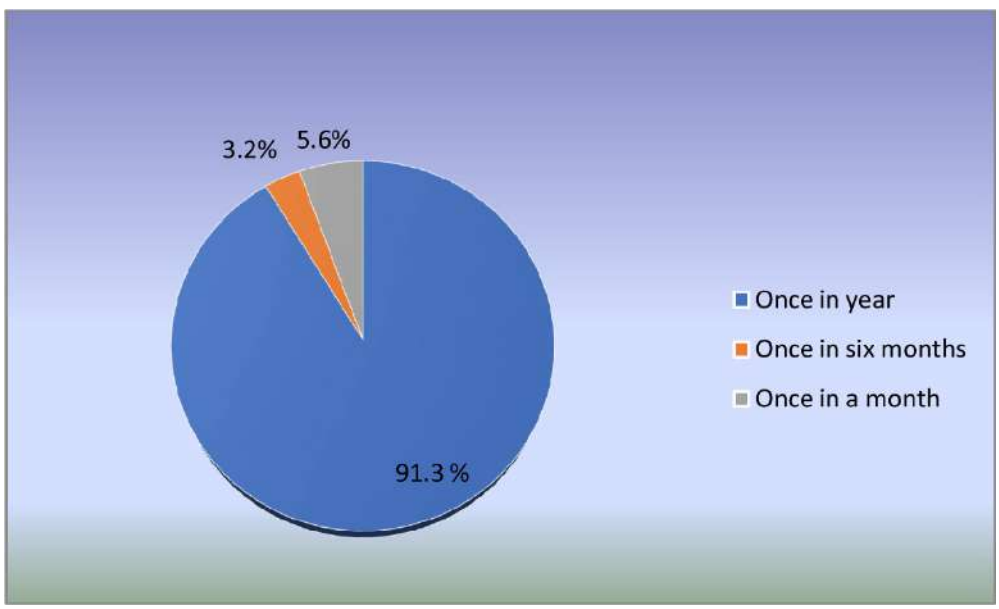

Fig. 2. Frequency of cleaning the water tank

Table 5. Waste disposal and drainage facilities in outdoor catering units (n=126)

S.No.	Waste disposal	Frequency	Percentage
1.	Adequate number of garbage bins		
	Yes	102	81
	No	24	19
2.	Type of garbage bins used		
	Plastic bins	12	96
	No specific bins	15	4
3.	Features of the garbage bins		
	i) Leak proof and pest proof	121	96
	Leaking with no adequate pest proof facility	5	4
	ii) Durable and easy to clean	121	96
	Not durable and easy to clean	5	4
	iii) Lined with wet strength bag	7	5.6
	Not lined with wet strength bag	119	94.4
4.	Bins are with lid	7	5.6
	Bins are without lid	119	94.4
5.	Manually operated	126	100
	Foot operated	0	0
6.	Garbage and refuse collected separately		
	Yes	126	100
7.	Garbage is periodically removed from the premises		
	Yes	126	100
8.	Bins are cleaned and dried before use	126	100
9.	Frequency of waste removal		
	Once in a week	16	12.7
	Once in two days	51	4
	Daily	05	83.3
10.	Method of disposal of food waste after an event		
	i) Feed to swine and poultry	67	53.2
	ii) Feed to swine and making feed	13	10.3
	iii) Bury in catering units and feed swine	46	36.5

Table 5 Contd...

S.No.	Waste disposal	Frequency	Percentage
11.	Method of disposal of refuse		
	i) Dumping	15	11.9
	ii) Dumping, tie in polythene bag and throw away at roadside	5	4
	iii) Incineration, collection by panchayat	101	80.2
	iv) Dumping, incineration and collection by panchayat	5	4
12.	Presence of empty crates, boxes and bottles in the premises	40	31.7
	Absence of empty crates, boxes and bottles in the premises	86	68.3
13.	Open drain	5	4
	Closed drain	121	96
14.	Presence of sewage treatment plant	80	63.5
	Absence of sewage treatment plant	46	36.5
15.	Chocked sink		
	Present	5	4
	Absent	121	96
16.	No sign of backflow	126	100
17.	Drain is connected to main sewage	126	100
18.	Drains are cleared and maintained	126	100

Water purification system was present in 42.9 percent units but majority *i.e.,*57.1 percent does not have the facility. Those who had the facility, has properly maintained it and the date of maintenance was recorded accordingly. Periodic water quality check was done by all the 126 catering units. Though signs of water leakage in the plumbing system was observed in 85 percent units, there was no cross contamination between potable and non-potable water.

Waste disposal and drainage facility

A major challenge to any catering establishment is the waste it produces. The wastes have to be disposed effectively in order to prevent the microbial growth and to promote hygiene. The data regarding waste management done in the outdoor catering units are furnished in Table 5.

Adequate number of garbage bins was available in 81percent units. Plastic bins were preferred by 96 percent units. Manually operated bins were used in by all caterers (100 percent) and daily disposal of waste was done by 105 units (83.3 percent). The most commonly employed method of food waste disposal was that, it was given as feed for poultry and swine (53.2 percent).The method adopted for the disposal of refuse was both incineration and collection by panchayat (80.2 percent). Proper closed drainage facility for liquid waste disposal was observed in 96

Table 6. Association of work experience with general hygiene of the premises

Parameters	Work Experience 10 years	Chi-square	P value	Significance
1. Location of unit away from industries	82.4%	$\chi 2$ =4.514	P=0.034	S*
2. Clean atmosphere	82.4%	$\chi 2$ =4.514	P=0.034	S*

S*- significant at 5% level

percent of units and sewage treatment plant was present in 63.5 percent units. Except one, rests of the plants were working and maintained properly (62.7 percent). In only four percent units the sinks were found to be chocked but the rest (96 percent) does not have choking or any signs of back flow. The drains were connected to a main sewage system which was well maintained in all the 126 units.

The manufacturer's or owner's, who had work experience of more than 10 years, located their units far from industries and households and the atmosphere was free from smoke, soot and dust. Statistically 5% significance was found between thetwogeneral hygiene parameters of the premises and work experience of the owner's of the unit ($\chi 2$ =4.514, P value= 0.034) (Table 6). This means that the more the years of experience, the more focus has been given to the location and cleanliness of the unit.This might be due to the fact that years of experience might havehelped in avoiding food poisoning cases and consumer preference for high quality food. Studies conducted among the hotel staff in Turkey by Sanlier *et al*. (2010) and amongcatering staff in Ankara by Hülya *et al*. (2015) showed that the workers who had more than 10 years of work experience possess high perception of hygiene on general hygiene of catering units.Safe and wholesome food is the key to success for any catering establishment.

CONCLUSIONS

Basic infrastructural facility along with its maintenance is very essential for the safe and hygienic preparation of food. Liquid (96 percent) and solid waste disposal techniques, both incineration and collection by panchayat (80.2 percent) were properly done by majority, but still garbage dumps were visible in the vicinity which attracted the animals (14.3 percent) into the catering units. Similarly, unidirectional work flow was observed in few units which again insist the importance of food preparation away from contaminants. Significant association at 5% was found between the experience of the manufacturer and location of the outdoor catering units as well as the cleanliness of the atmosphere.

REFERENCES

Bhat, R.V and Rao, N. 1997. Food Safety. Bangalore Printing and Publishing Company. pp. 75-78.

Chan, S.F and Chan, Z.C.Y. 2008. A review of food borne disease outbreaks from 1996

to 2005 in Hong Kong and its implications on food safety promotion. Journal of Food Safety. 28 (2):276-299.

Chaudhuri, D. 2015. Food safety: A public health priority. Indian Journal of Public Health. 59(2): 83-86.

Deshpande, J.D and Phalke, D.B. 2013. The sanitary condition of food establishments and health status and personal hygiene among food handlers in a rural area of Western Maharashtra, India. Asian Journal of Medical Sciences. 4(2): 23-29.

FAO. 2020. World food safety day 2020: overview of an inspiring virtual celebration, 7 June, 2020. Rome.

Girmay, A.M., Gari,S.R., Gessewc,G.T and Reta, M.T. 2021. Determinants of drinking water quality and sanitary risk levels of water storage in food establishments of Addis Ababa, Ethiopia, Journal of Water, Sanitation and Hygiene for Development.11(5): 831-840.

Hülya,Yardimci, Gülperi, Hakli and Funda Pinar Çakiroðlu. 2015. Hygiene knowledge of food staff in catering industry: A sample from Turkey, Sage Open. 1-7. https://doi.org/10.1177/2158244015580376.

Kibret, M and Abera, B. 2012. The sanitary conditions of food service establishments and food safety knowledge and practices of food handlers in Bahir Dar Town, Ethiopian Journal of Health Sciences. 22(1):27-35.

Olson, S.L., MacKinon, L. Goulding, J., Bean, N and Slutsker, L. 2000. Surveillance for foodborne diseases outbreaks- United States, 1993-1997. Morbidity Mortality Weekly Report. 49: 1-51.

Oyarzabal, O.A and Van Renterghem, B.B. 2020. The meaning of food safety. Food safety magazine eDigest. May.

Prabhu, P.M and Shah, R.S. 2014. A study of food handlers in public food establishments in Maharashtra, India. International Journal of Science and Research. 3(7):1485-1489.

Roday, S.2011. Food hygiene and sanitation. 2nd Edition. Oxford University Press, New Delhi. pp. 139-140.

Sanlier, N., Comert, M and Durlu-Ozkaya, F.2010. Hygiene perception: Condition of hotel kitchen staffs in Ankara, Turkey. Journal of Food Safety. 30 (2):415-431.

Velusamy,V., Arshak, K., Korostynska, O., Oliwa, K and Adley, C. 2010. An overview of food-borne pathogen detection: In the perspective of biosensors. Biotechnology Advances. 28: 232-254.

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NUTRIENT ANALYSIS OF GUAVA BASED RTS BEVERAGE

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ABSTRACT

The study was carried out to standardize the method of preparation of guava RTS (ready-to-serve) beverage and to evaluate organoleptic attributes such as colour, appearance, flavour, taste, texture and overall acceptability. The study was carried out in College of Community Science, ANGRAU, Lam, Guntur in the year of 2021-2022. In this study guava based RTS beverage was formulated with different proportions of guava pulp and water *i.e.,* (RTSBF1) 20:80, (RTSBF2) 30:70 and (RTSBF3) 40:60 with equal amounts of sugar and citric acid. The products were organoleptically evaluated using 9 points hedonic rating scale by a semi-trained judge. The one-way ANOVA was used for a significant difference test in the mean scores of sensory evaluation. The RTS beverage prepared from (RTSBF3) 40:60 guava pulp and water were found to be superior over other proportions in respect of mean scores of organoleptic attributes *i.e.*, colour (7.96), appearance (8.16), taste (7.52), flavour (7.20), consistency (6.88) and overall acceptability (7.60). Acceptability of the product was increased with the quantity of pulp in preparation for the RTS beverage. RTSBF3 has high nutritive content compared to regular beverages and other formulations due to the high quantity of guava pulp.

Key Words: Guava, Guava-based RTS beverage, RTS beverage

Fruits are modified into ready-to-serve beverages to provide more amounts of nutrients and to increase their availability over an extended period. Beverages such as ready-to-serve, ready-to-drink, squash, nectar etc. can be prepared using fruits as a base (Thakkar e*t al.,* 2018). Guava *(Psidium guajava)* is a common tropical fruit cultivated in many tropical and subtropical regions. The common guava *Psidium guajava* (lemon guava, apple guava) is a small tree in the myrtle family native to Mexico, Central America, the Caribbean and Northern South America. Guava is considered as a super fruit due to its low cost and rich nutrient content (Rajan and Hudedamani, 2019). It has high amounts of antioxidants such as phenols, flavonoids, ascorbic acid etc. which prevent the risk of cardiovascular diseases and cancer. Guava is rich in vitamins A and C in the pericarp, omega-

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3 and 6 polyunsaturated fatty acids in the seeds and has high levels of dietary fibre. Guava has an adequate level of dietary minerals, potassium, magnesium and an otherwise broad, low-calorie profile of essential nutrients (Josiah *et al.,* 2019).

Guava *(Psidium guajava)* is considered as perishable due to its adverse physiological changes such as loss of weight due to respiration and transpiration, softening of flesh and loss of resistance to microbial attack (Ramakrishna and Sudhakar*,* 2014). Due to inappropriate handling, transportation and processing 30-50% of guava fruits are often subjected to spoilage. The losses of a seasonal surplus of guava fruits should be avoided by processing and preserving the fruit into different products like guava nectar, jam, jelly, toffee, bars etc (Kanwal *et al.,* 2017). The post-harvest losses can be reduced or mitigated through processing and preservation techniques (Pooja *et al.,* 2020). Jam, jelly, dairy products, different types of beverages etc. can be prepared with the addition of guava to increase the availability of nutrients.The objectives of the study are: 1. To standardize RTS beverage prepared from guava; 2.To carry out acceptability studies on guava based RTS beverage and 3.to analyze the nutritional parameters of guava based RTS beverage.

MATERIALS AND METHODS

Matured but not ripened white fleshed guava fruits were selected. Damage-free and disease-free fruits were cleaned and sorted separately. The experimental material was purchased from the Guntur fruit market. Other raw materials such as sugar, citric acid, preservatives and glass jars were procured from a local market for the study.The study was conducted between February and April month of 2022.

Preparation of guava Pulp

Fruits were crushed or diced into pieces with a stainless-steel knife and steamed for 20-30 minutes at 250°F to retain the maximum amount of nutrients in guava. The steamed fruits were ground and passed through a fine sieve to obtain smooth pulp (Patil *et al.,* 2013). The flow chart for the guava pulp preparation process is presented in Figure 1.

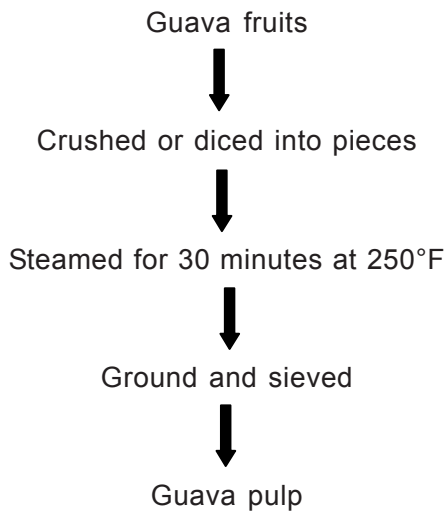

Figure 1. Flow chart depicting guava pulp preparation

Preparation of Guava RTS Beverage

The processed guava pulp was used to prepare the RTS beverage. The amount of guava pulp, water, sugar and citric acid was calculated according to the formulations as presented in Table 1. Guava pulp (20%, 30% and 40%) was blended with sugar (10% TSS) and water (80%, 70% and 60%). The blended RTS beverage was boiled for 15 minutes at 85 ^{o}C. Boiled RTS beverage was blended with citric acid and bottled in clean and sterilized

Table 1. Formulations of Guava pulp and water used for the preparation of RTS beverage

S. No	Ingredients	Formulations		
		RTSBF1	RTSBF2	RTSBF3
1.	Guava pulp (g)	20	30	40
2.	Water (ml)	80	70	60
3.	Sugar (g)	10	10	10
4.	Citric acid (g)	0.3	0.3	0.3

*RTSBF1 - Ready to serve beverage formulation 1, RTSBF2 - Ready to serve beverage formulation 2; RTSBF3 - Ready to serve beverage formulation 3

bottles. Bottled RTS beverage was pasteurized for 20 minutes in boiling water, cooled and labelled (Rafia *et al.,* 2018). The flow chart for the guava RTS beverage preparation process is presented in Figure 2.

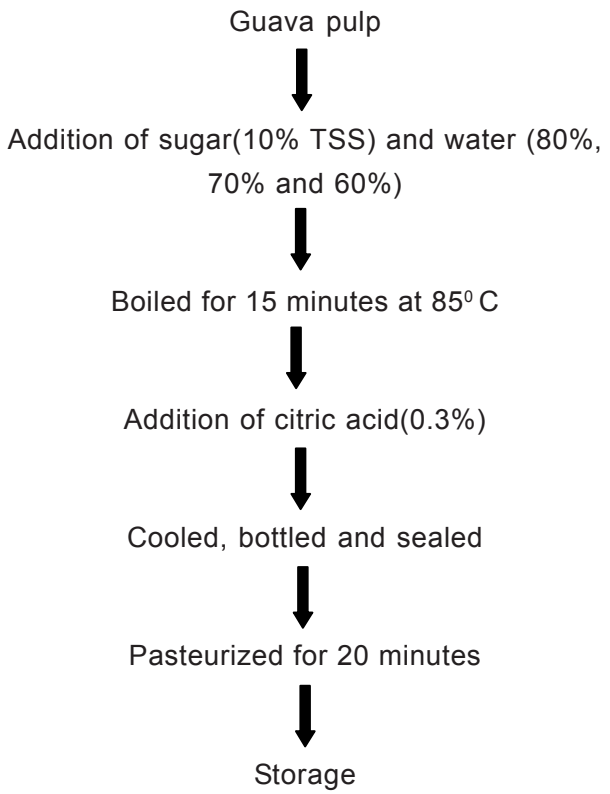

Figure 2. Flow chart depicting guava RTS beverage preparation

Formulations

Generally, fruit beverages were prepared with 10 per cent fruit juice or pulp, 10 per cent TSS (Total Soluble Solids) and 0.3 per cent acid for preservation(Rafia *et al.,* 2018). Accordingly, guava RTS beverages were prepared using three different ratios of guava pulp and water *i.e.,* 20:80, 30:70 and 40:60 with 10 g and 0.3 g of sugar and citric acidwhich were coded as RTSBF1, RTSBF2 and RTSBF3. Homogenized guava pulp was used to prepare different blends at different mixing ratios as presented in Table 1.

