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EFFICACY OF NEW GENERATION HERBICIDES ON WEED DYNAMICS, NUTRIENT UPTAKE AND YIELD OF BLACKGRAM (*VIGNA MUNGO* L.)

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ABSTRACT

The field experiment was conducted during *rabi,* 2022-23 at Wetland Farm of S.V. Agricultural College, Tirupati, to evaluate theefficacy of new generation herbicides for weed management in blackgram with nine weed management practices in a randomized block design replicated thrice.Results revealed that among all the weed management practices at 60 DAS lower density (8.06 No.m^{-2}) and biomass (6.26 g m^{-2})of total weeds coupled with higher weed control efficiency and weed control index(74.67 & 74.50 %) was recorded withpre-emergence application of diclosulam 20 g ha^{-1} + 1 HW at 15 DAS, which was followed by PoE application of fluazifop-p-butyl + fomesafen 222 g ha^{-1}(69.32 & 69.28 %) and PoE application of sodium acifluorfen + clodinafop propargyl 245 g ha^{-1}(68.46 & 68.62 %). Higher seed yield (971 kg ha^{-1}) of blackgram was noticed with HW twice at 15 and 30 DAS, which was at par with PoE application of fluazifop-p-butyl + fomesafen 222 g ha^{-1}(957 kg ha^{-1}) and PoE application of sodium acifluorfen + clodinafop propargyl 245 g ha^{-1}(910 kg ha^{-1}).

Keywords: Blackgram, Efficacy, New generation, Pre and post-emergence herbicides.

INTRODUCTION

Blackgram (*Vigna mungo* L.) is an important short-duration pulse crop grown in many parts of India. It is a widely consumed and highly valued legume in Indian cuisine due to its taste, versatility and nutritional benefits with 26% proteins, vitamins and other minerals. It differs from other pulses due to its peculiarity in attaining mucilaginous pasty character when soaked in water. India is the world's largest producer and consumer of blackgram contributing to about 70 per cent of theworld's production. Among the different pulse crops in India, blackgram is with 19 per cent of the area and with 23 per cent of production. India produces approximately 24.5 lakh tones of blackgram per year from 4.6 million hectares of land with an average productivity of 533 kg ha^{-1}in 2021-22(www.agricoop.nic.in). Weeds grow luxuriantly and pose a serious threat to short statured crops like blackgram during early stage of crop growth and the most sensitive period is between 3 to 6 weeks after sowing. Weeds compete with the resources like nutrient, moisture and light benefits of applied inputs cannot be fully utilized unless it is

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followed by a proper weed control programme. The yield loss of black gram due to weeds has been reported to the extent of 27 to 90% depending upon type and intensity of weed flora.Manual removal of weeds is labour intensive, tedious, back breaking and does not ensure weed removal at critical stages of crop weed competition due to non-availability of labour and bad weather conditions. The viable alternative is chemical weed control and a number of post-emergence herbicides with varied modes of action, higher weed control efficiency even at a lower dose, shorter half-life and low mammalian toxicity have evolved. But single application of one herbicide is not effective against complex weed flora throughout the crop-growing season. Moreover, grasses, sedges and broadleaved weeds were not effectively controlled by the sole application of any herbicide. To overcome these ready-mix herbicides were formulated for broad-spectrum weed control. Besides this, herbicide mixtures will help to prevent the resistance problem and shift in weed population, which is always a problem associated with the use of asingle herbicide (Duary *et al*., 2016). Some of the ready-mix herbicides like fluazifop-p-butyl + fomasafen and sodium aciflourofen + clodinafop propargyl are broad spectrum in nature and effectively control grasses, sedges and broadleaved weeds (Yadav *et al.,* 2022 and Mudalagiriyappa *et al.,* 2022). Keeping this in view, the present investigation was conducted to evaluate the bio-efficacy of pre and post-emergence herbicides on weed dynamics, nutrient uptake and productivity of blackgram.

MATERIAL AND METHODS

The field experiment was conducted during *rabi* 2022-23 at wetland farm, S. V. Agricultural College, Tirupati, located at 13.5°N latitude and 79.5°E longitude with an altitude of 182.9 m above mean sea level in the Southern Agro-Climatic Zone of Andhra Pradesh, India. The soil of the experimental site was sandy loam in texture, neutral in soil reaction, low in organic carbon (0.26%) and available nitrogen (172 kg ha^{-1}), medium in available phosphorus(29 kg ha^{-1}) and potassium(193 kg ha^{-1}). The experiment was laidout in Randomized Block Design with nineweed management practices and three replications.The treatments includespre-emergence (PE) application of diclosulam 20 g ha^{-1} +1 hand weeding (HW) at 15 DAS (T_1), Post-emergence (PoE) application of imazethapyr 50 g ha^{-1} at 20 DAS (T_2), PoE application of quizalofop-p-ethyl + imazethapyr 98 g ha^{-1} at 20 DAS (T_3), PoE application of imazethapyr + imazamox 70 g ha^{-1} at 20 DAS (T_4), PoE application of propaquizafop + imazethapyr 125 g ha^{-1} at 20 DAS (T_5), PoE application of sodium acifluorfen + clodinafop propargyl 245 g ha^{-1} at 20 DAS (T_6), PoE application of fluazifop-p-butyl + fomesafen 222 g ha^{-1} at 20 DAS (T_7), Hand weeding twice at 15 and 30 DAS (T_8) and Weedy check (T_9).The pre emergence herbicide was applied on the next day after sowing and post emergence herbicides were applied at 20 DAS when the weeds are at 2-3 leaf stage. The blackgram variety TBG-104 was sown on 16.11.22, with a spacing of 30 x 10 cm. A total rainfall of 211.6 mm was received during the crop growth period in 12 rainy days.The crop was fertilized with 20 kg Nand 40 kg P_2O_5 ha^{-1} was applied in the form of ureaand single super phosphate basally at the time of sowing to all the plots. All other recommended management practices were followed to raise the crops. Weed sampling was done at random by placing a quadrant of 1 m x 1 m in each plot and the number of weed species were counted and expressed as no. m^{-2} and dry weight was attained after drying the weed samples in a

hot air oven at 65 ºC till constant dry weight was attained and expressed as g m^{-2}. In view of the larger variation in the recorded values of density and dry weight of weeds, the corresponding data were subjected to square root transformation $\left(\sqrt{x+0.5}\right)$ and the corresponding transformed values were used for statistical analysis. Five randomly selected plants were tagged in each treatment and from each replication in the net plot area and used for recording observations on growth parameters and yield attributes at harvest of blackgram.The seed and haulm yield of blackgram was recorded based on the yield obtained from the net plot. Plant samples of crops as well as weeds were collected from all the plots at harvest and both plant and weed samples were dried, ground into fine powder and used for estimation of nitrogen, phosphorus and potassium.