Sensory analysis of Guava RTS Beverage

The sensory parameters such as appearance, colour, taste, flavour, consistency and overall acceptability were evaluated by 25 members of a semi-trained panel based on 9 points hedonic rating scale. The formulation with the maximum score was considered as the best (Anju *et al.,* 2017).

Nutrient analysis

The nutritional parameters such as energy, carbohydrates, protein, fat and crude fibre content of the most highly accepted

formulation of guava RTS beverage were estimated by using AOAC methods (2000).

Energy

The energy was estimated by using a bomb calorimeter. About 0.5-1g of sample was taken in crucibles of the bomb and the temperature was noted. It was titrated with a standard alkali solution using a mixed indicator. The water equivalent of one calorimeter and finally gross heat of combustion (cal/g) were calculated.

$$\text{Gross heat of combustion (cal/g)} = \frac{T \times W - (C1 + C2 + C3)}{M}$$

Where,

T= Rise in temperature

W= Water equivalent

M= Weight of substance

C1 and C2= Correction of combustion (cal) of H_2SO_4 and HNO_3, respectively.

C3= Correction of combustion of fuse wire and thread

Carbohydrates

Carbohydrate content was estimated by the Anthrone method. A sample of 100mg was taken and boiled with 5ml of HCl. It was neutralized with solid Na_2CO_3 and made up to 1ml with distilled water. 4ml of anthrone reagent was added and boiled for 8 minutes in a water bath. Optical density at 630nm was estimated in a spectrophotometer. The carbohydrate content in the sample was calculated.

$$\text{Amount of Carbohydrates present} = \frac{\text{mg of Glucose}}{\text{Weight of test sample}} \times 100$$

Protein

Protein content was estimated by the Kjeldahl method. A 5g of sample was taken with concentrated sulphuric acid and digested by heating for 8 h. A 5 ml of a digested sample with 40 ml of NaOH was neutralized for 15 minutes until about 40 ml of distillate was collected in boric acid solution. The ammonia collected in boric acid was titrated against the standard 0.1 N sulphuric acid solution.

$$\text{Protein (\%)} = \frac{(\text{Titre volume of the sample} - \text{Titre volume of the blank}) \times N \times 14 \times 100 \times 6.25}{\text{Weight of the sample (mg)}}$$

Where,

N= Normality of H2SO4

6.25= Protein-nitrogen conversion factor

Fat

Fat content was estimated by the Soxhlet extraction method. A sample of 5g was taken into extraction thimble of soxhlet. 250ml of petroleum ether was taken and sample was heated for 14 h. Solvent was evaporated by using vacuum condenser, incubated and weight was noted. Fat content in sample was calculated.

$$\text{Fat (\%)} = \frac{\text{Weight of the ether extract}}{\text{Weight of the sample used}} \times 100$$

Fibre

Fibre content was estimated by the enzymatic-gravimetric method. A sample of 1-2g of defatted sample was taken in a fibre bag inserted into tubes and placed in a beaker and boiled/digested with 300 ml of 0.255 + 0.005N H_2SO_4 for 30 minutes. Residues were collected,

precipitated with 300 ml of 0.313 + 0.005 N NaOH for 30 minutes, filtered, cooled and weighed.

$$\text{Crude Fibre (g/100g of sample)} = \frac{[100 - (\text{Moisture} + \text{Fat}) \times (W1 - W2)]}{\text{Weight of sample taken (moisture and fat free)}}$$

Where,

W1= Pre-weighed ashing dish

W2= Weight of the dish after ashing

Statistical analysis

The data obtained in the study were statistically analyzed using ANOVA (one way analysis) technique.

RESULTS AND DISCUSSION

The mean scores obtained for various formulations for different sensory attributes are presented in Table 2.

As per the results obtained there is no significant difference (P<0.05) in appearance between the formulation 1, 2 and 3 of RTS beverage. The sensory scores for appearance ranged from 7.24±1.4 to 7.96±0.7. Among the three samples tested for appearance, formulation 3 (RTSBF3) was rated high with the score of 7.96±0.7 and minimum score was obtained for RTSBF2 (7.24±1.4).

Results of colour attribute indicated no significant differences (P<0.05) among tested samples. Highest score was obtained for RTSBF3 (8.16±0.9) and least score was obtained for RTSBF2 (7.32±0.8) among the developed products. The sensory scores for colour ranged from 7.32±0.8 to 8.16±0.9. The results of flavour had a significant difference (P>0.05)between the samples tested. Maximum score for flavour was rated for RTSBF3 (7.20±0.7) and least by RTSBF1 (6.72±1.1). The sensory scores for flavour ranged from 6.72±1.1 to 7.2±0.7.

Table 2.Mean scores of evaluation of sensory characteristics of Guava based RTS beverage

S.No.	Sensory parameters	Mean Scores				
		RTSBF1	RTSBF2	RTSBF3	F-value	P-value
1.	Appearance	7.28±1.10	7.24±1.40	7.96±0.70	3.18	0.04
2.	Colour	7.44±1.05	7.32±0.80	8.16±0.90	3.28	0.04
3.	Taste	7.00±1.30	6.88±0.70	7.52±0.90	1.56	0.21
4.	Consistency	6.92±1.05	6.68±0.80	6.88±0.90	0.28	0.05
5.	Flavour	6.72±1.10	6.96±0.78	7.20±0.70	0.66	0.51
6.	Overall acceptability	7.12±0.70	7.16±0.84	7.60±0.90	0.90	0.04

*RTSBF1 - Ready to serve beverage formulation 1, RTSBF2 - Ready to serve beverage formulation 2; RTSBF3 - Ready to serve beverage formulation 3

Table 3. Nutritional parameters of formulation three of guava based RTS beverage per 100 ml

S.No.	Nutrients	Values (%)
1.	Energy (K.cal)	43
2.	Carbohydrates (g)	10.02
3.	Protein (g)	0.76
4.	Fat (g)	0.16
5.	Crude fibre (g)	1.52

Results of taste attribute indicates significant difference (P>0.05) between RTSBF1 (7.00±1.3), RTSBF2 (6.88±0.7) and RTSBF3 (7.52±0.9). Highest score for taste was rated for RTSBF3 (7.52±0.9) and least by RTSBF2 (6.88±0.7). The sensory scores for taste ranged from 6.88±0.7 to 7.52±0.9. Results of consistency attribute indicates no significant difference(P<0.05) between RTSBF1 (6.92±1.05), RTSBF2 (6.68±0.8) and RTSBF3 (6.88±0.9). Highest score for consistency was rated for RTSBF1 (6.92±1.05) and least by RTSBF2, RTSBF3 (6.68±0.8, 6.88±0.9). The mean scores for consistency ranged from 6.92±1.05 to 6.88±0.8.

Overall acceptability of the tested samples is not significantly differed (P<0.05). Highest score for overall acceptability was rated for RTSBF3 (7.6±0.9) and least by RTSBF1 (7.125±0.7). The organoleptic scores for overall acceptability ranged from 7.125±0.7 to 7.6±0.9 indicating like moderately.

As per the sensory analysis of RTS beverage, the formulation 3 (RTSBF3) was assessed as a highly accepted product among the developed products. The results of sensory parameters of RTSBF3 Appearance (7.96±0.7), Colour (8.16±0.9), Taste (7.52±0.9), Consistency (6.88±0.9), Flavour (7.20±0.7) and Over all acceptability (7.60±0.9) were similar to the study conducted by Abdul *et al.* (2021) who used 15% guava pulp with 15°Brix. Their study results showed 7.15±1.1 for appearance, 8.17±0.5 for colour, 7.51±0.68 for taste, 8.09±1.31 for flavour and 7.69±0.59 for over all acceptability where in carbonated guava beverage was prepared.

The sensory evaluation results of RTSBF3 of the study showed similarity to the study carried out by Moussa and Gendy (2019) who used 30% guava pulp. Their study results showed 8.6 for 10 in case of colour where in guava-whey based beverage was prepared. The sensory evaluation results of RTSBF3 of the study showed similarity to the study carried out by Krishna and Freeda (2014) who used 60% papaya juice with 40% guava juice. Their study results showed 7.7±0.8 for taste, 7.7±0.7 for flavour and 7.8±0.7 for over all acceptability where in guava-papaya leaf beverage was prepared.

Energy and carbohydrate content (43 K.cal and 10.02g / 100 ml)of RTS beverage (Table 3) was similar to the values 38.55 ± 4.05 K.cal, 41.86±1.50 K.cal and 9.0±1.03g, 10.31±0.36g per 100 ml reported by Krishna

and Freeda (2014) where in guava-papaya leaves RTS was prepared and Siti *et al.* (2017) where in mixed tropical fruit juice was prepared.Carbohydrate content (10.02 g/100 ml) of RTS was lower than the value 14.8 g per 100 ml reported by Homi *et al.* (2017). Protein content (0.76 g/100ml) of RTS was higher than the values 0.2, 0.1, 0.06 g per 100 ml reported by Krishna and Freeda (2014) where in guava-papaya leaves RTS was prepared, Siti *et al.* (2017) where in mixed tropical fruit juice was prepared. and Homi *et al.* (2017). Fibre content (1.52 g/100 ml) of RTS was higher than the value 0.57 g per 100 ml reported by Homi *et al.* (2017).

RTSBF3 has high nutrient content when compared to the other formulations due to high amount of guava pulp.

CONCLUSIONS

Maximum overall acceptability score was obtained for RTSBF3 (guava pulp (40 g), water (60 ml), sugar (10 g) and citric acid (0.2 g)) is 7.6 ± 0.90 and hence formulation 3 was found to be superior and minimum overall acceptability score was obtained for RTSBF1 (guava pulp (20 g), water (80 ml), sugar (10 g) and citric acid (0.2 g)) is 7.12 and hence formulation I was found to be least. As the quantity of pulp increased in the preparation of RTS beverage, the acceptability also increased. Guava can be processed and RTS beverage can be prepared with high nutritive content when compared to regular beverages. Since, formulation III contains a higher amount of guava pulp it has high amount of nutritive value when compared to other formulations.

REFERENCES

Abdel, M.E.S. 2009. The impact of refrigerated storage on the chemical, physiochemical and sensory characteristics of some fruit nectars. Gezira Journal of Engineering and Applied Science. 4: 35-46.

Anju, K.D., Nagendra, B.G., Attri, S and Ramchandran, P. 2017. Development and standardization of ripe pumpkin based squash and its stability during storage. International Journal of Current Microbiology and Applied Sciences. 6(10): 821-831.

AOAC. 2000. Official Methods of Analysis. Association of Official Analytical Chemists. 17thEd. Gaithersburg, Maryland, USA .pp. 934.01-985.29.

Homi, J., Anita, K and Boora, R. S. 2017. Organoleptic and nutritional evaluation of value added products developed from new varieties of white and pink fleshed guavas. Chemical Science and Review Letters. 6(24): 2108-2113.

Josiah, C., Marcel, N., Katja, K and Elka, P. 2019. Variation in fruit chemical and mineral composition of kenyan guava (*Psidium guajava L.*): Inferences from climatic conditions and fruit morphological traits. Journal of Applied Botany and Food Quality. 92: 151-159.

Kanwal, N., Randhawa, M. A and Iqbal, Z. 2017. Influence of processing methods and storage on physico-chemical and antioxidant properties of guava jam. International Food Research Journal. 24(5): 2017-2027.

Krishna, V. P and Freeda, T. 2014. Formulation, nutrient and microbial analysis of papaya leaves and guava incorporated RTS beverage. International Journal of Current Microbiology and Applied Sciences. 3(5): 233-236.

Moussa, M. E. M and El-Glendy, M. A. 2019. Physiochemical, microbiological and sensory properties of guava whey blend beverages. Middle East Journal of Applied Sciences. 9(2). 326-331.

Patil, E.M.M., Kalse, E.S.B and Sawant, E.A.A. 2013. Preparation of guava jam blended with sapota. Agriculture Engineering international: CIGR Journal. 15(1): 167-172.

Pooja, J., Ghanshyam, D. S and Kumar, V. 2020. Preparation and evaluation of guava (*Psidium Guajava*) jelly. Journal of Pharmacognosy and Phytochemistry. 9(6): 2061-2063.

Rafia, R., Anju, B., ANkit, D., Monika, S and Sushil, S. 2018. Studies on storage stability of guava RTS. The Pharma Innovation Journal. 7(5): 230-233.

Rajan, S and Hudedamani, U. 2019. Genetic resources of guava: importance, uses and prospects. In: Rajasekharan, P and Rao, V. (Editors) Conservation and utilization of horticultural genetic resources. Springer, Singapore.https://doi.org/10.1007/978-981-13-3669-0_11.

Ramakrishna, K and Sudhakar, R.D.V. 2014. Effect of chitosan coating on the physiochemical characteristics of guava (*Psidium guajava L.*) fruits during storage at room temperature. Indian Journal of Science and Technology. 7(5): 554-558.

Siti, N. A. A. M., Hasnah, H., Wan, A. W. M and Suzana, S. 2017. Physico-chemical properties, total phenolic and antioxidant activity of mixed tropical fruit juice, TP 3 in 1 TM. Journal of Agricultural Science. 9(13): 50-61.

Thakkar, P., Vaghela, B., Patel, A., Modi, H.A and Prajapati, J.B. 2018. Formulation and shelf life of a whey-based functional beverage containing orange juice and probiotic organisms. International Food Research Journal. 25(4): 1675-1681.

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PERCEPTION OF TRIBAL AND NON–TRIBAL DAIRY FARMERS TOWARDS THE DAIRY FARMING IN CHHATTISGARH STATE: STRUCTURAL EQUATION MODELING APPROACH

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ABSTRACT

Dairy farming is a secondary occupation for millions of farmers in the Central Indian State of Chhattisgarh. This study used the Principal Component Analysis (PCA) and Structural Equation Modeling (SEM) to determine how tribal and non-tribal dairy farmers in Chhattisgarh perceive about dairy farming and what makes them feel that way. In this study, the data was gathered from dairy farmers during 2020–21. The results of the paired sample t-test showed that both tribal and non-tribal farmers are performing significantly. In the Principal Component Analysis, KMO's sample adequacy test result was 0.724, which means there were enough signs in each element to study. Twelve items of dairy farmers' perceptions were conglomerated into three factors: rational perception, opportunistic perception, and scientific perception. The results of the SEM showed that the absolute fit indices match the sample data and that the proposed model is a good fit because it matches the values of the perception items.