Weed Control Efficiency (WCE) was worked out by using the following formula

$$\text{Weed Control Efficiency} = \frac{WP_C - WP_T}{WP_C} \times 100$$

Where,

WP_C = Weed population in control (unweeded) plot.

WP_T= Weed population in treated plot.

Weed Control Index (WCI): It was calculated by the formula as given below

$$\text{Weed Control Index} = \frac{W_C - W_T}{W_C} \times 100$$

Where,

W_C = Weed dry weight in control (unweeded) plot.

W_T = Weed dry weight in treated plot.

RESULTS AND DISCUSSION

Weed floraof the experimental field

The weed flora associated with blackgram belonged to thirteen taxonomic families, of which the predominant weed species noticed were *Dactyloctenium aegyptium* and *Digitaria sanguinalis* among grasses, *Cyperus rotundus* asedge, *Boerhavia erecta, Commelina benghalensis* and *Euphorbia hirta* among the broadleaved weeds.

Weed density and dry weight

All the weed management practices significantly influenced weed density, biomass weed control efficiency and weed control index at 20 DAS and 60 DAS of blackgram (Table 1). Among the different weed management practices significantly lower density and dry weight of total weeds at 20 DAS was recorded with PE application of diclosulam 20 g ha^{-1} + 1 HW at 15 DAS (0.71No.m^{-2} & 0.71 g m^{-2}), which was comparable with HW twice at 15 and 30 DAS(0.71 No.m^{-2} & 0.71 g m^{-2}). PE application of diclosulam or HW performed at 15 DAS were found to be effective in reducing the density and dry weight of total weeds. Similar views were also endorsed by Tamang *et al.* (2015). Post emergence herbicides were not applied by the time of sampling at 20 DAS. So there is no significant difference among the remaining treatments. At 60 DAS among the different weed management practices lower density and biomass of total weeds was recorded with pre-emergence application of diclosulam 20 g ha^{-1} + 1 HW at 15 DAS (8.06 No.m^{-2} & 6.26 g m^{-2}), which was statistically comparable with HW twice at 15 and 30 DAS (8.46 No.m^{-2} & 6.56 g m^{-2}), but the later treatment was in turn atpar with PoE application of fluazifop-p-butyl + fomesafen 222 g ha^{-1}(9.35 No.m^{-2} & 6.86 g m^{-2}) and PoE application of sodium acifluorfen + clodinafop propargyl 245 g ha^{-1}(9.54 No.m^{-2} &6.98 g m^{-2}).Pre-emergence application of

diclosulam along with hand weeding was effective in reducing the density and dry weight of weeds but due to phytotoxicity the crop growth was stunted as evident by reduced growth. Hand weeding twice (or) combined post emergence application of fluazifop-p-butyl + fomesafen (or) sodium acifluorfen + clodinafop propargyl were effective in reducing the density and dry weight of total weeds during the crop growing period. Similar results were also put forth by Prachand *et al.* (2015).The highest density and dry weight of total weeds was obtained with weedy check at 20 and 60 DAS due to heavy weed infestation because of uninterrupted weed growth throughout the crop growing period.

Weed control efficiency and weed control index

At 20 DAS among the different weed management practices higher weed control efficiency and weed control index was recorded with pre-emergence application of diclosulam 20 g ha^{-1} + 1 HW at 15 DAS (100 &74.67 %), which was followed by HW twice at 15 and 30 DAS (80.64 & 100 %), but at 60 DAS the former treatment was followed by with PoE application of fluazifop-p-butyl + fomesafen 222 g ha^{-1} (69.32 & 69.28 %) and PoE application of sodium acifluorfen + clodinafop propargyl 245 g ha^{-1} (68.46 &68.62 %). Higher weed control efficiency in the above treatments might be due to reduced density and dry weight of total weeds as also reported by Mudalagiriyappa *et al.* 2022.

Growth parameters, yield attributes and yield

Growth parameters of blackgram, *viz*, plant height(36.1 cm), leaf area index (1.39) and drymatter production (1446kg ha^{-1}) and yield attributes, *viz*, number of filled $pods^{-1}$(17.6), number of seeds pod^{-1}(6.5) and hundred seed weight (41.8 g) and seed (971 kg ha^{-1}) and haulm yield (1501kg ha^{-1}) were significantly higher with HW twice at 15 and 30 DAS, which was however comparable with PoE application of fluazifop-p-butyl + fomesafen 222 g $ha^{-1}$with a seed yield of 957 kg ha^{-1} and haulm yieldof 1490kg $ha^{-1}$and PoE application of sodium acifluorfen + clodinafop-propargyl 245 g ha^{-1}(910&1410kg ha^{-1}). Increase in growth parameters, yield attributes and yield of blackgram in the above treatments might be due to reduced crop weed competition during the entire growing season, which inturn increased the availability of growth resources leading to higher vegetative and reproductive potential as indicated by higher seed yield. Hand weeding performed at 30 DAS might favoured the crop to perform better than post emergence herbicides. Similar findings were reported by Yadav *et al.* 2022. The next best treatment was PoE application of propaquizafop + imazethapyr 125 g ha^{-1}, which was at par with PoEapplication of quizalofop-p-ethyl + imazethapyr 98 g ha^{-1}. Weedy check recorded significantly lower growth parameters of blackgram, *viz*, plant height (20.4 cm), leaf area index (0.83) and drymatter production (810 kg ha^{-1}) and yield attributes, *viz*, number of filled $pods^{-1}$ (7.0), number of seeds pod^{-1}(3.0) and hundred seed weight (36.1 g) and seed (343 kg ha^{-1}) and haulm yield(798kg ha^{-1}) due to severe competition offered by weeds for growth resources.