Keywords: Dairy Farming, Perception, Principal Component Analysis **(**PCA), Structural Equation Modeling (SEM), Tribal and Non-Tribal Farmers

INTRODUCTION

Dairy farming is a crucial instrument for rural people seeking self-employment and undergoing socioeconomic change, particularly for small farmers, landless laborers, educated unemployed and tribal people(Pradesh, 2017). India is primarily an agricultural nation, and the dairy industry plays a significant role in supplementing family income and creating employment in rural areas, particularly among landless, small and marginal farmers and farm women, in addition to providing inexpensive and nutritious food to millions of people (Jaiswal*et al.,* 2018). One of the primary reasons for the low productivity of milk is a widening gap between the technologies developed and those actually adopted or utilised by farmers, which may be the result of insufficient information dissemination to farmers (Calicioglu *et al.,*2019). The absence of suitable dairy technologies for all types of farmers is the

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greatest obstacle for achieving sustainable dairy production. Access to information and enhanced communication are essential for the sustainability of dairy farming (Puupponen *et al.,* 2022). Millions of houses in villages rely on the dairy industry for a living, guaranteeing that both urban and rural residents have access to high-quality milk and milk products (LMIS, 2015). Millions of small and marginal dairy farmers who own two to three cows and produce an average of five liters daily make up most of the Indian dairy farming (Mooventhan *et al.,* 2016). Because livestock distribution is far more equal than land distribution, dairy development activities and livestock development, in general, are essential parts of pro-poor development policies (Quisumbing *et al.,* 2015). Eventhough, Chhattisgarh state has a healthy amount of cattle compared to other top milk-producing states, the state is still in the early stages of dairy farming(Gamit *et al.,* 2021). Cattle ranching is primarily concentrated in the region of the state's center that surrounds the capital city of Raipur(Sikarwar, 2017). There are many cattle in the state's northern part. It has been noted that raising livestock, particularly in rural areas, is done more for draught power than milk production(Henry *et al.,* 2018). Tribal people comprise 8.6% of India's population (Census, 2011). Moreover, one-fourth of the world's absolute poor live in India, an extensive and diverse nation (Abdullah *et al*.,2015). The Scheduled Tribes (S.T.) is the socioeconomic category in India with the most significant percentage of the needy(Pathak *et al.,* 2022). They make up 40% of the displaced population, only 8% of the entire population. The large share of Scheduled Tribes in Chhattisgarh's population, which makes up 31.8% of the state's overall population, is significant (Mooventhan, 2017).). The production of dairy products is thought to be a crucial tool for creating self-employment and raising the standard of living of rural residents, tiny farmers, landless laborers, educated unemployed, and tribal people of the state. Scientific management is essential to dairy units' capacity to make a profit **(**Chitere, 2015). Suppose the tribal dairy farmers receive information on good dairy farming techniques through effective communication (Ohe, 2017). In that case, their scientific knowledge base will grow, making them more economically independent (Gyimóthy, 2015). To distinguish and assess the perceptions of tribal and non-tribal dairy farmers, this study was designed to compare and contrast the perceptions of tribal and non-tribal dairy farmers about dairy farming in the Central Indian State of Chhattisgarh. The main objectives of the study were:

1. To differentiating the perceptional parameters between the tribal and non-tribal farmers; 2. To identifying the perceptional determinants of the dairy farmers and 3.To evaluating the model good fit of the structural model for the collected perceptional data.

MATERIALS AND METHODS

This research used a perceptions-only measure to collect data from the dairy farmers. The study was carried in four districts of Chhattisgarh state, two from the tribal Surguja and Bastar districts and two from the Raipur and Durg districts during the year 2020-21. From each district, two blocks were selected, and from each block, two villages were chosen; from each village, 20 respondents were selected through random sampling; thus, making a total sample of 320 respondents was

chosen for perceptional analysis. In this study, dairy farmer's perceptions were measured with a self administered questionnaire. This study used both primary and secondary data. Secondary data was collected from the websites and various journals. Preliminary data was collected based upon the dairy farmers" perception. To measure the perception level of respondents on dairy farming, a list of items seeking different contents was prepared. These listed items were administrated to the respondents. The individual farmer was asked to state on a five-point continuum, strongly agree, agree, undecided, disagree, and strongly disagree with the statements in his hand, with a score of 5, 4, 3, 2, and 1 for the responses, respectively. Collected data were analysed with the help of the software package SPSS version 23 and analysis of moment structure (AMOS) 23.

RESULT AND DISCUSSION

Descriptive statistics of dairy farmer's attitude towards the dairy farming in Chhattisgarh

Table 1 represents the farmers attitude towards dairy farmers of Chhattisgarh .The individual farmer was asked to state on a five-point continuum, strongly agree, agree, undecided, Disagree, and strongly disagree with a statement by placing them into one of these categories with the following statements:

1. The traditional practice of animal rearing is time wasted: About 49.00 percent of tribal dairy farmers and 60.00 percent of highest non- tribal dairy farmers agreed with this statement. Half (55.00%) of the dairy farmers agreed with this statement. (Babel and Sornapudi, 2020).

2. Scientific dairy practices have yet to prove their potential: The highest result for this particular assertion was around 61.00 percent of tribal dairy farmers being undecided with this statement. Despite the fact that 79 percent of non-tribal dairy farmers, 70.00 percent of cumulative dairy farmers agreed with the statement.

3. A Cross-breed animal is a symbol of progressiveness: Around 67.00 percent of tribal dairy farmers strongly disagreed with this statement. Even after the fact that the biggest percentage of non-tribal dairy farmers was undecided and that the highest percentage of cumulative dairy farmers was also undecided, 79.00 percent.

4. I look forward to the adoption of scientific dairy innovation: Regarding this particular assertion, the highest possible score is approximately 63.00 percent of tribal dairy farmers who disagreed with this statement. Despite the fact that the majority of non-tribal dairy farmers, 69.00 percent, and highest percentage of cumulative dairy farmers, 45. 00 percent were 'undecided'.

5. Scientific dairy practices must be given a chance: With regard to this particular assertion, the maximum score was approximately 63.00 percent of tribal dairy farmers who disagreed with this statement. Despite the fact that the biggest percentage of non-tribal dairy farmers (66.00%) and highest percentage of cumulative dairy producers (36.0%) disagreed with the statement.

6. Only fools are eager to adopt dairy farming: For this statement, the highest score was around 61.00 percent of tribal dairy farmers who strongly disagreed. Aside from

the fact that the highest 76.00 percent of non-tribal dairy farmers 'undecided' and the highest 47. 00 percent of total dairy farmers also in 'undecided' category.

7. In my view, people will come forward for dairy farming in a big way: The highest score for this particular assertion was approximately 59.00 percent of tribal dairy farmers who disagreed with the statement. Considering the fact that the biggest percentage of non-tribal dairy farmers was undecided (73.00 percent), as well as the highest percentage of cumulative dairy farmers (45. 00 percent) was also 'undecided'.

8. Unfortunately, we are moving to dairy farming: With regard to this particular remark, the highest score given was approximately 56.0 percent of tribal dairy farmers who disagreed with this statement. The large percentage of Non-tribal dairy farmers was undecided (52.0 percent), as well as the highest percentage of cumulative dairy farmers (40.0 percent) was also 'undecided'.

9. I don't think dairy farming offers anything advantageous: The highest result for this particular statement was about 76.00 percent of tribal dairy farmers who said 'undecided'. It is noticed that the highest 69.00 percent of non-tribal dairy farmers were in agree, and the highest 48.00 percent of cumulative dairy farmers were undecided,

10. It's unfortunate, but we don't have a substitute for traditional dairy farming: The score that was the highest has been something around 73.00 percent of tribal dairy farmers who disagreed with this statement. Despite the reality that highest percentage (59.00 percent) of non-tribal dairy farmers 'agreed' and highest percentage (41.00 percent) of cumulative dairy farmers 'disagreed'.

11. Good or bad, we have to adopt scientific dairy practices: Regarding this particular assertion, the highest possible score were approximately 67.00 percent of tribal dairy farmers who 'disagreed' with this statement. Despite the fact that greatest 59.00 percent of non-tribal dairy farmers 'agree', and the highest 33.00 percent of cumulative dairy farmers 'disagree'.

12. Dairy farming may not be good very good, but other options are worse: The highest score possible was approximately 74.000 percent of tribal dairy farmers being undecided with this statement. despite the fact that highest percentage of non-tribal dairy farmers, 49.00 percent, and highest percentage of cumulative dairy farmers, 62.00 percent, were both 'undecided' in regards to this statement.

Table 2 shows the mean and standard deviation of the difference scores between each pair of variables. If the population's means are equal, it should be nearly zero. At both the 0.01 and 0.05 levels of significance, the mean difference between Non - tribal and tribal dairy farmers is significant. This is due to the significance levels of Sig. (2-tailed), or *p* 0.01 and *p* 0.05. A mean difference of zero is comfortably within the 95% confidence interval for the population of dairy farmers. For comparison between the perceptions of Non – tribal and tribal dairy farmers, twelve pair statements have been taken where ten pairs of tribal dairy farmers' statements (1. The traditional practice of animal rearing is time wasted, 2. Scientific dairy practices have yet to prove their potential, 3. A Cross-breed animal is a symbol of progressiveness, 5. Scientific dairy practices must be given a

chance, 6. Only fools are eager to adopt dairy farming, 7. In my view, people will come forward for dairy farming in a big way, 8. Unfortunately, we are moving to dairy farming, 10. Unfortunately, we don't have a substitute for traditional dairy farming, 11. Good or bad, we have to adopt scientific dairy practices, and 12. Dairy farming may not be good very good, but other options are worse) were statistically significant at μ = 0.01 level of confidence. Where two pairs of non–tribal and tribal dairy farmers' statements (I look forward to the adoption of scientific dairy innovation and 9. I don't think dairy farming offers anything advantageous) were statistically significant at μ = 0.05 level of confidence.

Paired Sample t-test for tribal and non-tribal dairy farmers

Hypotheses

Null hypothesis (H0): The perception of dairy farmers does not have differences between tribal and non –tribal.

Alternative hypothesis (H1): The perception of dairy farmers has differences between the tribal and non –tribal.

Reliability statistics of dairy farmers

The Cronbach's alpha coefficient must be determined to ensure reliability and consistency while using Likert-type scales in research. As per the findings, tribal dairy farmers' perception items had Cronbach's alpha values over 0.70**,** indicating a high degree of internal consistency for the scale. Additionally, as per Table 3, Cronbach's alpha value for the perceptional items for tribal dairy farmers is 0.899, whereas, it is 0. 569 for non-tribal dairy farmers. Further analysis on the perceptions of tribal dairy farmers has been performed in accordance with Cronbach's alpha standard.

Principal Component Analysis of tribal dairy farmers

Table 4 shows the corrected item-total correlations. This means that the score for an item and total score of the other items in a subscale (for example, the subscale measuring the credibility aspect of service quality) were related. All the individual perception items had a higher correlation with the total scores than the 0.35 threshold**.** The correlations between each item on the scale and the total score range from 0.395 to 0.844. (Table 4). Means and standard deviations for each item are also shown in Table 3.

KMO and Bartlett's Test of tribal dairy farmers

The purpose of factor analysis is to uncover a smaller number of underlying components for a more significant number of observable variables. Kaiser-Meyer-Olkin (KMO) and Bartlett's Test results are displayed in Table 5. Higher KMO levels indicate a better degree of appropriateness. This number should ideally be more significant than 0.7. According to Kaiser, a KMO score of 0.9 to 1.0 is marvelous, 0.8 to 0.9 meritorious, 0.7 to 0.8 middling, 0.6 to0.7 mediocre, and 0.5 to 0.6 miserable. Table 5 indicates that the Kaiser-Meyer-Olkin measure of sample adequacy (MSA) is 0.724, and Bartlett's test of sphericity is significant [Chi-square x2 (66) = 2232.69, p 0.001] in terms of the perceptions of tribal dairy farmers. Based on more than one Eigen value, the twelve perceptions of dairy farmers were aggregated into three categories (Figure 1): logical perception, opportunistic perception, and scientific perception. Table 6 displays the correlations between the variable and factor, with values ranging from -1 to 1. For a valid factor solution, a variable should have a high

Table 1. Descriptive statistics of dairy farmer's Attitude towards the dairy farming in Chhattisgarh (n=360)

S.No.	Statements	Categories	Tribal (n = 160)		Non- Tribal (n = 160)		Cumulative (n = 320)	
			Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
1.	The traditional practice of animal rearing is time wasted	Strongly Disagree	46	29	3	2	49	15
		Disagree	**79**	**49**	**96**	**60**	**175**	**55**
		Undecided	35	22	61	38	96	30
		Agree	46	29	3	2	49	15
2	Scientific dairy practices have yet to prove their potential	Strongly Disagree	43	27	7	4	50	16
		Disagree	20	13	27	17	47	15
		Undecided	**97**	**61**	**126**	**79**	**223**	**70**
3	A Cross-breed animal is a symbol of progressiveness	Strongly Disagree	**107**	**67**	11	7	118	37
		Disagree	22	14	23	14	45	14
		Undecided	31	19	**126**	**79**	**157**	**49**
4	I look forward to the adoption of scientific dairy innovation	Strongly Disagree	26	16	19	12	45	14
		Disagree	**100**	**63**	30	19	130	41
		Undecided	34	21	**111**	**69**	**145**	**45**
5	Scientific dairy practices must be given a chance	Strongly Disagree	26	16	8	5	102	32
		Disagree	**100**	**63**	**105**	**66**	**116**	**36**
		Undecided	34	21	47	29	102	32
6	Only fools are eager to adopt dairy farming	Strongly Disagree	**97**	**61**	1	1	98	31
		Disagree	34	21	2	1	36	11
		Undecided	29	18	**122**	**76**	**151**	**47**
		Agree	0	0	35	22	35	11

(Table 01 Contd.)

7.	In my view, people will come forward for dairy farming in a big way	Strongly Disagree	38	24	9	6	47	15
		Disagree	**95**	**59**	1	1	96	30
		Undecided	27	17	**116**	**73**	**143**	**45**
		Agree	0	0	34	21	34	11
8	Unfortunately, we are moving to dairy farming	Strongly Disagree	26	16	7	4	33	10
		Disagree	**90**	**56**	9	6	99	31
		Undecided	44	28	**83**	**52**	**127**	**40**
		Agree	0	0	61	38	61	19
9	I don't think dairy farming offers anything advantageous	Strongly Disagree	30	19	17	11	30	9
		Disagree	9	6	33	21	26	8
		Undecided	**121**	**76**	0	0	**154**	**48**
		Agree	0	0	**110**	**69**	110	34
10	It's unfortunate, but we don't have a	Strongly Disagree	30	19	0	0	30	9
		Disagree	**116**	**73**	16	10	**132**	**41**
		Undecided	14	9	38	24	52	16
		Agree	0	0	**94**	**59**	94	29
	substitute for traditional dairy farming.	Strongly Agree	0	0	12	8	12	4
11	Good or bad, we have to adopt scientific dairy practices	Strongly Disagree	30	19	0	0	30	9
		Disagree	**107**	**67**			**107**	**33**
		Undecided	23	14	33	21	56	18
		Agree	0	0	**95**	**59**	95	30
		Strongly Agree	0	0	32	20	32	10
12	Dairy farming may not be good very good, but other options are worse	Strongly Disagree	30	19	1	1	31	10
		Disagree	11	7	6	4	17	5
		Undecided	**119**	**74**	**79**	**49**	**198**	**62**
		Agree			45	28	45	14
		Strongly Agree	0	0	29	18	29	9

Table 2. Paired sample t-test for tribal and non-tribal farmers

pair	Comparison between non-tribal and tribal dairy farmers	Paired Differences			t-value	Sig. (2-tailed)
		Mean	Std. Deviation	Std.Error Mean		
Pair 1	PNT1 - PT1	0.431	0.962	0.076	5.669	0.00
Pair 2	PNT2 - PT2	0.406	1.077	0.085	4.769	0.00
Pair 3	PNT3 - PT3	1.194	0.915	0.072	16.51	0.00
Pair 4	PNT4 - PT4	**0.525**	**0.876**	**0.069**	**7.584**	**0.02**
Pair 5	PNT5 - PT5	0.488	1.149	0.091	5.366	0.00
Pair 6	PNT6 - PT6	1.619	1.009	0.080	20.301	0.00
Pair 7	PNT7 - PT7	1.163	0.971	0.077	15.151	0.00
Pair 8	PNT8 - PT8	1.125	1.026	0.081	13.864	0.00
Pair 9	PNT9 - PT9	**1.013**	**1.082**	**0.086**	**11.842**	**0.03**
Pair 10	PNT10 - PT10	1.738	0.981	0.078	22.406	0.00
Pair 11	PNT11 - PT11	2.038	0.924	0.073	27.89	0.00
Pair 12	PNT12 - PT12	1.038	1.218	0.096	10.777	0.00

PNT = Perception of non- tribal farmers
PT= Perception of tribal farmers
1= Traditional practices of animal rearing is time wasted
2 = Scientific dairy practices have yet to prove their potential
3 = Cross breed animal is a symbol of progressiveness
4 = I look forward to the adoption of scientific dairy innovation
5 = Scientific dairy practices must be given a chance
6 = Only fools are eager to adopt dairy farming
7 = In my view, people will come forward for dairy farming in a big way
8 =, Unfortunately, we are moving to dairy farming
9 = I don't think dairy farming offers anything advantageous
10 = It's unfortunate, but we don't have a substitute for traditional dairy farming
11 = Good or bad, we have to adopt scientific dairy practices
12 = Dairy farming may not be good very good, but other options are worse

Table 3. Reliability Statistics

Sl. No.	Farmers	Cronbach's Alpha
1.	Non – Tribal	0.569
2.	Tribal	0.899

loading on one factor and a low loading on all other factors. It can be indicated that all 12 perceptional items of dairy farmers have factor loadings greater than 0.50. (Table 6 and Figure 2). These 12 items were selected for additional examination.

Structural equation modeling (SEM): Model fit assessment

The structural equation modeling was utilized to assess the model's viability. As suggested, the measurement model for testing the reliability and validity of the survey instrument was studied first, followed by the structural model analysis using AMOS version 23. The structural equation model (SEM) is particularly beneficial for evaluating the causal link between variables and confirming the model's compatibility. Structural equation modeling aims to determine if the data match

a theoretical model. Priority was given to Chi-square/degrees of freedom (x2/df), CFI, GFI, AGFI, TLI, IFI, RMSEA, and PGFI when evaluating the model (Table 6). According to the results, Chi-square values with p = 0.000 do not indicate a satisfactory model fit. However, a sample size of above 200 (160 in this study) might influence Chi-Square statistics to show a statistically significant probability level (p=0.00). Therefore, this model is considered for further interpretation in the goodness of fit metrics. Standard model-fit measures such as chi-square/degree of freedom (x2/df), the comparative fit index (CFI), the root mean square error of approximation (RMSEA), the normed fit index (NFI), the incremental fit index (IFI), and the Tucker Lewis index (TLI) were employed to estimate the measurement model fit. The estimations of model fit indices using AMOS structural modeling displayed (Table 6) provide the following requirements for an acceptable model: RMSEA of 0.08 or less, CFI of 0.90 or higher, and NFI of 0.90 or higher. The fit between the data and the suggested measurement model can be evaluated using the chi-square goodness-of-fit (GFI) test, where a probability of 0.9 or above indicates a satisfactory fit. This study's GFI was 0.937% more than the suggested value of 0.90, and the other measures fitted effectively; AGFI=0.974, CFI=0.965, TLI=0.902, IFI=0.966, and NFI=0.957 with x2/df 5 at 4.945 and RMSEA=0.071 show an absolute satisfactory fit of the model. These highlighted indices demonstrate the acceptability of this structural

Table 4. Descriptive analysis of Tribal Dairy Farmers

S. No.	Parameters	Mean	Std. Deviation	Corrected Item-Total Correlation
1	The traditional practice of animal rearing is time wasted	1.9313	0.71041	0.598
2	Scientific dairy practices have yet to prove their potential	2.3375	0.87515	0.395
3	A Cross-breed animal is a symbol of progressiveness	1.525	0.80055	0.493
4	I look forward to the adoption of scientific dairy innovation	2.05	0.61224	0.718
5	Scientific dairy practices must be given a chance	1.7563	0.93665	0.588
6	Only fools are eager to adopt dairy farming	1.575	0.78147	0.499
7	In my view, people will come forward for dairy farming in a big way	1.9313	0.63565	0.605
8	Unfortunately, we are moving to dairy farming	2.1125	0.65385	0.844
9	I don't think dairy farming offers anything advantageous	2.5688	0.79005	0.709
10	It's unfortunate, but we don't have a substitute for traditional dairy farming	1.9	0.5164	0.759
11	Good or bad, we have to adopt scientific dairy practices	1.9563	0.57568	0.784
12	Dairy farming may not be good very good, but other options are worse	2.5563	0.79104	0.696

Table 5. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.724
Bartlett's Test of Sphericity	Approx. Chi-Square	2232.69
	Df	66
	Sig.	0

Table 6. Rotated Component Matrix (a) of Tribal dairy farmers

Items	Compo-nent 1	Compo-nent 2	Compo-nent 3
TP4- I look forward to the adoption of scientific dairy innovation	0.752		
TP7- In my view, people will come forward for dairy farming in a big way	0.600		
TP9- I don't think dairy farming offers anything advantageous	0.949		
TP10- It's unfortunate, but we don't have a substitute for traditional dairy farming	0.828		
TP11-Good or bad, we have to adopt scientific dairy practices	0.775		
TP12- Dairy farming may not be good very good, but other options are worse	0.874		
TP5-Scientific dairy practices must be given a chance		0.881	
TP6- Only fools are eager to adopt dairy farming		0.915	
TP1-Traditional practices of animal rearing are time wasted			0.823
TP2-Scientific dairy practices have yet to prove their potential			0.649
TP3-Cross breed animal is a symbol of progressiveness			0.650
TP8- Unfortunately, we are moving to dairy farming			0.662
Eigen values	**6.22**	**2.24**	**1.31**
Percentage of Variance	**51.81**	**18.65**	**10.92**
Cumulative Percentage	**51.81**	**70.46**	**81.38**
Rename Component	Rational Perception	Opportunistic Perception	Scientific Perception

model and support the model's fit. The null and alternative hypotheses are formulated to assess the model fit null hypothesis.

HYPOTHESES

Null hypothesis (H0): The hypothesized model does not have a good fit.

The alternative hypothesis (H1): The hypothesized model has a good fit.

As per Table 7, it is evident that where Chi-square/degree of freedom (x2/d.f.) values within the proposed limit of 5.00 the closer the fit between the hypothesized model and the ideal fit, the greater the Chi-square at 0.01 probability . The test of our null hypothesis H0 that the perception of dairy farmers is a three-factor structure, as depicted in Figure 3, produced a chi-square value of 49.451 with 10 degrees of freedom and a probability of less than 0.0001 (p 0.0001). It suggests that the match between the data and the hypothesized model is unsatisfactory. As per the results, Chi-square values with p = 0.000 do not indicate a satisfactory model fit. However, a sample size greater than 200 (160 in our study) might influence Chi-square statistics to imply a significant probability level (p=0.00). Therefore, this model is considered for further interpretation in the goodness of fit metrics. Both the sensitivity of the Likelihood ratio test to sample size and its reliance on the chi-square distribution, which implies that the population (*i.e.,* H_0 is actual) is right, have led to fit issues. The chi-square statistic equals (N-1) sample size-1 multiplied by the minimal fit function. When the model does not hold and the sample size is big, this number is likely to be considerable. Researchers have addressed the shortcomings of chi-square by inventing goodness-of-fit indexes that take a more pragmatic approach to the evaluation process, The value for the fit statistic minimal discrepancy/degrees of freedom (CMIN/DF) or chi-square/degrees of freedom should be 5. Table 7, The chi-square/degrees of freedom number is 4.945, which is less than the commonly accepted cutoff value of 5.00 (Table 7).

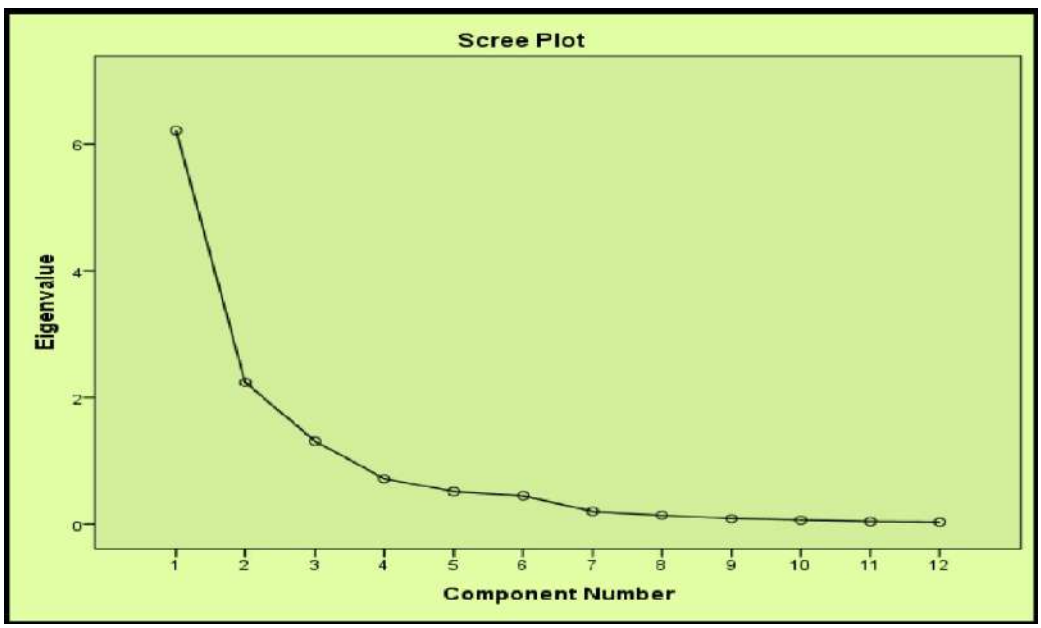

Figure 1. Component Screen plot for tribal dairy farmer's perception

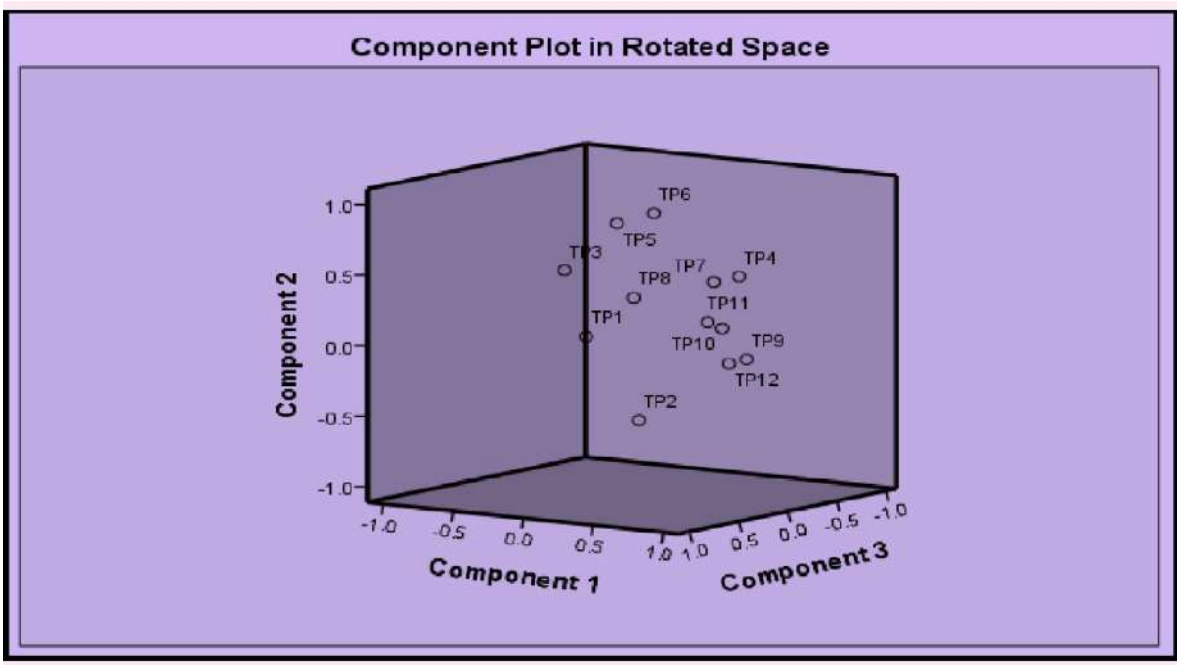

Figure 2. Component plot in rotate space for tribal dairy farmer's perception

Significance tests of individual parameters

Table 8 displays the unstandardized coefficients and accompanying test statistics. The unstandardized regression coefficient is the amount of change in the dependent or mediating variable for every unit change in the variable predicting it. Table 8 displays the unstandardized estimate, its standard error (abbreviated S.E.), and the estimate split by the standard error (abbreviated C.R. for Critical Ratio). The probability value associated with the null hypothesis that the test is zero is shown in column P.

Table 7. Model fit indices of Tribal dairy Farmers

Fit Indices	Results	Suggested values
Chi-square	49.451 (0.000) DF-10	P-value >0.05
Chi-square/degree of freedom (x2/d.f.)	4.945	≤ 5.00
Comparative Fit index (CFI)	0.965	>0.90
The goodness of Fit Index (GFI)	0.937	>0.90
Adjusted Goodness of Fit Index (AGFI)	0.974	> 0.90
Normal Fit Index (NFI)	0.957	≥ 0.90
Incremental Fit Index (IFI)	0.966	Approaches 1
Tucker Lewis Index (TLI)	0.902	≥ 0.90
Root mean square error of approximation (RMSEA)	0.071	< 0.08
Parsimony goodness-of-fit index (PGFI)	0.260	Within 0.5

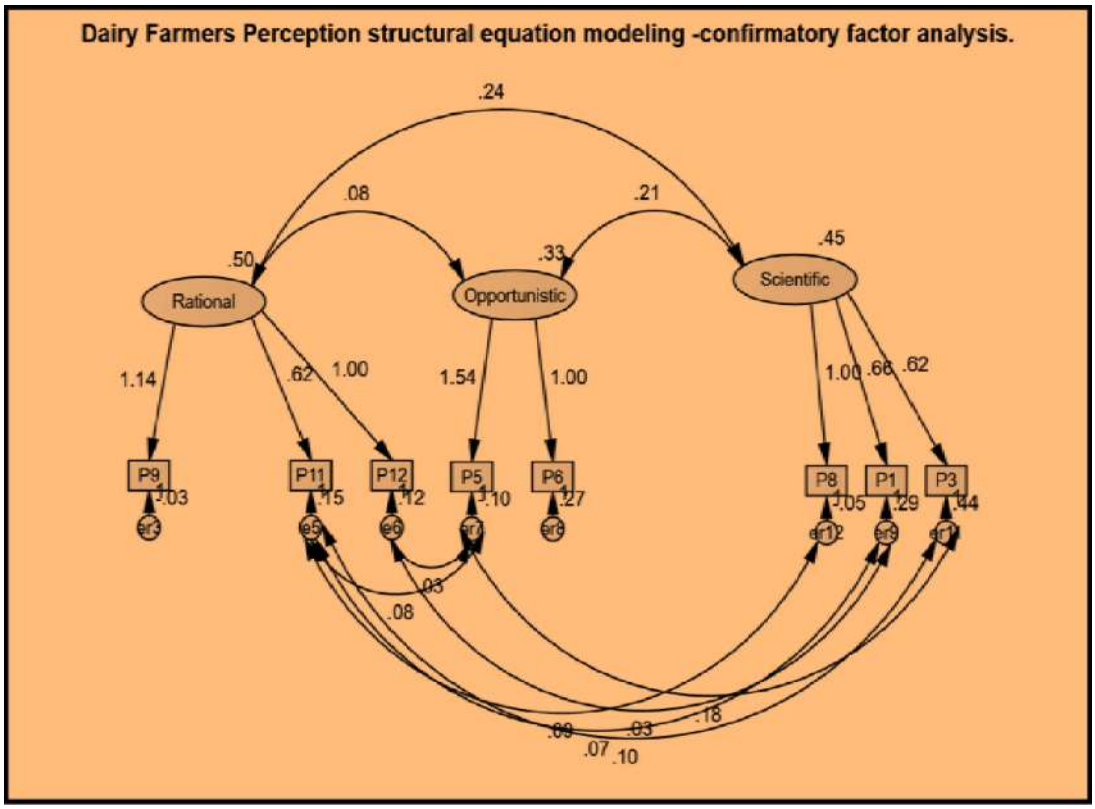

Figure 3. Structural equation modeling for tribal dairy farmer's perception.

Level of significance for regression weight

The likelihood of obtaining a critical ratio with an absolute value of 22.045 is less than 0.001. In other words, at 0.001 level, the regression weight for Factor 1 in the prediction of P9 is substantially different from zero (two-tailed). The likelihood of obtaining a critical ratio with an absolute value of 13.022 is less than 0.001. In other words, at 0.001 level, the regression weight for Factor 1 in the prediction of P11 is substantially different from zero (two-tailed). These statements are substantially valid for large samples considering suitable assumptions

Maximum likelihood estimates

Table 9 represents the standard estimates for the model that was fitted. Standardized estimates determine the relative contributions that each predictor variable has made to each outcome variable. The structural model of seen reality is depicted in figure 3. Only eight of the 12 items asked about dairy farmers' perceptions were used for confirmatory factor analysis. As per the Figure 1, it is abundantly evident that dairy farmers impose a high amount of emphasis on logical perception in comparison to other perceptions items. In addition, confirmatory factor analysis is sometimes known as the model fit. The root means square error of approximation is a metric that sheds information on how well the model, with its uncertain parameter estimates, would match the population covariance matrix. The Chi-square test, the CFI, and the RMSEA are all viable options for determining whether or not the measurement model is fit, as stated by the goodness-of-fit statistic, often known as GFI, as an alternative to the Chi-square test.

Table 8. Regression Weights: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	P	Label
P6 <— Opportunistic	1.000				
P5 <— Opportunistic	1.544	.164	9.427	***	par_1
P8 <— Scientific	1.000				
P9 <— Rational	1.142	.052	22.045	***	par_2
P11 <— Rational	.615	.047	13.022	***	par_6
P12 <— Rational	1.000				
P1 <— Scientific	.656	.076	8.676	***	par_7
P3 <— Scientific	.619	.086	7.197	***	par_8

Table 9. Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
P6	<—-	Opportunistic	0.742
P5	<—-	Opportunistic	1.066
P8	<—-	Scientific	1.064
P9	<—-	Rational	1.025
P11	<—-	Rational	0.749
P12	<—-	Rational	0.897
P1	<—-	Scientific	0.632
P3	<—-	Scientific	0.527

Scalar estimates (group number 1 - default model)

GFI can measure a study's variance proportion. The value of the model's Chi-square may be compared to the value of the null model's Chi-square to determine how well the model fits the data. This can be done using the Normed fit index**.** CFI is essential for all SEM programs since its measure is least impacted by the total number of observations.