Nutrient uptake by blackgram and weeds at harvest

Nutrient uptake *viz*., nitrogen, phosphorous and potassium by blackgram and weeds at harvest was significantly influenced by different weed management practices (Table 3). Among all the weed management practices tried, higher nitrogen(84.3 kg ha^{-1}), phosphorous (30.6kg ha^{-1}) and potassium (97.4 kg ha^{-1}) uptake by blackgram was noticed with HW twice at 15 and 30 DAS, which was statistically comparable with PoE application

Table 1. Weed dynamics of blackgramas influenced by various weed management practices

S.No.	Treatment	Weed density (No. m^{-2})*		Weed dry weight (g m^{-2})*		Weed control efficiency (%)		Weed control index (%)	
		20 DAS	60 DAS	20 DAS	60 DAS	20 DAS	60 DAS	20 DAS	60 DAS
1.	T_1 : PE application of diclosulam 20 g ha^{-1} + 1 HW at 15 DAS	0.71 (0.00)	8.06 (64.67)	0.71 (0.00)	6.26 (38.76)	100.00	74.67	100.00	74.50
2.	T_2 : PoE application of imazethapyr 50 g ha^{-1} at 20 DAS	13.02 (169.01)	12.28 (150.67)	6.26 (38.74)	8.53 (72.26)	6.16	51.47	2.56	52.90
3.	T_3 : PoE application of quizalofop-p-ethyl + imazethapyr 98 g ha^{-1} at 20 DAS	12.80 (163.85)	11.29 (127.00)	6.10 (36.82)	8.00 (63.64)	15.97	60.57	7.69	58.16
4.	T_4 : PoE application of imazethapyr + imazamox 70 g ha^{-1} at 20 DAS	12.86 (164.76)	11.99 (143.33)	5.74 (32.55)	8.55 (72.70)	11.40	52.49	17.94	52.28
5.	T_5 : PoE application of propaquizafop + imazethapyr 125 g ha^{-1} at 20 DAS	12.96 (168.51)	11.33 (127.70)	5.90 (34.32)	8.11 (67.33)	3.84	58.45	12.82	56.20
6.	T_6 : PoE application of sodium acifluorfen + clodinafop propargyl 245 g ha^{-1} at 20 DAS	12.99 (168.18)	9.54 (90.66)	6.14 (37.25)	6.98 (48.26)	8.33	68.46	5.12	68.62
7.	T_7 : PoE application of fluazifop-p-butyl + fomesafen 222 g ha^{-1} at 20 DAS	12.94 (166.98)	9.35 (87.00)	6.00 (35.51)	6.86 (46.64)	11.25	69.32	10.25	69.28
8.	T_8 : Hand weeding twice at 15 and 30 DAS	0.71 (0.00)	8.46 (71.33)	0.71 (0.00)	6.56 (42.50)	80.64	54.82	100.00	71.89
9.	T_9 : Weedy check (Control)	12.86 (164.98)	16.48 (270.67)	6.33 (38.74)	12.37 (153.04)	-	-	-	-
	SEm ±	0.204	0.273	0.160	0.209	-	-	-	-
	CD @ 5 %	0.61	0.82	0.48	0.62	-	-	-	-

*Data in parentheses are original values, which were square root transformed and analysed statistically.

Table 2. **Growth, yield attributes and yield of blackgram as influenced by various weed management practices**

Treatment	Plant height (cm)	Leaf area index	Dry matter production (qha^{-1})	Number of filled pods plant^{-1}	Number of seeds pod^{-1}	Test weight (g)	Seed Yield (kg ha^{-1})	Haulm Yield (kg ha^{-1})	Harvest index (%)
T_1 : PE application of diclosulam 20 g ha^{-1} + 1 HW at 15 DAS	23.1	0.97	920	9.1	4.0	37.7	527	1021	34.08
T_2 : PoE application of imazethapyr 50 g ha^{-1} at 20 DAS	26.1	1.00	959	9.2	4.1	38.5	575	1075	34.89
T_3 : PoE application of quizalofop-p-ethyl + imazethapyr 98 g ha^{-1} at 20 DAS	29.3	1.14	1240	11.6	5.9	38.6	836	1390	37.82
T_4 : PoE application of imazethapyr + imazamox 70 g ha^{-1} at 20 DAS	26.6	1.01	988	9.5	4.2	38.5	589	1132	34.19
T_5 : PoE application of propaquizafop + imazethapyr 125 g ha^{-1} at 20 DAS	30.1	1.16	1282	12.2	6.0	40.1	840	1410	37.86
T_6 : PoE application of sodium acifluorfen + clodinafop propargyl 245 g ha^{-1} at 20 DAS	34.0	1.30	1422	16.0	6.0	40.9	910	1410	38.91
T_7 : PoE application of fluazifop-p-butyl + fomesafen 222 g ha^{-1} at 20 DAS	35.1	1.33	1431	16.5	6.2	41.4	957	1490	39.16
T_8 : Hand weeding twice at 15 and 30 DAS	36.1	1.39	1446	17.6	6.5	41.8	971	1501	39.31
T_9 : Weedy check (Control)	20.4	0.83	810	7.0	3.0	36.1	343	798	30.01
SEm ±	0.81	0.004	35.8	0.63	0.25	0.48	22.2	72.2	1.33
CD @ 5 %	2.4	0.12	107	1.9	0.7	1.4	67	216	3.3

Table 3. Nutrient uptake (kg ha^{-1}) by blackgram and weeds at harvest as influenced by various weed management practices

Treatments	Blackgram			Weeds		
	N	P	K	N	P	K
T_1 : PE application of diclosulam 20 g ha^{-1} + 1 HW at 15 DAS	58.5	15.1	60.4	8.5	2.6	10.3
T_2 : PoE application of imazethapyr 50 g ha^{-1} at 20 DAS	60.4	16.7	65.1	25.4	8.6	28.4
T_3 : PoE application of quizalofop-p-ethyl + imazethapyr 98 g ha^{-1} at 20 DAS	70.6	24.3	78.5	19.0	6.1	16.8
T_4 : PoE application of imazethapyr + imazamox 70 g ha^{-1} at 20 DAS	62.2	18.4	67.2	24.8	8.2	27.1
T_5 : PoE application of propaquizafop + imazethapyr 125 g ha^{-1} at 20 DAS	72.0	25.0	83.0	18.5	5.7	15.1
T_6 : PoE application of sodium acifluorfen + clodinafop propargyl 245 g ha^{-1} at 20 DAS	80.2	29.5	95.2	9.8	3.0	11.6
T_7 : PoE application of fluazifop-p-butyl + fomesafen 222 g ha^{-1} at 20 DAS	82.2	30.1	95.4	9.4	2.9	11.4
T_8 : Hand weeding twice at 15 and 30 DAS	84.3	30.6	97.4	9.0	2.8	10.4
T_9 : Weedy check (Control)	35.2	12.7	43.3	32.5	9.2	32.5
SEm ±	2.43	0.70	3.53	0.52	0.15	0.72
CD (P = 0.05)	7.3	2.1	10.6	1.5	0.4	2.1

of fluazifop-p-butyl + fomesafen 222 g ha^{-1} and PoE application of sodium acifluorfen + clodinafop propargyl 245 g ha^{-1}. The weed biomass was suppressed with hand weeding twice or withpost emergence application of ready mix herbicides resulting in favourable environment for increased absorption of nutrients, increased dry matter accumulation and nutrient content in crop.These results are in close conformity as reported by Khot *et al.* (2016).Weedy check recorded significantly lower uptake of nitrogen (35.2kg ha^{-1}), phosphorous (12.7kg ha^{-1}) and potassium (43.3kg ha^{-1}) this might be due to severe weed infestation resulting in lower dry matter production by blackgram.

The lowest nitrogen (8.5kg ha^{-1}), phosphorous(2.6kg ha^{-1}) and potassium (10.3kg ha^{-1}) uptake by weeds at harvest of blackgram was recorded with PE application of diclosulam 20 g ha^{-1} + 1 HW at 15 DAS which was however on par with HW twice at 15 and 30 DAS, PoE application of fluazifop-p-butyl + fomesafen 222 g ha^{-1} and PoE application of sodium acifluorfen + clodinafop propargyl 245 g ha^{-1}. Effective weed control in the above treatments might provided a competition free environment leading to increased crop stature with increased nutrient uptake by crop and decreased nutrient uptake by weeds. Similar results were also reported by Kumar *et al*. (2018). Weedy check reported significantly highest nitrogen (32.5kg ha^{-1}), phosphorous (9.2kg ha^{-1}) and potassium (32.5kg ha^{-1}) uptake by weeds. Poor weed control in weedy check might resulted in highest weed biomass there by increased nitrogen, phosphorous and potassium uptake by weeds.

CONCLUSIONS

The present study has revealed Pre-emergence application of diclosulam 20 g ha^{-1} + 1 HW at 15 DAS was effective in reducing the density and dry weight of weeds but due to phytotoxicity the crop growth was stunted as evident by reduced growth which inturn reduced the seed yield. Higher seed yieldwas realized with and weeding twice at 15 and 30 DAS (971kg ha^{-1}), which was however comparable with PoE application of fluazifop-p-butyl + fomesafen 222 g ha^{-1}(957kg ha^{-1})and PoEapplication of sodium acifluorfen + clodinafop-propargyl 245 g ha^{-1} (910kg ha^{-1}). So, the above investigation clearly revealed that post-emergence herbicides were considered to be the most effective for obtaining broad-spectrum weed control and to maximize the productivity of blackgrambut at times of labour shortage.

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SCREENING COTTON GERMPLASM AGAINST *CORYNESPORA* LEAF SPOT

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ABSTRACT

Corynespora leaf spot of cotton is an important foliar disease infecting leaves, stems, squares and bolls. Severe defoliation is the principal effect of this leaf spot, thus affecting the yield. Identification of resistant cotton varieties/hybrids is an important disease management strategy. Hence a study was conducted to screen cotton germplasm against Corynespora leaf spot in comparison to a popular hybrid (Jaadoo BG II) and two straight varieties (NDLH 1938 and L 1060) during *kharif* 2021-2022 at Regional Agricultural Research Station, Lam, Guntur, Andhra Pradesh. The disease was recorded at different stages of crop *viz.,* seedling, squaring, flowering, boll formation and boll development, boll maturity and bursting and picking stages by adopting standard disease scale of 0-4 and per cent disease index (PDI) was calculated. Boll formation and boll development was found to be the most susceptible stage of the crop as the entries recorded the highest PDI. Out of 150 entries, 68 scoring less than 10.0 PDI were considered resistant for further testing against Corynespora leaf spot. In check entries, Jaadoo BG II (4.25 PDI), NDLH 1938 (4.50 PDI) and L 1060 (6.50 PDI) the disease appeared at seedling stage itself and reached peak of 28.75, 31.25 and 41.25 PDI at boll formation and development stage expressing susceptibility.

Keywords: Corynespora leaf spot, Cotton, Germplasm, Resistant, Screening

INTRODUCTION

Cotton is one of the most important commercial crops of India and is the largest source of natural fiber. It plays a dominant role in the economy as of textile industry. Cotton fibre is used as raw material in the pulp, paper and textile industries, while oil extracted from the cotton seed is used in food, cosmetics, chemicals, pharmaceuticals *etc*. Cotton seed cake is also used as a cattle feed (Proto *et al*., 2000). Linters, kernels and hulls are used in various consumer products, delicious food and can be used as organic manure. India is the largest country in the world cultivating cotton in an area of 124.69 lakh ha with a production of 323.11 lakh bales of 170 kg lint in 2023-2024. However, productivity was 441 kg ha^{-1}, which is far behind the leading countries. Andhra Pradesh ranks 8th in position both in cultivated area (4.27 Lakh ha) and production (11.58 Lakh bales) and 6thin productivity with 461kg lint ha^{-1} in India (ICAR-AICRP on Cotton,

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2024). Among all the fungal foliar diseases, Corynespora leaf spot caused by *Corynespora cassiicola* has been increasing its prevalence and severity (Salunkhe *et al*., 2019). Itis a necrotrophic fungus belonging to *Corynespora scaceae* family under Pleosporales order and well known as a leaf spotting plant pathogen. Corynespora leaf spot has been observed in Andhra Pradesh since 2017 and emerged as major leaf spot in cotton (ICAR-AICRP on Cotton, 2021). Irregular to circular spots develop on lower leaves and spread upwards towards shoot tips. These spots enlarge and concentric zonations were form with a depression at the centre resulting in target board symptom.

Corynespora target spot caused 224-448 kg ha^{-1} equivalent to 5% to 40% loss of lint in susceptible cotton cultivars (Conner *et al*., 2013; Hagan *et al*., 2015). In India 20-30% losses were estimated due to cotton diseases. In the absence of resistant varieties/hybrids management depends on fungicidal applications. Intensive screening played an important role in *C. cassiicola* management on rubber (Fernando *et al*., 2010). Bt hybrids resistant to Alternaria leaf spot were reported earlier by Gurava Reddy *et al*. (2015), Bhattiprolu and Durga Prasad *et al*. (2017). Moderate susceptibility of cotton entries was reported during *kharif* 2019 (ICAR-AICRP on Cotton, 2020).Considering increasing occurrence of Corynespora leaf spot, cotton germplasm was screened as a strategy to identify resistant lines against this important disease.