CONCLUSIONS

This study validates and develops a perception instrument within the context of dairy farming and investigates the relationship between dairy farmers' perceptions. The suggested model is calibrated using the data received from dairy farmers. Cronbach's alpha for all items of perceptions of tribal dairy farmers is above 0.70, indicating a high level of internal consistency, but perceptions of non-tribal dairy farmers are below 0.70. In addition, the overall Cronbach's alpha value for the perception of tribal dairy farmers is 0.899, above the threshold value of 0.7. Therefore, perceptional data about tribal dairy has been collected for further factor confirmation analysis. Based on the confirmatory factor analysis, it is possible to infer that the perception data of dairy farmers fit the gathered data sufficiently. It is plausible to

conclude that the proposed three-factor model fits the data sample. Based on the viability and statistical significance of important parameter estimates with the remarkably good fit of the model (CFI, GFI, AGFI, NFI, IFI, TLI, RMSEA), it can be concluded that the three-factor model and eight items provide a sufficient description of the dairy farmers' perceptional structure. The fit indices support the model fit, and these highlighted indices indicated the acceptability of this structural model. This offers a compelling case for planning regional strategies to increase milk production, elevate the economic status of this tribal group, and make the state self-sufficient.

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REFERENCES

Abdullah, N., Derus, A. M and Al-Malkawi, H. A. N. 2015. The effectiveness of zakat in alleviating poverty and inequalities: A measurement using a newly developed technique. Humanomics. pp.156-166.

Calicioglu, O., Flammini, A., Bracco, S., Bellù, L and Sims, R. 2019. The future challenges of food and agriculture: An integrated analysis of trends and solutions. Sustainability. 11(1): 222 -234.

Chitere, P. O. 2015. The rural poverty reduction programme in Kenya: Its achievements and limitations. Working with Rural Communities Participatory Action Research in Kenya. pp.173-177.

Dredge, D and Gyimóthy, S. 2015. The collaborative economy and tourism: Critical perspectives, questionable claims and silenced voices. Tourism Recreation Research. 40(3): 286-302.

Fatima, N and Pradesh, U. 2017. Employment generation and development strategy during the pre and post globalisation period in India: Major schemes overview. International Journal of Research Culture Society. 1(7):122-129.

Gamit, V., Odedra, M., Ahlawat, A., Prajapati, V., Patel, H and Gamit, K. 2021. Constraints faced by the dairy farmers in different states of India: An Overview. Journals of Entomology and Zoology Studies. 9(2): 1901-1906.

Henry, B. K., Eckard, R. J and Beauchemin, K. A. 2018. Adaptation of ruminant livestock production systems to climate changes. Animal. 12(2):445-456.

Jaiswal, P., Chandravanshi, H and Netam, A. 2018. Contribution of dairy farming in employment and household nutrition in India. International Journal of Avian and Wildlife Biology. 3(1):78-79.

LMIS. 2015. Report on dairy sector. Agricultural Skill Council of India. Haryana, India. pp. 24-32.

Mooventhan, P., Kadian, K. S., Kumar, R. S., Manimaran, A and Selvan, A. S. 2016. Tribal dairy farming status in the Northern Hills Zone of Chhattisgarh state, India - A survey research. Asian Journals of Dairy and Food Research. 35(4):278-282.

Mooventhan, P., Kadian, K. S., Kumar, R. S., Manimaran, A and Karpagam, C. 2017. Tribal farmers' perceived constraints in the adoption of good dairy farming practices in the northern hills zone of Chhattisgarh, India. Journal of Applied and Natural Science. 9(1): 533-538.

Ohe, Y. 2017. Assessing managerial efficiency of educational tourism in agriculture: case of dairy farms in Japan. Sustainability. 9(11):1931-1943.

Pathak, P. K., Singh, Y., Mahapatro, S. R., Tripathi, N and Jee, J. 2022. Assessing socio-economic vulnerabilities related to COVID-19 risk in India: A state-level analysis. Disaster Medicine and Public Health Preparedness. 16(2):590-603.

Puupponen, A., Lonkila, A., Savikurki, A., Karttunen, K., Huttunen, S and Ott, A. 2022. Finnish dairy farmers' perceptions of justice in the transition to carbon-neutral farming. Journal of Rural Studies. 90:104-112.

Quisumbing, A. R., Rubin, D., Manfre, C., Waithanji, E., Vanden Bold, M., Olney, D and Meinzen-Dick, R. 2015. Gender, assets, and market-oriented agriculture: learning from high-value crop and livestock projects in Africa and Asia. Agriculture and Human Values. 32(4):705-725.

Sikarwar, R. L. S. 2017. Ethnic diversity of the indo-gangetic region and central India. In: Ethno botany of India. Volume series: 5 (Pullaiah, T., Krishnamurthy, K.V., Bahadur, B.V., Editors). Apple Academic Press. pp. 19-57.

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FORECASTING OF SMALL CARDAMOM PRICE USING SARIMA MODEL

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ABSTRACT

The study was undertaken to identify a model for forecasting the price of small cardamom using the data consisting of prices from January 2001 to December 2021 obtained from Spices Board, Government of India, Ministry of Commerce and Industry, New Delhi. Seasonal Auto regressive Integrated Moving Average (SARIMA) model was used to forecast the future monthly prices. The SARIMA model, ARIMA(1,1,0)(1,1,1)[12] was identified to be the best model for forecasting the monthly cardamom price according to the minimal Bayesian Information Criterion.

Key Words: Cardamom, SARIMA, Autocorrelation, Partial Autocorrelation, Seasonality

INTRODUCTION

Cardamom is a perennial, herbaceous rhizomatous monocot belonging to the family Zingiberaceae. It is a native of the moist evergreen forests of the western Ghats of South India. This is often referred to as the 'Queen of Spices' because of its very pleasant aroma and taste and is highly valued from ancient times. Cardamom production in India during 2019-20 was 20,650 MT obtained from an area of 69,330 ha covering the southern states of Kerala, Karnataka and TamilNadu. The global cardamom market is being highly concentrated as over 60% of the global production of this spiceis accounted for by two major producing countries, Guatemala and India. Various forecasting methods were developed for perennial crops *viz.,* clove (Martin and Riley 1989) and rubber (Golbon et al.2015). Yield forecasting model in cardamom plantations under intensive management was developed (Priya *et al.*, 2003). Autoregressive model for forecasting Cardamom price was developed (Priya *et al.*, 2006).

Dwivedi (2017) predicted the cardamom price for the period of Aug 2015 to 2017. Harini *et al.* (2018) applied seasonal ARIMA model to the time series cardamom price data for forecasting monthly price of cardamom for the period Jan 2016 to 2017. Prakash *et al.*(2022) forecasted sweet potato price by using SARIMA model by analysing the past data from the year Jan 2010 to December 2021.This research

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study aimed to forecast the future monthly prices of cardamom for the year 2022.

MATERIALS AND METHODS

The study was conducted using the monthly cardamom price from 2001 January to 2021 December, collected from Spices Board, Government of India, Ministry of Commerce and Industry, New Delhi. As the data consists of monthly price of cardamom it has seasonality which is a regular pattern of changes that repeats over 's' time periods where's' defines the number of time periods until the pattern repeats again.

An Autoregressive Integrated Moving Average (ARIMA) model which is a generalization of an autoregressive moving average (ARMA) model is used to for ecast future points in the time-series data. ARIMA models are applied in the cases where the data showed evidence of non-stationarity.If the observed time series is non stationary we candifferencethe series to get a stationary model.

In a Seasonal ARIMA model, seasonal AR and MA terms predict future prices using data values and errorsat times with lags that are multiples of's'. The Seasonal ARIMA model in corporates both non-seasonal and seasonal factors in a multiplicative model. The need of seasonal autoregressive and seasonal moving average parametersis established by examining the autocorrelation and partial autocorrelation patterns of a stationary series at lags that are multiples of number of periods per season. Seasonal differencing was done as the auto correlations at the lags did not decrease rapidly. To check stationarity of the data Unit root tests such as Dickey Fuller test was employed. From the possible models the model with the smallest BIC was adopted to choose the bestmodel. A statistically adequate model is the one whose random shocks are statistically independent and not auto correlated. The estimated residuals were used to test the hypothesis that the random shocks

Fig. 1. Time series plot of monthly cardamom price from January 2000 to December 2021

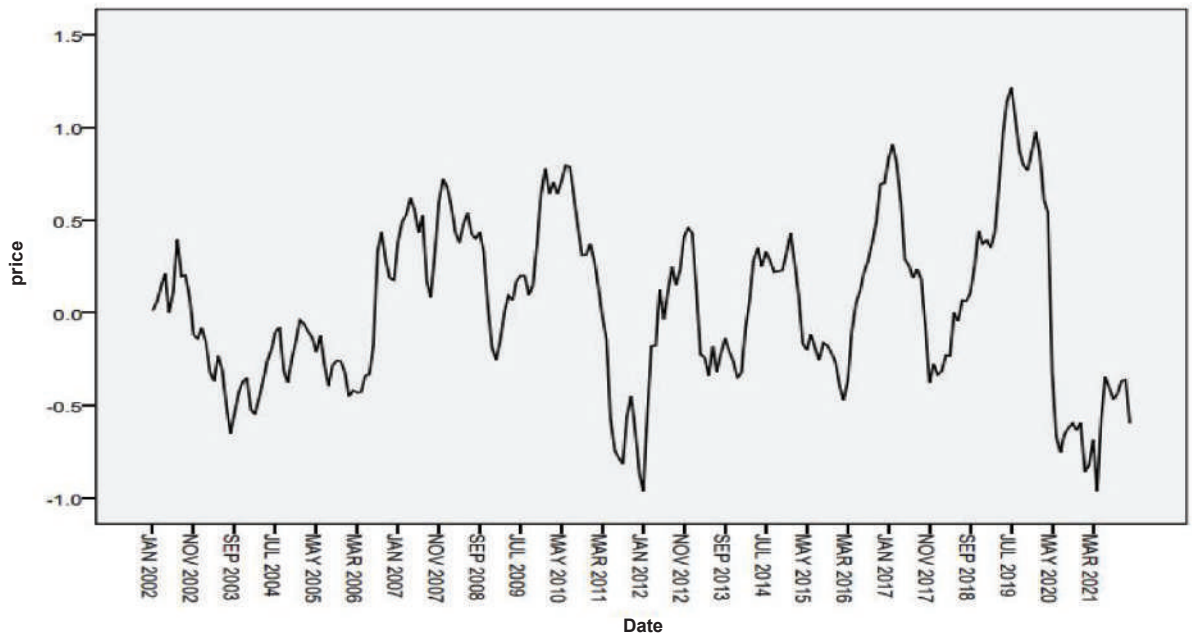


Fig. 2. Time series plot of seasonal differences of natural logarithm of monthly price

of the model are independent by constructing residual ACF. Inorder to check the normality assumptions of random shocks, histogram of residuals and normal probability plot of the residuals were drawn. The zero mean and constant variance of random shocks were checked using residual plots which is the scatter plot of residuals against the fitted values. Using the best model, the price of cardamom can be predicted.

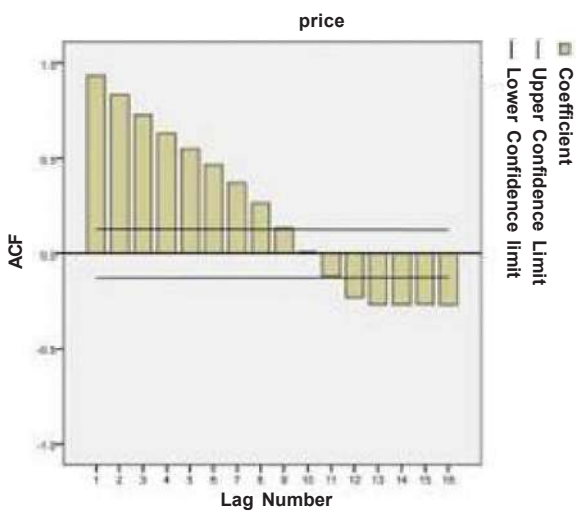


Fig. 3. ACF of plot of seasonal difference of natural logarithms of monthly price

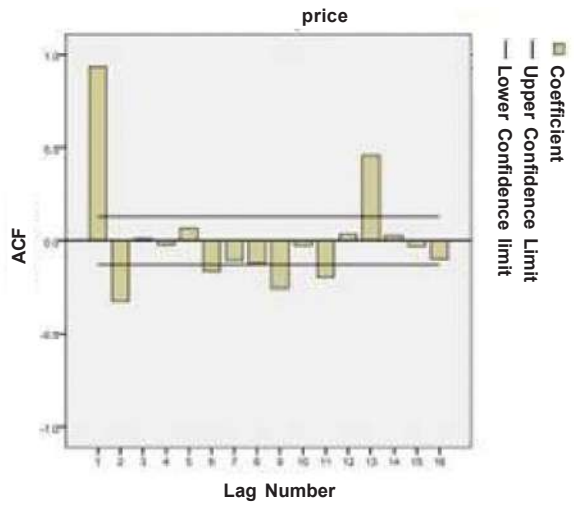
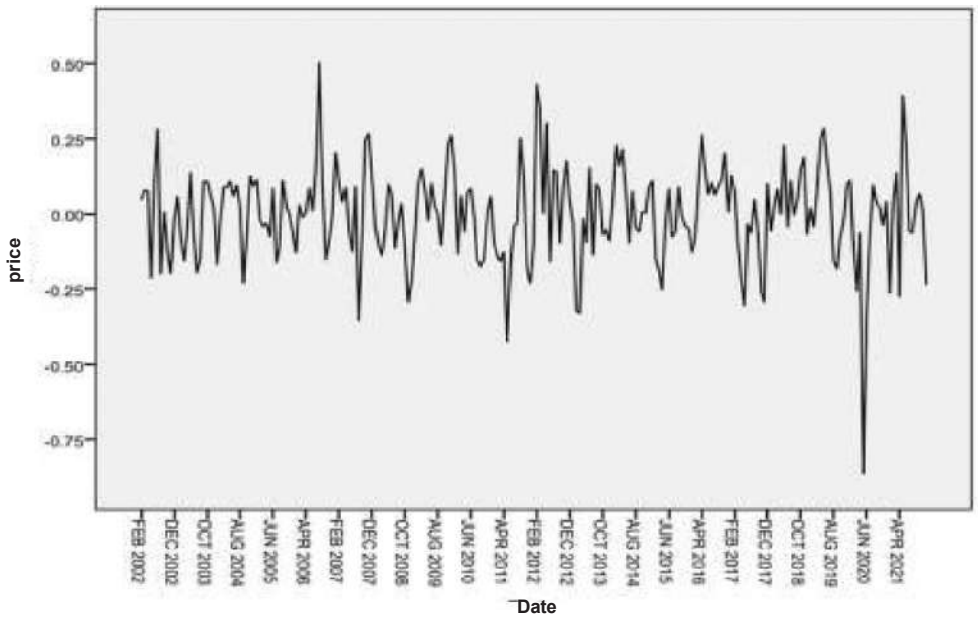


Fig. 4. PACF plot of seasonal difference of natural logarithms of monthly price



Transforms, natural log, difference(10) seasonal difference(1, period 12)

Fig. 5. Time Series plot of first difference of seasonality differenced logged data

RESULTS AND DISCUSSION

Box Jenkins approach was followed to analyze the cardamom price data to build the forecast model. The data was plotted to observe the seasonality and from the plot it was concluded that there was seasonality and the graph showed a slight increasing trend.

As the data was not stationary, seasonal differencing was done using the logarithm of the data in order to make the data stationary.