MATERIAL AND METHODS

One hundred and fifty germplasm lines of cotton were screened against Corynespora leaf spot during *kharif* 2021-22 under natural conditions at Regional Agricultural Research Station, Lam, Guntur, A. P. and compared with popular hybrid *i.e.,* Jaadoo BG II along with two varieties, NDLH 1938 and L 1060. Observations on disease severity were recorded at six different stages *viz.*, seedling squaring; flowering; formation and development of boll; boll maturity and bursting; boll bursting and picking. Ten plants were tagged at random, in the middle rows of each genotype and in each plant 10 leaves, three from bottom, four from middle and three from top portion were scored by using 0-4 scale given by Sheo Raj (1988).

Per cent Disease Index (PDI) (Wheeler, 1969) and location severity index were calculated as mentioned below.

$$PDI = \frac{\text{Sum of all the individual ratings}}{\text{Total number of leaves scored} \times \text{Maximum disease grade}} \times 100$$

Disease scale for fungal leaf spot diseases of cotton

Scale	Per cent of leaf area covered
0	No infection
1	Few spots of less than 2 mm size, leaf area covering less than 5%
2	Spots of 3 mm size, covering 6-20% of leaf area
3	Spots of 3-5 mm size, irregular in shape coalesce and covering 21-40% of leaf area.
4	Spots covering more than 40% of leaf area

$$LSI = \frac{\text{Sum of all the individual ratings}}{\text{No. of entries} \times \text{Maximum disease grade}} \times 100$$

RESULTS AND DISCUSSION

As Corynespora leaf spot is an emerging disease in cotton and almost all the cultivars are prone to the disease, screening for disease resistance was carried out in 150 cotton germplasm lines along with three check entries (BG II hybrid/varieties) under natural conditions at RARS, Lam, Guntur, Andhra Pradesh. Data on disease severity were collected at six stages of the crop *viz.,* seedling, squaring, flowering, boll formation and boll development, boll maturity and bursting, and boll bursting and picking stages.

The disease appeared in check entries as minute necrotic lesions at seedling stage and progressed up to boll formation and development stage. In case of Jaadoo BG II the disease progressed from 4.25 to 28.75 PDI; in NDLH 1938, from 4.5 to 31.25 PDI and in L 1060 from 6.5 to 41.25 PDI (Table 1). Thus, popular hybrid Jaadoo BG II and the cultivars NDLH 1938 and L 1060 were considered as susceptible due to their disease proneness from seedling stage itself. It may also be observed that at and after boll maturity and bursting stage, the disease appears to have decreased probably due to severe defoliation associated with the disease.

It was observed that none of the test germplasm was affected at seedling and squaring stages.The disease was initiated at 60 days and 86 entries registered less than 5.0 PDI indicating possible resistance in these germplasm lines against Corynespora leaf spot. Boll formation and development stage was observed to be the most susceptible stage of the crop as the disease recorded in all the entries was found to be the highest. However at this stage, none of the test entries recorded less than 5.0 PDI. Hence, less than 10 PDI at the most susceptible stage (boll formation and boll development) was regarded as resistance parameter. Accordingly, 68 entries expressing less than 10.0 PDI were considered resistant for further evaluation against Corynespora leaf spot (Table 1).

The location severity index (LSI) was calculated at flowering stage, boll formation and boll development stage. At flowering stage LSI was 35.7% while at boll formation and boll development stage LSI increased to 50.0% indicating the increase in disease from flowering stage to boll formation and boll development stage. Of all the stages, boll formation and boll development stage appeared more susceptible and hence while screening observations on Corynespora leaf spot need to be taken at boll formation and boll development stage.

Shirsath and Patil (2016) reported that *C. cassiicola* severity was 43.63% on RCH-2 hybrid grown in North Maharashtra region. Divyamani *et al*. (2019) recorded severity of Corynespora leaf spot in farmers' fields during the year 2017 in Guntur district of Andhra Pradesh, to the tune of 0.0 to 10.0 PDI in Jaadoo BG II and 0.0 to 9.0 PDI in ATM BG II during vegetative stage and 16.0 to 33.0 PDI in Jaadoo BG II and 9.0 to 12.0 PDI in ATM BG II during flowering stage.

Two cotton entries, RAH 1046 and CNH 19480 recorded the lowest PDI of 17.0 followed by RAHC 1031, RAHC 1032 (18.0 PDI) and TSH 354 (18.75 PDI) for Corynespora leaf spot during *kharif* 2020 at RARS, Lam, Guntur whereas disease severity was negligible at Junagarh (ICAR-AICRP on Cotton, 2021). Two entries, DHCC 215 and TCH 1941 recorded PDI of 7.75 and 9.0, respectively, for Corynespora leaf spot during *kharif* 2021 (ICAR-AICRP on Cotton, 2022). All the test entries expressed PDI above 20.0 during *kharif* 2022