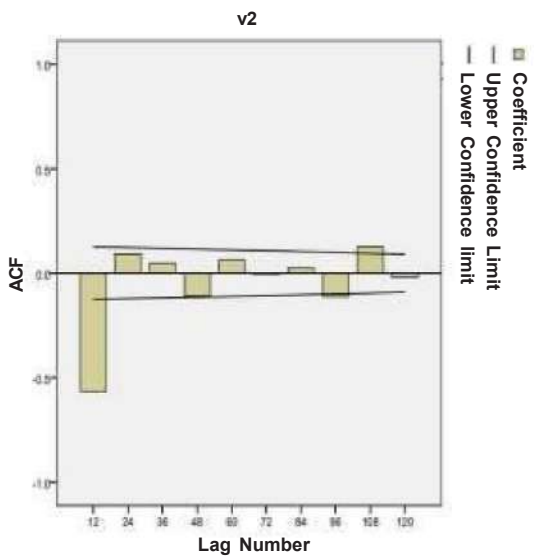


Fig. 6. Plot of auto correlation function of stationary data at seasonal lags

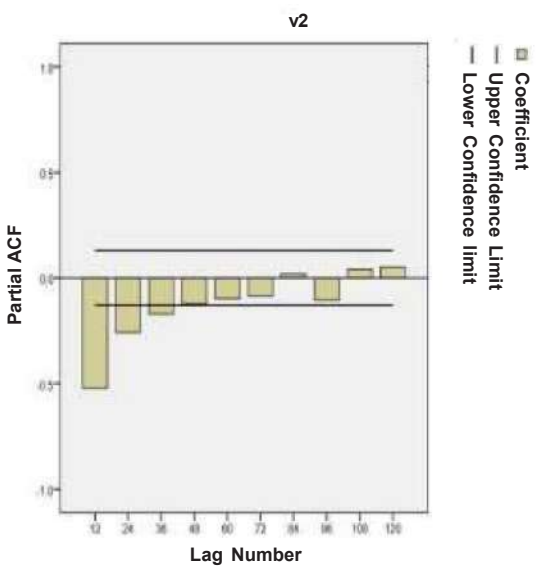


Fig. 7. Plot of partial auto correlation stationarity data at seasonal lags

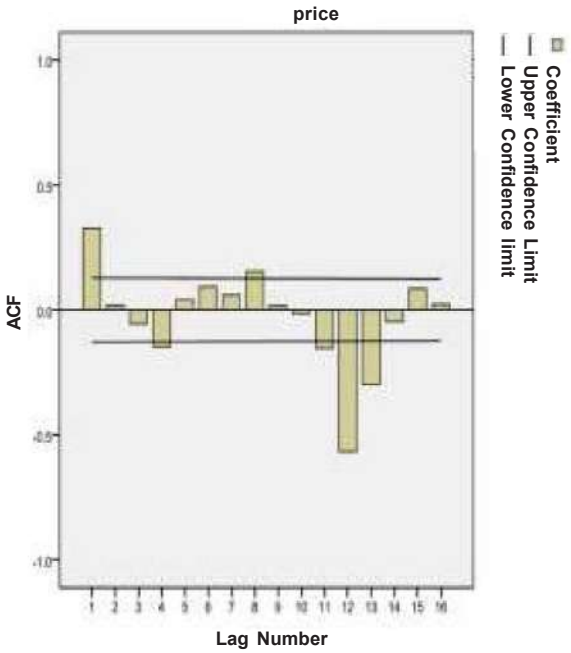


Fig. 8. Plot of auto correlation function for stationary data

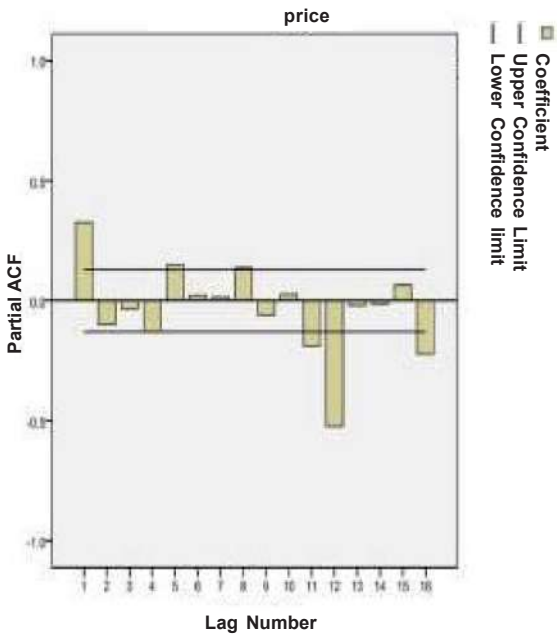


Fig. 9. Plot of partial auto correlation function for stationary data

The time series plot of seasonally differenced logged data was drawn.

The series was still non stationary, but the seasonal behaviour was removed from the series. In order to determine the proper degree of differencing ACF and PACF of the seasonal differenced data was plotted. It was observed that ACF decayed very slowly. Therefore, first order non-seasonal differencing was performed to the seasonally differenced data. From the resulting time series plot the series was apparently stationary. For further clarification, Augmented Dickey Fuller (ADF) test was employed which suggested that D=1 and d=1. In order to identify the seasonal AR order (P) and the seasonal MA order (Q), ACF and PACF of the stationary data was plotted at the seasonal lags.

To identify the non-seasonal AR order (p) and the non seasonal MA order(q) the ACF and PACF of the stationary data were drawn.

The ACF plot showed a significant peak at lag of 12 and declined to 0 after lag 12. The PACF plot showed significant peakat lags of 12, 24 and 36 and declined to 0 after lag 36. The exponentially declining PACF at seasonal lags and a significant ACF spike at lag 12 suggested a seasonal MA coefficient. Whereas, exponentially declining ACF at seasonal lags and a significant PACF spike at lags 12 and 24 and 36 suggested a seasonal AR coefficient. The ACF and PACF atseasonal lags suggest either a seasonal MA or AR term in the model with maximum P = 3 or maximum Q =1. The significant ACF spike at lag 1 and significant PACF spike at lag1, in Figures 8 & 9 it is suggested that either a non-seasonal MA or AR term in the model with maximum p =

Table 1. ARIMA model parameters

		Estimate	SE	t	Sig.
Constant		.00	.002	.110	.913
AR	**Lag 1**	.275	.063	4.370	.000
Difference		1			
AR Seasonal	**Lag 1**	-.172	.079	-2.187	.030
Seasonal Diff		1			
MA Seasonal	**Lag 1**	.856	.066	12.918	.000

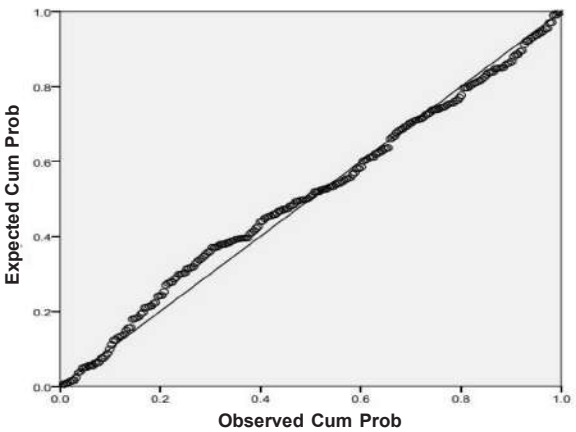


Fig. 10. ACF plot of residuals for ARIMA (1,1,0) (1,1,1) [12] model

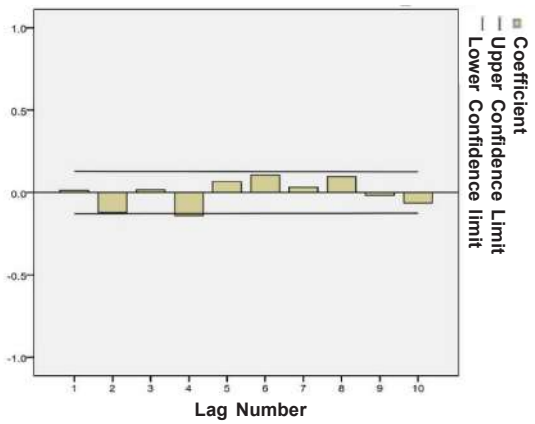


Fig. 11. Probability plot of residuals

Table 2. Forecasted values

S.No.	Month & Year	Forecast	95% of Significance Level	
			Lower	Upper
1	Jan 2022	1017.14	824.45	1241.39
2	Feb 2022	1001.05	708.47	1374.96
3	Mar 2022	962.07	610.04	1446.16
4	Apr 2022	1043.21	602.56	1686.94
5	May 2022	980.79	521.76	1687.13
6	Jun 2022	988.74	488.23	1795.21
7	Jul 2022	1050.38	484.21	2001.38
8	Aug 2022	1110.52	480.05	2210.68
9	Sep 2022	1132.70	460.79	2347.33
10	Oct 2022	1053.75	404.62	2266.61
11	Nov 2022	1087.45	395.10	2421.87
12	Dec 2022	1160.10	399.68	2669.36

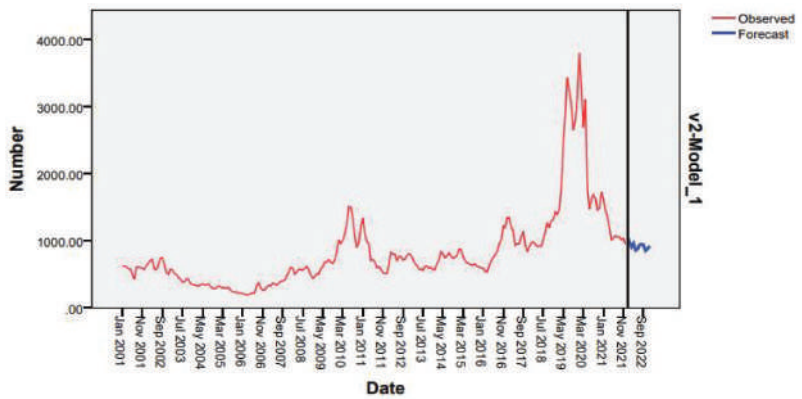


Fig. 13. Time Series plot of cardamom with forecasted values

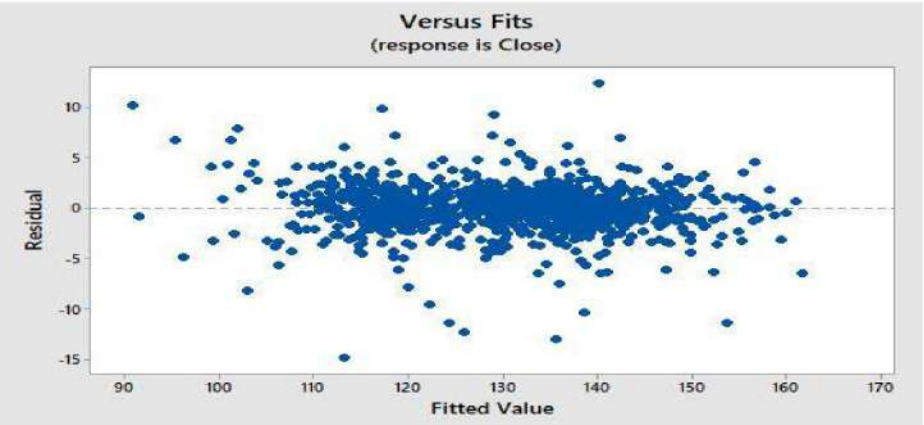


Fig. 13. Residual plot

1 or maximum q = 1. In order to choose the best model, the normalized Bayesian Information Criterion (BIC) was utilized. Out of a class of appropriate models the best model is the one with the smallest BIC statistic.

According to minimum Bayesian Information Criterion ARIMA (1,1,0) (1,1,1) [12] model has been chosen as the most appropriate one. The estimates of the parameters for the model are given in Table 1. The model is given by:

$$(1+.172B^{12})\ (1-.275B)\ (1-B12)^{12}$$

$$(1-B)lnXt-(1-856B^{12})Zt$$

where X_t is the monthly cardamom price during time period t. The residuals were examined in order to check adequacy of the model. A statistically adequate model is the one whose random shock sare statistically independent. The estimated residuals were used to test the hypothesis that the random shocks of the model were independent by constructing residual ACF.

An examination of the residual ACF showed that the residual autocorrelation at any lag was not significant and it was concluded that the random shocks are independent. In order to check the normality assumptions of random shocks, normal probability plot of the residuals was drawn.

From the probability plot of the residuals it was concluded that the random shocks follow normality assumption.The assumptions that random shocks have zero mean and constant

variance were checked using residual plot which is the scatter plot of residuals against the fitted values.

Since the residuals vary randomly around zero and spread of residuals is almost same through out except at few outlier points, it could be concluded that the random shocks have zero mean and constant variance.

The diagnostic checking revealed that the fitted ARIMA (1,1,0) (1,1,1) [12] model is statistically adequate. The estimated seasonal and non-seasonal AR coefficients were statistically significant. It is concluded that the SARIMA model developed can be efficiently used to forecast the future price of cardamom. The forecast values of the monthly cardamom price during January 2022 to Dec 2022 is given in the Table 2. The graphical representation of the original monthly cardamom price and these forecasted values are given in Fig. 13.

CONCLUSIONS

The Seasonal Autoregressive Integrated Moving Average time series model was used to forecast the monthly cardamom prices in India. The study indicated that SARIMA models are capable of predicting the future trend and seasonality of the price series. The SARIMA model, ARIMA (1,1,0)(1,1,1) [12] was found to be the best model for forecasting the monthly cardamom prices according to the minimal Bayesian Information Criterion.

REFERENCES

Harini,B.,Mohanamani and Rajini,S.2018.Price forecasting of cardamom (large) using ARIMA model. International Journal of Pure and Applied Mathematics.119 (17):2537-2546.

Dwivedi, N. 2017. Application of SARIMA model in cardamom (large) price forecast in Gangtok market. International Journal of Management and Applied Science. 3 (6):13-19.

Golbon, R., Ogutu, J.O., Cotter, M and Sauerborn, J.2015. Rubber yield prediction by meteorological conditions using mixed models and multi-model inference techniques. International Journal of Biometeorology. 59:1747-1759.

Martin, P.J and Riley, J. 1989. Indirect method for estimating clove tree yields. Tropical Agriculture. 66(4):361-364.

Prakash,P., Jaganathan, D., Immanuel, S., Lama, A., Sreekumar, J and Sivakumar, P.S. 2022. Fore casting of sweet potato (*Ipomoea batatas L.*) prices in India. Indian Journal of Extension Education. 58(2):15-20.

Priya, P.M., Radhakrishnan, V.V., Madhusoodanan, K.J and Kuruvilla, K.M. 2003. Yield fore casting in cardamom (*Elettaria cardamomum* M.) plantations under intensive management. Journal of Spices and Aromatic Crops. 12 (1): 55-56.

Priya,P.M., Kuruvilla,K.M., Madhusoodanan, K.J and Thomas, J. 2006. Autoregressive model for forecasting cardamom price. Journal of Plantation Crops. 34(3):679-680.

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RELATIONSHIP ANALYSIS BETWEEN MARKETING BEHAVIOUR AND PROFILE OF VEGETABLE GROWERS OF RANGA REDDY DISTRICT

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ABSTRACT

Ranga Reddy district of Telangana state tops in area and production of vegetables and was selected to study the marketing behaviour in year 2021. The profile variables were finalized after the judge's opinion with the dependent variable was drafted as the interview schedule to collect responses from 150 farmers. The results displayed half of the respondents were middle-aged, mostly (30.67%) with high school education taking up only agriculture (50.67%) as the occupation. The respondents (68.67%) were having medium experience in vegetable production with 84.67 per cent of them allocated a medium share of their land for vegetable production. A lion's share (90.00%) of respondents had a medium annual income and no one recorded a low annual income. Respondents had only a medium to low marketing behaviour of vegetable growers that can be improved by increasing education, the area under vegetable production, market orientation, market intelligence, information-seeking behaviour, and decision-making ability of respondents that had a significant positive relationship with the marketing behaviour of vegetable growers at a 1% level of significance. The variables market orientation (0.378) and market intelligence (0.331) had positive direct impact, whereas experience in vegetable farming (-0.251) had negative direct effect. Information-seeking behaviour (0.332), decision-making ability (0.290) and area under vegetable production (0.288) were the top three variables causing a higher indirect effect on dependent variable. Now, these findings will help in further development of marketing behaviour.

Key Wards: Correlation, Marketing behaviour, Path analysis, Profile, Vegetable growers.

INTRODUCTION

The diverse climatic conditions of India favor the growth of 40 kinds of vegetables of families: Solanaceae, Cucurbitaceae, Fabaceae, Umbelliferae, etc. Shorter duration, and higher productivity that fetches good economic returns, encourage small and large farmers to take up vegetable production extensively. These factors made India the second-largest producer of vegetables,

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following China with an area of 10.3 Million hectares producing 1,89,464 '000 MT (GOI, 2020). Even with an annual increase in the production of vegetables, the inefficiencies of the supply chain, menace of intermediaries, inadequate infrastructure, and lack of transport facilities and processing units leading to post-harvest losses, a rise in price paid by the consumer, yet farmers' share in consumer price is low.

Behaviour is said to be individuals' actions or reactions to the external environment. In this study, marketing behaviour was operationally defined as the practices/ actions related to the marketing aspect of the respondents. Activities such as acquiring information about markets, making decisions regarding crop cultivation, time and place of sale, grading, storage, transport, and evaluation were included. Improvement in marketing behaviour will have a direct increase in farmers' income (Aku *et al*., 2018) creating scope for diversifying farms, availing credit, and participating in post-harvest activities and exports. A study by Regasa Megerssa *et al.* (2020) emphasized that variables like age, education, distance from the market, labour availability, and access to market information had a significant effect on the market participation of Ethiopian smallholder vegetable growers. Another study by Amao and Egbetokun (2017) in Nigeria conveyed that gender, years of experience in leafy vegetable production, being involved in group marketing, land ownership, and farm size all determined the market participation among leafy vegetable farmers. A relationship analysis provides a deeper understanding of the chosen variables and varies across the areas. In this context, the objectives of this study were (1) To understand the profile of vegetable growers of the study area, (2) To elucidate their marketing behaviour with regard to vegetables, and (3) To ascertain the relationship of marketing behaviour with the profile of respondents.The results obtained will help in taking up necessary actions for further upscalement of activities.