Table 1. Reaction of cotton germplasm lines against Corynespora leaf spot

S.No.	Entry	Per cent Disease Index (PDI) of Corynespora leaf spot at					
		Seedling stage	Squaring stage	Flowering stage	Boll formation and boll develop--ment	Boll maturity and bursting	Boll bursting and picking
1	Lam GPC426	0	0	3.25	11.50	7.75	3.50
2	Lam GPC427	0	0	2.50	8.00	4.00	1.00
3	Lam GPC428	0	0	3.50	11.25	5.50	2.00
4	Lam GPC429	0	0	3.25	10.50	5.75	2.00
5	Lam GPC430	0	0	3.00	9.75	6.00	2.75
6	Lam GPC431	0	0	2.75	9.25	6.50	2.50
7	Lam GPC433	0	0	3.75	10.25	6.50	2.75
8	Lam GPC434	0	0	3.25	11.50	7.50	3.75
9	Lam GPC435	0	0	3.50	9.50	7.25	3.00
10	Lam GPC436	0	0	3.25	10.25	7.50	3.50
11	Lam GPC437	0	0	3.50	11.25	7.50	3.00
12	Lam GPC438	0	0	3.25	11.00	7.00	3.00
13	Lam GPC439	0	0	3.50	11.50	7.50	3.25
14	Lam GPC441	0	0	3.50	11.25	7.00	3.50
15	Lam GPC442	0	0	3.25	11.75	7.75	4.00
16	Lam GPC443	0	0	3.00	10.50	4.00	2.50
17	Lam GPC444	0	0	3.25	10.00	7.25	3.00
18	Lam GPC447	0	0	3.50	11.50	7.00	3.00
19	Lam GPC448	0	0	3.25	8.25	4.75	1.75
20	Lam GPC449	0	0	3.25	9.50	5.25	2.75
21	Lam GPC450	0	0	2.75	9.25	5.75	3.00
22	Lam GPC451	0	0	2.75	8.75	5.25	3.25
23	Lam GPC453	0	0	3.25	11.50	6.50	4.00
24	Lam GPC454	0	0	2.75	9.50	6.50	3.50
25	Lam GPC456	0	0	3.75	9.75	7.25	3.75
26	Lam GPC458	0	0	4.25	9.00	5.50	2.50
27	Lam GPC460	0	0	4.50	9.25	5.00	2.50
28	Lam GPC466	0	0	4.25	8.50	5.50	3.00
29	Lam GPC467	0	0	4.25	8.75	6.25	3.50
30	Lam GPC468	0	0	4.25	9.00	6.50	3.75

S.No.	Entry	Per cent Disease Index (PDI) of Corynespora leaf spot at					
		Seedling stage	Squaring stage	Flowering stage	Boll formation and boll development	Boll maturity and bursting	Boll bursting and picking
31	Lam GPC471	0	0	3.75	8.50	6.25	3.25
32	Lam GPC475	0	0	4.50	10.00	7.50	3.75
33	Lam GPC477	0	0	3.25	8.50	6.00	3.00
34	Lam GPC478	0	0	4.25	8.75	7.50	3.50
35	Lam GPC481	0	0	4.25	8.50	7.50	3.75
36	Lam GPC484	0	0	4.75	8.75	6.75	2.00
37	Lam GPC485	0	0	3.50	8.25	5.75	3.25
38	Lam GPC488	0	0	3.75	8.75	6.50	2.75
39	Lam GPC489	0	0	3.75	9.25	7.00	3.25
40	Lam GPC490	0	0	4.25	9.75	6.25	2.75
41	Lam GPC491	0	0	4.75	10.50	7.25	3.50
42	Lam GPC492	0	0	4.25	10.00	7.50	3.75
43	Lam GPC493	0	0	4.75	11.50	7.25	3.00
44	Lam GPC494	0	0	4.25	8.25	4.75	2.25
45	Lam GPC495	0	0	3.75	9.50	5.50	2.75
46	Lam GPC496	0	0	3.50	9.50	6.00	3.00
47	Lam GPC497	0	0	3.75	8.75	4.75	3.25
48	Lam GPC498	0	0	4.50	11.5	6.50	3.75
49	Lam GPC499	0	0	3.50	9.50	6.50	3.50
50	Lam GPC500	0	0	4.50	9.75	7.25	3.75
51	Lam GPC501	0	0	4.25	10.00	7.50	3.50
52	Lam GPC502	0	0	4.25	9.25	5.00	2.50
53	Lam GPC505	0	0	4.50	8.75	6.25	3.00
54	Lam GPC506	0	0	4.25	8.25	4.75	1.75
55	Lam GPC507	0	0	9.00	12.00	8.00	4.00
56	Lam GPC508	0	0	4.25	8.25	5.00	2.75
57	Lam GPC509	0	0	4.75	9.50	6.50	3.50
58	Lam GPC510	0	0	5.75	10.50	7.25	3.75
59	Lam GPC511	0	0	5.50	10.75	6.25	3.25
60	Lam GPC512	0	0	5.25	10.25	6.75	3.50
61	Lam GPC513	0	0	5.50	11.25	7.50	3.75

S.No.	Entry	Per cent Disease Index (PDI) of Corynespora leaf spot at					
		Seedling stage	Squaring stage	Flowering stage	Boll formation and boll development	Boll maturity and bursting	Boll bursting and picking
62	Lam GPC514	0	0	5.75	11.50	7.25	3.25
63	Lam GPC515	0	0	5.50	11.25	7.75	3.00
64	Lam GPC516	0	0	5.50	10.75	5.75	2.75
65	Lam GPC517	0	0	5.25	10.25	4.75	3.00
66	Lam GPC518	0	0	5.50	11.25	5.75	2.75
67	Lam GPC519	0	0	5.75	11.50	7.75	3.50
68	Lam GPC520	0	0	5.75	10.50	7.00	3.50
69	Lam GPC521	0	0	6.50	10.75	8.50	4.75
70	Lam GPC523	0	0	6.50	8.50	8.25	4.50
71	Lam GPC524	0	0	6.00	9.50	6.75	3.50
72	Lam GPC525	0	0	6.75	8.75	8.50	4.50
73	Lam GPC526	0	0	6.50	8.75	7.75	4.75
74	Lam GPC527	0	0	4.75	6.50	5.00	3.00
75	Lam GPC528	0	0	7.00	9.50	7.50	3.50
76	Lam GPC529	0	0	7.00	12.75	9.00	5.00
77	Lam GPC530	0	0	5.00	9.75	4.75	3.25
78	Lam GPC531	0	0	5.50	10.75	5.00	2.50
79	Lam GPC539	0	0	3.75	12.75	4.75	3.50
80	Lam GPC540	0	0	5.75	16.50	7.00	4.00
81	Lam GPC542	0	0	5.25	18.00	8.00	3.75
82	Lam GPC543	0	0	4.25	10.25	4.25	2.50
83	Lam GPC544	0	0	5.50	16.75	5.50	3.00
84	Lam GPC545	0	0	5.25	15.75	5.75	2.75
85	Lam GPC546	0	0	4.75	14.75	6.00	3.50
86	Lam GPC547	0	0	5.00	14.50	6.75	2.75
87	Lam GPC548	0	0	6.00	17.25	6.50	3.50
88	Lam GPC549	0	0	5.75	17.75	7.25	3.75
89	Lam GPC550	0	0	6.75	19.50	7.50	3.00
90	Lam GPC552	0	0	6.00	17.75	8.50	3.75
91	Lam GPC556	0	0	5.75	18.50	7.75	2.75
92	Lam GPC557	0	0	6.00	18.50	8.00	4.00