MATERIALS AND METHODS

This study was conducted in 2021, in Ranga Reddy district of Telangana, a peri-urban area that stands first in possessing area under vegetables and production (Rythu Samagra Samachara Sekara, RSSS data). Three blocks were selected and from each block three villages were selected considering their area under vegetable production. A total of 150 respondents were selected proportionately from each village and were approached by using simple random sampling. Reviewing the literature, consulting with the advisory committee, and speaking with agriculture extension personnel helped to identify the independent variables that may influence the marketing behaviour of vegetable growers. A list of 37 variables in a three-point continuum followed a scoring procedure of "3" for the 'most relevant', a score of "2" and "1" for the 'relevant' and 'least relevant', respectively were given. Google forms were also used to contact a few more experts. With the obtained total scores for each variable, mean and standard deviation were determined further to calculate the Coefficient of Variation (CV).

$$CV = \frac{\text{Standard Deviation}}{\text{Mean}(\mu)} \times 100$$

A total of 15 independent variables were selected. The criteria for selection were the variable with an individual mean greater than the overall mean of the variables and coefficient of variation (CV) of a particular variable less than the overall CV. To measure the marketing behaviour of vegetable growers the scale developed by Nirban (2004) and adopted by Sapate (2018), was taken with certain modifications. The responses from vegetable farmers were collected with a 3-point continuum scale - 'Always,' 'Sometimes,' 'Never' with a numerical score of 2, 1 and 0, respectively thereby the maximum and minimum obtainable scores would be 124 and 0. The total score is calculated and divided into three categories using mean and standard deviation. A structured pre-tested interview schedule was prepared and the responses were collected accordingly with survey period that lasted for two months. For descriptive analysis and Pearson's correlation IBM SPSS version- 22 was used and R software for interpreting path analysis after performing Principal Component Analysis (PCA) mainly for variable reduction.

RESULTS AND DISCUSSION

Profile analysis: On analysing the profile of vegetable growers, results indicated that half of the respondents were middle-aged results in line with Naqvi *et al.* (2020), mostly (30.67%) with high school education taking up agriculture (50.67%) as the only occupation followed by agriculture plus animal husbandry (34.66%). Respondents involved in business activities such as real estate, milk collection centers, and transportation trucks along agriculture were 8.67 percent. Also, 4.00 per cent of them engaged themselves in the service sector *viz.,* postal and teaching. It could be inferred that middle and young-aged farmers still believe that vegetable cultivation is a quick and continuous source of income and wish to continue their cultivation. It highlights the scope for enhancing vegetable production in the study area. Basic education facilities such as secondary and high school education accessible to the respondents nearby depicted a significant education level. The unavailability of labour for the maintenance of livestock might have restricted the vegetable growers primarily to agriculture.

Among the respondents, 46.70 percent of vegetable growers were small-medium farmers having land of 5-10 acres, 68.67% were having medium experience in vegetable production (on par Uddhavarao, 2017) with 84.67 percent of them allocated a medium share of their land for vegetable production.Vegetables (carrots, beetroot, and tomato) were grown as a secondary crop along with the staple crops (6 months) such as rice, cotton and maize which occupy the major share of their land in the study area. The subsistence orientation towards farming associated with a labour shortage and transport problems in the cultivation of the vegetables might be discouraging to increase further acreage in vegetables. The property distributions might be one of the causes for such small and marginal landholdings. As the study area is closer to the city, where demand for vegetables persists throughout the year to a larger extent, fetching continuous income conditioned the farmers to take up vegetable cultivation. This could have contributed to the results where the

majority of vegetable growers had medium experience in vegetable farming.

A lion's share (90.00%) of the respondents had a medium annual income and no one recorded a low annual income, which could be because of the subsistence income created by vegetable production. It could also be noted that a higher value of standard deviation depicts the maximum variance of annual income received by the respondents in the study. Due notice to the point that vegetable growers had restricted income sources, as half of the respondents practiced only agriculture and only one-third of them diversified the farm with livestock. In addition to these small-medium landholdings, medium area under vegetable production as reported in the study might have contributed to the lower income of the vegetable farmers.

A medium level of market orientation (62.66%) (Kiran, 2018) and market intelligence (62.00%) were majorly observed. During the conversations, it was noted that while the respondents were aware of seasonal price differences, they did not monitor daily trends or adjust their sales. Because of the perishability of vegetables and the lack of storage facilities, they were forced to sell them right away, without monitoring the market trends.

About two-thirds of the respondents had a medium range of information-seeking behaviour and displayed moderate decision-making ability. An in-depth analysis of the information acquiring situation during the discussion with respondents showed that vegetable growers rely mostly on personal localities to collect information regarding crops they grow, pest management, and prevailing market prices. Private sources were approached for seeds purchase, pests, and disease management. It is significant to note that there existed poor to no contact between vegetable growers and institution sources (AO, AEO, etc.). Respondents mainly opted for vegetable cultivation to have continuous income throughout the year. Taking up vegetables clearly indicates the existence of economic motivation (66.67% with a medium level) among respondents. It could be noticed that 86.00 percentage of the vegetable growers had medium credit orientation and rest, (14.00%) were in the lower category. It is interesting to note that no vegetable grower had a higher credit orientation which could be due to their reasonable annual income. As income is highly volatile, vegetable growers were hesitant to avail themselves of credit. Infrastructure facilities were opted as good by 67.33 percent of the respondents and the facilities at the market were at medium (48.00%) level. The proximity of study areas with the city could be a potential rationale for the observed majority in good and better infrastructure facilities. The villages which are farther experienced a dearth of infrastructure availability accounted for poor infrastructure. All the markets accessed by the respondents provided basic amenities, which contributed to above results. However, the cooperation from market functionaries and the credibility of their performance is subjective, which caused vagaries in the response recorded.

Overall marketing behaviour

Marketing behaviour, in general, is defined as various activities performed from

Table 1. Profile of the respondents

(n=150)

S. No.	Profile	Category	Frequency	Percentage
1	Age	Young (Up to 35 years)	56	37.33
		Middle (36 to 55 years)	77	51.33
		Old (Above 55 years)	17	11.34
2.	Education	Illiterate	22	14.60
		Can read-only	02	1.30
		Can read and sign only	13	8.66
		Primary School	15	10.00
		High School	46	30.67
		Secondary School	28	18.67
		Graduate	20	13.33
		Postgraduate and above	04	2.77
3.	Occupation	Agriculture	76	50.67
		Agriculture + Labour work	02	1.33
		Agriculture + Animal Husbandry	52	34.66
		Agriculture + Labour work+ Animal Husbandry	01	0.67
		Agriculture + Service	06	4.00
		Agriculture + Business.	13	8.67
4.	Land Holding	Marginal (<2.5 acres)	15	10.00
		Small (2.5- 5 acres)	38	25.30
		Small- Medium (5-10 acres)	70	46.70
		Medium (10- 25 acres)	24	16.00
		Large (> 25 acres)	03	2.00
5.	Area under vegetable production (Mean =2.96 S.D =2.16)	Small (<0.790)	05	3.33
		Medium (0.79-5.12)	127	84.67
		Large (>5.12)	18	12.00
6.	Experience in vegetable farming Mean=18.88 S.D = 11.15	Low experience (<7.72)	29	19.33
		Medium experience (7.72 -30.03)	103	68.67
		High experience (>30.03)	18	12.00

Table 1 Contd...

Table 1 Contd..

S. No.	Profile	Category	Frequency	Percentage
7.	Annual Income	Low (<9,013.58)	00	00.00
	Mean = 2,86,223.96	Medium (9013.58-5,63,434.35)	135	90.00
	S.D = 2,77,210.38	High (>5,63,434.35)	15	10.00
8	Market orientation	Low (<3.76)	19	12.67
	Mean = 5.22	Medium (3.76-6.68)	94	62.66
	S.D = 1.46	High (>6.68)	37	24.67
9	Market intelligence	Low (<6.43)	30	20.00
	Mean = 9.11	Medium (6.43 -11.79)	93	62.00
	S.D = 2.67	High (>11.79)	27	18.00
10	Information seeking	Low (>10.57)	23	15.33
	behaviour	Medium (10.57-22.64)	102	68.00
	Mean = 16.60	High (>22.64)	25	16.67
	S.D = 6.03			
11	Decision-making ability	Low (<17.99)	20	13.33
	Mean = 21.84	Medium (17.99 - 25.68)	101	67.33
	S.D = 3.84	High (> 25.68)	29	19.34
12	Economic motivation	Low (<23.34)	23	15.33
	Mean = 27.55	Medium (23.34 - 31.76)	100	66.67
	S.D = 4.21	High (>31.76)	27	18.00
13	Credit orientation	Low (<2.66)	21	14.00
	Mean = 4.38	Medium (2.66-6.09)	129	86.00
	S.D = 1.71	High (>6.09)	00	0.00
14	Infrastructure facilities	Poor facilities (<19.6)	25	16.67
	Mean = 24.38	Good facilities (19.6-28.9)	101	67.33
	S.D = 4.76	Better facilities (>28.9)	24	16.00
15	Market facilities	Low (<13.78)	50	33.33
	Mean = 15.83	Medium (13.78-17.88)	72	48.00
	S.D = 2.04	High (>17.88)	28	18.67

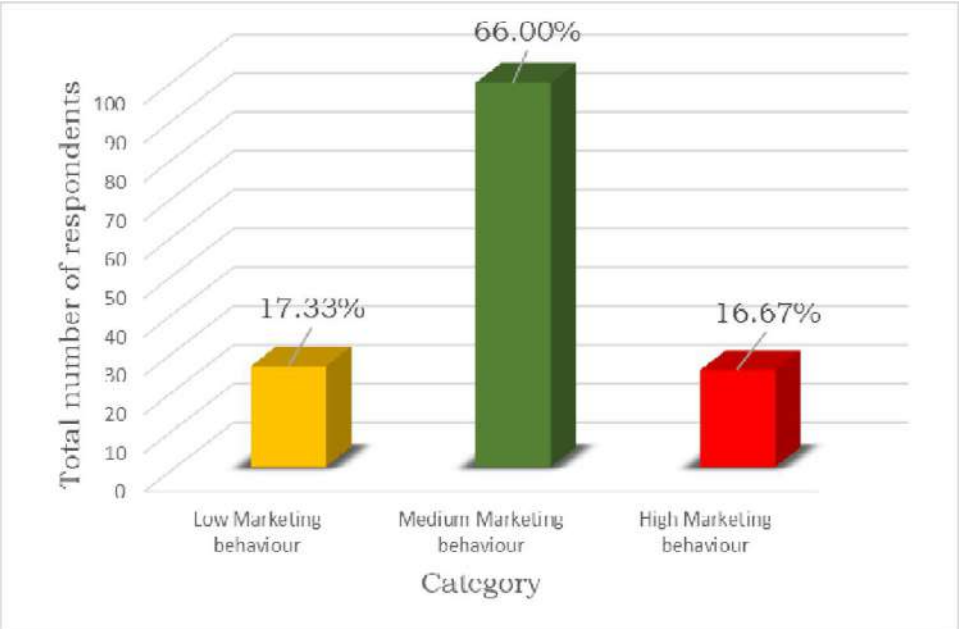

Figure 1. Distribution of vegetable growers according to their marketing behaviour (n = 150)

the time of harvest to the sale of the produce that dealt only with the implementation aspect. To understand the market inclination of the vegetable growers in detail, marketing behaviour was taken up as one of the dependent variables and was studied in four components v*iz*., planning, decision-making, implementation and review. The results obtained from the study can be viewed in Figure 1.

From above Figure 1, it could be depicted that two-thirds (66.00%) of vegetable growers in the study area had a medium marketing behaviour. About 17.33 percent of them were in a low category and 16.67 percent were found in the category of high marketing behaviour. The results found are inline with Chengappa(2017) and Sapate (2018) who studied marketing behaviour of coffee growers and pomegranate growers, respectively.

Interpretations that can be made from the study were vegetable growers focused only on the implementation aspect of the market whereas had lesser involvement and attention in planning, decision-making and reviewing aspects of their marketing behaviour. In the implementation aspect, regulated markets that are within the district were preferred and produce majorly sold through commission agents soon after harvest. Post-harvest practices – cleaning and grading were non-standardised, and storage and processing were not practiced.

Correlation between the independent variables and the marketing behaviour of the respondents

After understanding the marketing behaviour of the vegetable growers, an attempt was made to understand the relationship between the independent variable with

Table 2. The relationship between the independent variables and the marketing behaviour of vegetable growers

(n = 150)

S. No.	Independent Variables	Correlation Value (r)
1	Age	-0.026
2	Education	0.390**
3	Occupation	-0.132
4	Landholding	0.162*
5	Area under vegetable production	0.353**
6	Experience in vegetable farming	-0.98
7	Annual income	0.129
8	Market orientation	0.587**
9	Market intelligence	0.563**
10	Information seeking behaviour	0.432**
11	Decision-making ability	0.283**
12	Economic motivation	0.163*
13	Credit orientation	0.167*
14	Infrastructure facilities	-0.165*
15	Market facilities	-0.038

** Correlation is significant at 0.01 level (2- tailed); * Correlation is significant at 0.05 level (2-tailed)

marketing behaviour was analysed and tabulated in Table 2.

From Table 2, it could be observed that 10 variables significantly contributed to the respondent's market behaviour formation. The variables *viz.,* education (0.390), the area under vegetable production (0.353), market orientation (0.587) in line with Kiran (2018), market intelligence (0.563), information-seeking behaviour (0.432), and decision-making ability (0.283) had a significant positive relationship with the dependent variable at 0.01 level of significance. It means with the confidence level of 99 per cent the increase above variables could improve the marketing behaviour of vegetable growers.

The other variables *viz.,* landholding (0.162), economic motivation (0.163), and credit orientation (0.167), had a noteworthy positive relationship at a 5 per cent level of probability whereas studies of Nirban (2004), Uddhavarao (2017) showed 99 percent confidence level with the marketing behaviour of vegetable growers. The only variable that was negatively significant at the 5 per cent level was infrastructure facilities (-0.165).

Improved education could enlarge scope of information sources accessed and may incline respondents towards the market, improving their market orientation and intelligence. It would also contribute to better decisiveness about marketing activities, which in turn form behaviour. The increased landholding will allow individuals to allocate more area for vegetables. It would motivate vegetable farmers to take up credit, explore new markets (inter-state trade, exports) and improve their economic situation.

It is a general tendency to find that increased infrastructure facilities could contribute to better marketing behaviour. On the contrary, a negative relationship was found. It could be hypothesized that even with the existence of medium to better facilities, respondents could not justify it by practicing inter-state marketing and usage of public transport. Their routine marketing activities even when supplied with adequate infrastructure could be a possible reason for such a relationship that necessitates the need to improve effectiveness of infrastructure to contribute to marketing behaviour positively.

Path analysis

Path analysis, which is similar to multiple regression, was used to better understand the direct and indirect effects of independent variables on vegetable growers' marketing behaviour. There are 15 independent variables in this study, and the degree of variation induced by each variable varies. Therefore Principal Component Analysis (PCA) was done for variable reduction, as executed by Cebeci and Hanci (2019). On executing PCA, six components (PC1-PC6) having the eigenvalue >1 contributed to the cumulative percentage of the variance of 68.819 per cent. Of the above six components, the first three components itself had a percentage of variation of gretaer than 10 (20.01%, 14.49%, and 11.06%) and nearly 50% variation. Therefore, only three components were selected. From each principal component, variables that weigh greater than |0.35| were selected.

Direct effect - The variables market orientation (X8) had 0.378 as direct coefficient. The variable market intelligence (X9, 0.331) had positive direct impact, whereas, experience in vegetable farming (X6, -0.251) had negative direct effect. These were the top three variables that had a direct impact on marketing behaviour of the respondents.

Indirect effect- Information-seeking behaviour (X10, 0.332) on par with Effendy*et al*. (2020), decision-making ability (X11, 0.290) and area under vegetable production (X3, 0.288) were the top three variables causing a higher indirect effect on dependent variable, *i.e.,* marketing behaviour of vegetable growers.

Path coefficient analysis could be used as a tool to select variables that contribute to maximum variation. Thus, variables highlighted by it need to be prioritized to enhance marketing behaviour further. The path analysis had residual effect (unexplained variation) of 0.676. Therefore, gives scope to include other extraneous variables in the study.