S.No.	Entry	Per cent Disease Index (PDI) of Corynespora leaf spot at					
		Seedling stage	Squaring stage	Flowering stage	Boll formation and boll development	Boll maturity and bursting	Boll bursting and picking
93	Lam GPC558	0	0	5.50	19.50	7.50	3.25
94	Lam GPC559	0	0	5.25	19.00	7.00	3.50
95	Lam GPC560	0	0	5.50	19.75	7.75	4.00
96	Lam GPC563	0	0	4.75	18.75	5.75	3.75
97	Lam GPC565	0	0	5.50	15.50	7.50	3.25
98	Lam GPC566	0	0	5.75	14.75	7.25	3.50
99	Lam GPC568	0	0	5.00	12.50	4.50	2.00
100	Lam GPC569	0	0	4.50	13.25	5.25	3.00
101	Lam GPC578	0	0	5.25	13.75	5.75	3.25
102	Lam GPC579	0	0	4.25	12.50	5.25	3.25
103	Lam GPC581	0	0	5.75	16.25	7.50	4.75
104	Lam GPC582	0	0	5.00	16.75	6.75	3.50
105	Lam GPC583	0	0	5.25	17.50	7.00	3.75
106	Lam GPC586	0	0	4.25	12.25	6.00	4.00
107	Lam GPC587	0	0	4.75	18.50	7.25	4.25
108	Lam GPC588	0	0	5.50	9.25	5.75	3.50
109	Lam GPC589	0	0	5.75	9.50	5.25	2.75
110	Lam GPC594	0	0	5.00	8.25	6.50	3.25
111	Lam GPC595	0	0	4.50	8.75	6.25	4.00
112	CP 304	0	0	5.00	9.00	6.50	3.75
113	CP 320	0	0	4.25	8.50	6.25	3.25
114	CP 323	0	0	5.50	10.00	7.50	3.75
115	CP 314	0	0	4.25	8.50	6.00	3.00
116	CP 317	0	0	5.00	8.75	7.50	3.50
117	CP 301	0	0	4.75	8.50	7.50	3.75
118	CP 302	0	0	5.25	8.75	6.75	2.00
119	CP 305	0	0	4.25	8.25	5.75	3.25
120	CP 303	0	0	4.75	8.75	6.50	2.75
121	CP 308	0	0	4.25	9.25	7.00	3.25
122	CP 316	0	0	5.00	9.75	6.25	2.75
123	CP 310	0	0	5.75	10.50	7.25	3.50
124	CP 313	0	0	5.25	10.00	7.50	3.75

S.No.	Entry	Per cent Disease Index (PDI) of Corynespora leaf spot at					
		Seedling stage	Squaring stage	Flowering stage	Boll formation and boll development	Boll maturity and bursting	Boll bursting and picking
125	CP 322	0	0	5.75	11.50	7.25	3.00
126	CP 319	0	0	4.75	8.25	4.75	2.25
127	CP 318	0	0	4.50	9.50	5.50	2.75
128	CP 309	0	0	4.25	9.50	6.00	3.00
129	CP 323	0	0	4.00	8.75	4.75	3.25
130	CP 307	0	0	5.50	11.50	6.50	3.75
131	CP 403	0	0	4.25	9.50	6.50	3.50
132	CP 402	0	0	5.25	9.75	7.25	3.75
133	CP 407	0	0	6.50	13.25	5.75	3.25
134	CP 408	0	0	6.75	13.75	6.75	3.50
135	CP 401	0	0	4.50	12.75	7.50	4.00
136	CP 406	0	0	4.00	11.50	8.00	3.00
137	Lam GPC8	0	0	8.75	15.25	9.25	7.50
138	Lam GPC10	0	0	7.25	13.50	6.75	4.50
139	Lam GPC18	0	0	6.25	12.75	6.50	3.50
140	Lam GPC59	0	0	7.75	15.50	7.75	4.50
141	Lam GPC94	0	0	6.75	12.50	6.00	3.00
142	Lam GPC103	0	0	6.75	14.00	7.25	3.75
143	Lam GPC114	0	0	6.50	13.5	7.50	4.25
144	Lam GPC116	0	0	6.25	14.25	6.50	2.25
145	Lam GPC135	0	0	6.75	13.25	5.50	3.75
146	Lam GPC137	0	0	6.75	13.00	6.25	3.00
147	Lam GPC161	0	0	8.00	15.50	19.00	5.25
148	Lam GPC166	0	0	7.25	14.75	6.50	3.75
149	Lam GPC175	0	0	8.00	13.50	6.75	4.50
150	Lam GPC177	0	0	8.25	12.50	7.25	5.75
	Mean PDI	0	0	4.92	11.45	6.64	3.35
151	Jaadoo BG II (C)	4.25	10.50	21.25	28.75	11.25	5.75
152	NDLH 1938 (C)	4.50	12.00	25.00	31.25	15.50	7.25
153	L 1060 (C)	6.50	16.75	25.50	41.25	18.75	6.00
	Mean PDI	5.08	13.08	23.92	33.75	15.17	6.33

and 2023 at RARS, Lam, Guntur (ICAR-AICRP on Cotton, 2023) and (ICAR-AICRP on Cotton, 2024). At Junagarh GISV 328 (7.0 PDI) and Suraj (13.5 PDI) and other entries recorded above 20.0 PDI during *kharif* 2022 (ICAR-AICRP on Cotton, 2023). At Khandawa, AKH 10-3 recorded 15.0 PDI and three entries *viz*., GSHV 269, CNH 1154 and KGH-VS 2323 showed 17.5 PDI; all the other entries expressed 20.0 to 52.5 PDI during *kharif* 2023 (ICAR-AICRP on Cotton, 2024).

Yamuna *et al*. (2019) observed target leaf spot to an extent of 3.0-5.0 PDI at boll maturity and boll bursting stage in compact cotton germplasm lines, 4.6 PDI in L 604, 4.5 PDI in L 1060 and 4.6PDI in NDLH 1938 at RARS, Lam. Such a low severity was due to the fact that observations were taken at maturity and boll bursting stage which is not the most susceptible stage of the crop as per our findings and also due to the dry weather conditions prevailed during the season, *kharif* 2018-19 with deficit rainfall. Different reactions of cotton cultivars to diseases were related to histochemical, morphological and anatomical factors of each cultivar (Mukewar and Mayee, 2001).