CONCLUSIONS

The main purpose of growing vegetables by most small and marginal farmers is to avail a year-round income. The short-

Table 3. Depiction of components, percentage of variance and variables selected from each component

S. No.	Components	Percentage of variance	Selected independent variables
1	PC- 1	20.01	X2, X5, X8, X9, X11
2	PC - 2	14.49	X1, X6
3	PC - 3	11.06	X7, X10, X12, X14

These variables were used to execute path analysis and following path coefficients were observed.

Table 4. Depicting direct and indirect coefficients of the variables

S. No.	Variables selected after PCA	Direct effect	Indirect effect	Total effect
1	Age (X1)	0.239	-0.264	-0.025
2	Education (X2)	0.102	0.286	0.388
3	Area under vegetable production (X5)	0.064	**0.288**	0.352
4	Experience in vegetable farming (X6)	**-0.251**	0.155	-0.096
5	Annual income (X7)	-0.040	0.168	0.128
6	Market orientation (X8)	**0.378**	0.208	0.586
7	Market intelligence (X9)	**0.331**	0.231	0.562
8	Information seeking behaviour (X10)	0.100	**0.332**	0.432
9	Decision-making ability (X11)	-0.008	**0.290**	0.282
10	Economic motivation (X12)	0.108	0.054	0.162
11	Infrastructure facilities (X14)	0.006	-0.170	-0.164
	R2		0.541	
	Residual effect		0.676	

duration nature of it makes it take up multiple times on the same piece of land. In Focus Group Discussions (FGDs), it was confirmed that the market price received by respondents was low raising questions about their marketing behaviour. The medium to low marketing behaviour of vegetable growers observed in the study area can be improved by increasing education, the area under vegetable production, market orientation, market intelligence, information-seeking behaviour, and decision-making ability as conveyed by correlation analysis. Path coefficients that have a higher indirect effect (Information seeking behaviour, decision-making ability, and area under vegetable production) act as a special insight in improving marketing behaviour.

REFERENCES

Aku, A., Mshenga, P.,Afari-Sefa, V and Ochieng, J. 2018. Effect of market access provided by farmer organizations on smallholder vegetable farmers income in Tanzania. Cogent Food & Agriculture. 4(1). https://doi.org/10.1080/23311932.2018.1560596.

Amao, I. O and Egbetokun, O. A. 2017. Market participation among vegetable farmers. International Journal of Vegetable Science. 24(1):3–9. https://doi.org/10.1080/19315260.2017.1346030.

Cebeci, Esra and FatihHanci. 2019. A simple approach to bolting tendency in purple carrot: Correlation and path analysis between some morphological and biochemical traits. International Journal of Advance Research in Biological Science. 6 (2): 38-45.

Chengappa.K.K. 2017. Marketing behaviour of coffee growers in Kodagu District of Karnataka. M.Sc.Thesis submitted to MPKV, Rahuri, Maharashtra.

Effendy, L., Pradiana, W., Si, M., Aria, J and Bogor, S.C. 2020. Farmer behavior transformation on Tomato farming business in Mega MendungSubdistrict Bogor, West Java. Scientific Research Journal (SCIRJ), *8*(8), 112. https://doi.org/10.31364/SCIRJ/v8.i8.2020.P0820799.

Government of India. 2021. Pocket book of Agriculture Statistics, 2020. Delhi Government of Telangana. 2019. Area under vegetables RSSS data 2018-19 (Ranga Reddy district). Rythu Samagra Samachara Sekara (RSSS). Telangana, India.

Kiran Patil Sagar. 2018. Marketing behaviour of chilli growers in Kolhapur district. M.Sc.Thesis submitted to MPKV, Rahuri.

Naqvi, S. M. H., B. N. Siddiqui, W. U. H. Tareen, M. A. Q. Naqvi, and N. Hussain. 2020. Usage of mobile phone by vegetable growers and its impact on vegetable production. Sarhad Journal of Agriculture.36 (3): 900-905.

Nirban, Ashok Kumar Jai Kisan. 2004. Analysis of Agriculture Produce market committees in Konkan and West Maharashtra with reference to their potential role in Agriculture Marketing Extension. Ph.D. Thesis, submitted to MPKV, Rahuri, Maharastra.

Regasa Megerssa, G., Negash, R., Bekele, A. E and Nemera, D. B. 2020. Smallholder market participation and its associated factors: Evidence from Ethiopian vegetable producers. Cogent Food & Agriculture. 6(1). https://doi.org/10.1080/23311932.2020.1783173.

Sapate, A.U. 2018. Marketing behaviour of pomegranate growers. M.Sc. Thesis submitted to MPKV, Rahuri, Maharashtra.

Uddhavarao Devede Pradip. 2017. Marketing behaviour of vegetable growers. M.Sc. Thesis submitted to VNMKV, Parbani.

Anusha, V. V. S. S and Padma, S. R. 2023. Relationship analysis of marketing behaviour and profile of vegetable growers of Ranga Reddy district. The Journal of Research ANGRAU. 50(4):125-135.

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CONSUMPTION PATTERN OF FAST FOOD AMONG WOMEN IT PROFESSIONALS

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Women in the IT industry are steadily increasing, and IT is regarded as the non-agricultural sector's second-largest employer. According to NASSCOM, the IT industry in India employs approximately 3.9 million people, 34 percent of whom are women. Also,nearly 50 percent of women in this field were unmarried and had less responsibility than married women (Raghuram *et al*., 2017). Trivandrum Corporation was selected for the study because it was India's first and most significant IT destination. The largest technology park in India, Technopark, plus a few chosen government offices, made up this study's sample. The study decided on 500 female professionals with two or more years of experience, and it was conducted from 2014-2015. The fifth office out of all the offices was randomly selected by systematic sampling method. Information gathered on food consumption practices to gain a deeper understanding of the fast food consumption pattern of food items. The consumption choices were assessed using a three-point scale with scores of 3, 2, and 1, respectively, with a maximum score of 66. Each respondent's total scores were computed and were divided into the low, moderate and high intake.

The findings showed that 58.8 percent of the respondents in the private sector had age below 30, while 60 percent in the government sector were between the ages of 30 and 40. The monthly family income showed that 44.4 percent of the respondents from the private sector had income from Rs.50000 to Rs.1,00,000, whereas, 71.6 percent of the respondents from the government sector had income upto Rs.50000/-. The data on the working hours of respondents revealed that respondents preferred nine or more than nine hours for official work by 32 and 5.2 percent of the total respondents, which comprised only women who worked in the private sector. In contrast, most women in the government sector limited their working hours to seven.

In this study, the primary family expenditure was food, and the data revealed that amounts between Rs.3001 and Rs.5000 were spent for food by 53.70 percent of the respondents from the government sector and between Rs.8001 to Rs.10000 were spent by 63.40 percent from the private sector. There was an association between expenditure on food and the employment sector (Chi-square = 18.452a, df = 5, p = 0.002) at 1 percent level. The reason could be that individuals from the private sector favoured eating out because they had less spare time at home, which was shown in the raise in their food spending habits.

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The data regarding the type of food consumed showed that 86.4 percent of the respondents chose non-vegetarian food. When considering the money spent on dining out, 81.2 percent of the respondents from the government sector spent below Rs. 1000 per month, while 38 percent of respondents from the private sector spent between Rs. 1001 and Rs. 2000. It was clear from the above data that respondents from the private sector spent more money dining out than those from the government sector. The information also revealed that 26.8 percent of the respondents from the government sector and 38.4 percent from the private sector preferred fast food. It was summed up that homemade food was mostly preferred by respondents in the government sector, whereas, hotels, fast food, and ready-to-eat food were preferred more by respondents in the private sector.

As part of the growing influence of the west, dining out had differed due to changes in income, demographic profiles and the increasing power of the west. In this study, the frequency of dining out data showed that 93.2 percent of the respondents from the private sector sometimes ate from outside, whereas 5.6 percent of the respondents always chose to eat out. Based on the distribution, the frequency of dining out and employment sector were tested for independence and were found to be dependent (chi-square value = 31.452a, df = 3, p-value = 0.000). The frequency of dining out among private sector respondents may be explained by the fact that it was primarily due to time constraints and busy work schedules. The reasons given were similar to the study by Latif *et al*. (2015) that busy professionals must rely on dining out due to increased involvement in professional lives.

The reason for choosing outside food revealed that 72.8 percent of the government and 64.7 percent of the private sector preferred dining out for a change. Even though most of the respondents ate outside for a change, respondents from the private sector preferred dining out due to their busy schedules, lack of cooking time, and craving for hotel foods. A study by Goon *et al*. (2014) specifies that fast food is chosen as it is quick and convenient. Srividhya (2014) listed various reasons, such as the inability to cook meals at home, the need to unwind after a stressful day at work, the desire to spend time with family, and many others.

For further examination, fast food or low-nutritional-value food items were classified as deep-fried foods, savoury snacks, battered and dough-based foods, confectionery,

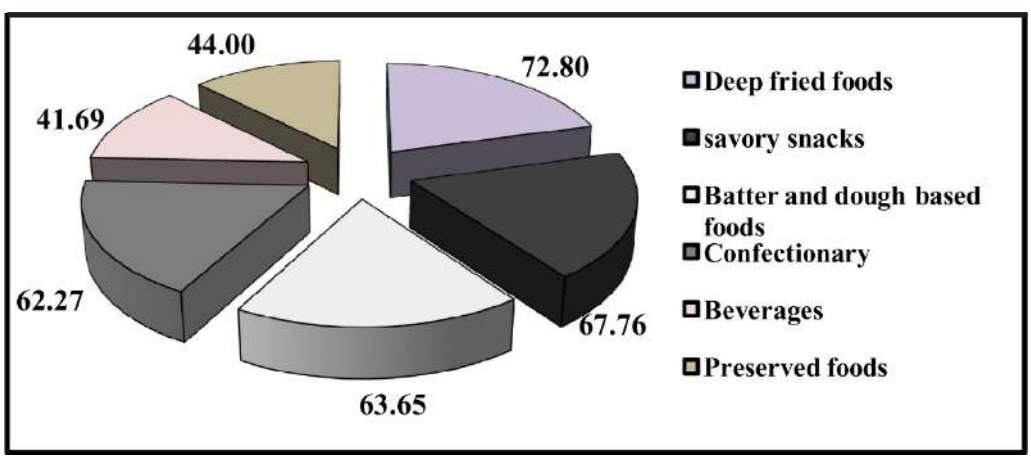

Fig.1. Fast food consumption (n=500) (Multiple-responses)

beverages and preserved foods. The data pointed out that a majority of 72.8 percent of the respondents consumed deep-fried foods, and 67.76 percent consumed savoury snacks. It also specified that 63.65 percent of the respondents had batter and dough-based foods, and 62.27 percent chose confectionary from fast food centres (Fig. 1). The study also showed that bread-type foods, which included pizza, paratha, etc. were consumed by a maximum of 93.8 percent of the respondents, and rice dishes like fried rice, mixed rice, etc. were taken by 93 percent of the respondents. Another highly consumed item from outside was hot beverages such as tea, coffee, etc., by 92.2 percent of the respondents, and the least consumed was refreshing triples, carbonated drinks etc. The study by Zyl *et al*. (2010) showed that the most popular fast foods consumed by the respondents were burgers (69.5 percent) and pizza (56.6 percent), and it was also similar to this study findings that the most consumed food was bread-type foods.

According to the consumption pattern of fast food, the data showed that 55.2 percent of respondents moderately consumed fast food, with 63.2 percent from the government sector and 47.2 percent from the private sector. High consumption was shown among 32.8 percent of the respondents from the government sector and 52.4 percent from the private sector. Based on the distribution, according to consumption of fast food and employment sector, the two attributes were tested for independence and found to be dependent (Chi-square value = 24.433a, df = 2, p =.000) and was significant at 1 percent level.

The data also revealed that 62.6 percent of the respondents with family income below Rs.50000/- consumed fast food moderately, whereas 50.3 percent of the respondents with family income between Rs. 50000/- and Rs.1 lakh and 55.6 percent of the respondents with family income between Rs.1 lakh and Rs. 2 lakh had high consumption. Fifty-seven percent of the respondents with family income above Rs. 2 lakh showed moderate consumption. The two attributes tested for independence according to fast food consumption and family income, and the value was significant at the 5 percent level. This study's findings contradicted the findings of Haward (2018), who discovered that

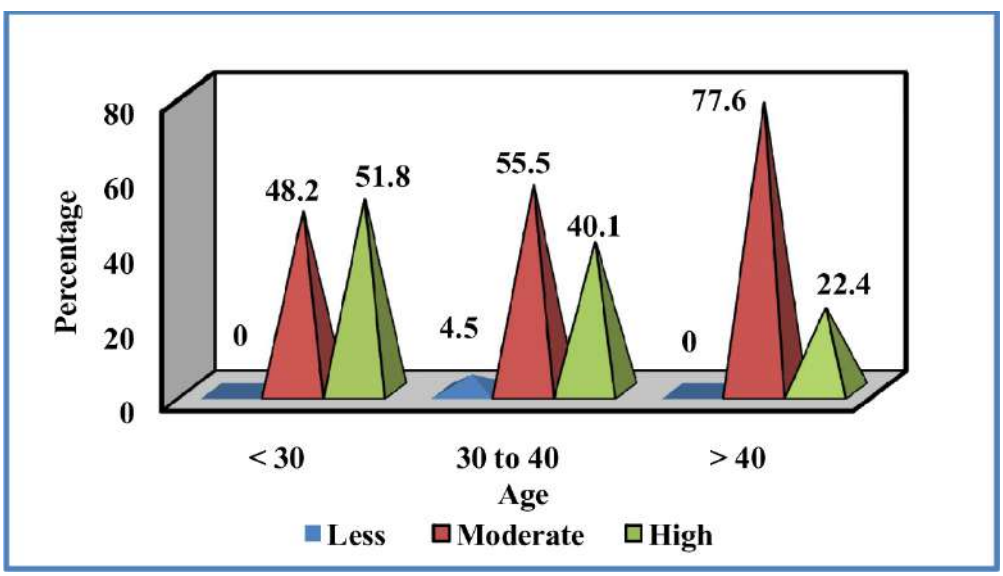

Fig. 2. Consumption of fast food and age

fast food consumption increases with family income level.

The data also showed that 51.8 percent of the respondents from the age group less than 30 years highly consumed fast food, whereas, 55.5 percent and 77.6 percent of the respondents in the age groups 30 to 40 and greater than 40 years moderately had it (Fig. 2). The distribution of respondents according to age and consumption of fast food was tested for independence and found to be (chi-square value = 28.050a, df = 4, p = 0.000) significant at the 1 percent level.

Regarding working hours and fast food consumption, 62.8 percent of the respondents who spent seven hours consumed fast food moderately. In contrast, respondents who spent nine or more working hours had high fast food consumption. The two attributes were tested for independence and were found to be significant (chi-square value = 25.578a, df = 6, p = 0.000) at the 1 percent level. Zyl *et al.* (2010) found that most women who were always concerned about health less frequently purchased fast food, as they worried about obesity, followed by heart disease and cancer.As a result of the hectic schedules, many of the respondentsoften consume-dunhealthy junk food, such as fast food, comfort food, or food eaten at any time of the day. Most respondents in both economic sectors dined out occasionally, with those spending between Rs. 1000 and Rs. 2000 each. The Chi-square test revealed a significant association between how often people dine out and their occupation, with a value of 31.452a. More than 90 percent of the respondents also reported regularly consuming foods, including varieties of bread, rice meals, and hot drinks. Younger respondents from the private sector ate more fast food than older ones, which was significant at 1 percent.

REFERENCES

Goon, S., Bipasha, M. S and Islam, M. D. 2014. Fast food consumption and obesity risk among university students of Bangladesh. European Journal of Preventive Medicine. 2 (6): 99-104.

Howard, J. 2018. Here's how much fast food Americans are eating. Retrieved from the website (https://edition.cnn.com/2018/10/03/health/fast-food-consumption-cdc-study/index.html) on 20.09.2022.

Latif, A., Yeasmin, S., Islam, M and Jony, A. H. 2015.Habit of eating out by professionals of Bangladesh: A way to save time and efforts for more productive works. International Journal of Advances in Management and Economics. 4 (6): 106-113.

Srividhya, N. 2014. Eating out habit of individuals- An analytical study. International Journal of Business and Management Invention. 3 (6): 38-44.

Raghuram, P., Herman, C., Ruiz Ben, Eand Sondhi, G. 2017. Women and IT score card– India. A survey of 55 firms.Spring, 2017. UK: NASSCOM.DOI:10.13140/RG.2.2.10118.98882.

Zyl, M. K., Steyn, N. Pand Marais, M. I. 2010. Characteristics and factors influencing fast food intake of young adult consumers in Johannesburg, South Africa. South African Journal of Clinical Nutrition. 23 (3): 124-130.

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