CONCLUSIONS

In popular BG II hybrid/varieties assessed, Corynespora leaf spot appeared at seedling stage itself (4.25-6.50 PDI) and progressed up to boll formation and development stage (28.75-41.5 PDI) indicating susceptibility to Corynespora.Hence efforts need to be directed towards resistance breeding aimed at Corynespora duly identifying the resistant sources. Cotton germplasm lines (150 no.) screened in the present investigation expressed disease initiation at flowering stage (less than 5.0 PDI) indicating possible resistance against Corynespora leaf spot. Boll formation and boll development stage was found to be the most susceptible stage of the crop with the highest PDI disease recorded in all the entries. Accordingly, 68 entries scoring less than 10.0 PDI were considered resistant for further testing against Corynespora leaf spot under breeding programme.

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FIELD EFFICACY OF INSECTICIDES AGAINST *MYZUS PERSICAE* (SULZER) IN POTATOES

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ABSTRACT

During the 2020–2021 and 2021–2022 growing seasons, the efficacy of various insecticidal treatment regimens—T_1 (spiromesifen + spiromesifen), T_2 (thiamethoxam + thiamethoxam), T_3 (thiacloprid + thiacloprid), T_4 (imidacloprid + imidacloprid), T_5 (cartap hydrochloride + cartap hydrochloride), T_6 (chlorpyriphos + chlorpyriphos) and T_7 (untreated control)—was evaluated for controlling *Myzus persicae* (Sulzer) on the potato cultivar Kufri Chandramukhi. Among the seven treatment options, the two foliar sprays of thiamethoxam 25 WG at 125 g a.i./ha—applied first in the third week of January and then 15 days later—and the two foliar sprays of spiromesifen 240 SC at 96 g a.i./ha—applied in the third week of January and repeated 30 days later—proved to be the most effective in reducing aphid populations. The highest marketable potato yield (40.50 t/ha) was achieved in T_2, followed by T_1 (38.87 t/ha), while the control (T_7) recorded the lowest yield (28.66 t/ha). T_2 also had the highest benefit-cost ratio (BCR) at 5.87:1, whereas T_6 had the lowest at 1.77:1. Among all treatment regimens, T_1 and T_2 were the most effective in boosting marketable potato yield and reducing aphid incidence compared to other treatments, including the control.

Keywords: Aphids, Benefit-Cost Ratio, Insecticides, Potato, Yield.

INTRODUCTION

The potato (*Solanum tuberosum* L.) is an essential component of daily nutrition, alongside other staple vegetables. Globally, it ranks third in potato production and fourth in cultivated area, and it is grown across various agroclimatic zones in India. According to the Indian Horticulture Database (2019), India produced 41.55 million tons of potatoes from 1.99 million hectares, with an average yield of 21.10 tons per hectare. Potato crops worldwide are attacked by over 100 insect and non-insect pests (Simpson, 1977). Among these, the nymphs and adults of the aphid *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) are particularly significant, as they damage plants by feeding on sap and tender tissues, leading to premature senescence (Konar *et al*., 2003). Pest infestations present a major challenge to boosting agricultural yields, with herbivorous insects estimated to consume 26% of potential food production. Kennedy *et al*. (1962) and Blackman and Eastop (2000) reported that *Myzus persicae* transmits over 100 plant

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viruses and secretes honeydew, which fosters sooty mold growth and hinders photosynthesis. Additionally, Sutton (1991) highlighted that aphids and whiteflies are significant pests during vegetative stages, causing yield losses ranging from 20% to 40%. Banerjee *et al*. (2014) noted that farmers often rely on conventional insecticides, such as alpha-cypermethrin, methyl parathion, dichlorvos, phorate, imidacloprid, endosulfan, and profenofos, to manage aphid populations. In this context, the present study aims to evaluate the bio-efficacy of selective insecticides against major insect pests of potato, providing insights for developing improved pest management strategies.

MATERIAL AND METHODS

Various insecticidal treatment schedules were assessed for their impact on potato aphid incidence over two consecutive cropping seasons, 2020–21 and 2021–22. The Kufri Chandramukhi potato variety was planted in late November at the District Seed Farm in Burdwan District, under the supervision of the Department of Agriculture, Government of West Bengal. The farm is located at 23.2324° N latitude, 87.8615° E longitude, and an elevation of 30 meters above sea level. The experiment followed a randomized block design (RBD), with potatoes planted in 3x4 m² plots at a spacing of 60 x 20 cm. The experimental field was thoroughly prepared through plowing and harrowing, and stubbles from the previous crop were removed to clean the land. The crop was cultivated using all standard agronomic practices recommended for the region. The plants were dehaulmed 90 days after sowing, in the first week of March, and harvested 100 days after sowing, during the second week of March.

The efficacy of seven insecticidal treatment schedules, including an untreated control, was evaluated against aphid incidence using three replications. The treatments, detailed in Table 1, involved various insecticides applied initially in the third week of January, with a second spray administered 15 or 30 days later. The first insecticide application was conducted when the pest population was nearing the Economic Threshold Level (ETL). Aphid (both nymph and adult) incidence was monitored by recording pre-treatment data from the third week of December until the week prior to spraying, and post-treatment data from the fourth week of January until the crop's dehaulming in the first week of March. Aphid counts were taken from 30 leaves—one each from the top, middle, and bottom of 10 randomly selected plants per plot. The percentage reduction in aphid population was calculated by comparing the mean aphid population before and after treatment, using the formula provided by Flemming and Retnakaran (1985).

A one-way ANOVA was applied to statistically analyze the mean yield of each treatment from the pooled data, with treatment means compared using LSD at p=0.05 (Gomez and Gomez, 1984). The benefit-cost ratio (BCR) for each treatment schedule was calculated based on the market value of the potato tubers and insecticides to identify the most cost-effective treatment. The returns from crop yield and cultivation costs for each treatment were standardized to one hectare of land, and the ratio was computed using the following formula:

$$BCR = \frac{\text{Net profit in treatment}}{\text{Total cost in treatment}}$$

$$\text{Per cent Population reduction} = 1 - \frac{\text{Post treatment population in treatment}}{\text{Pre treatment population in treatment}} X \frac{\text{Pre treatment population inuntreated control}}{\text{Post treatment population in untreated control}} X100$$

Where, Net profit in treatment = Added benefit over control – Total cost in treatment. Added benefit over control= Increased yield over control (ton/ha) x selling price of potato per tonne.

RESULTS AND DISCUSSION

The data in Table 2 indicate that, over the two years of testing, all the evaluated pesticides provided a significant advantage over the untreated control. Although treatments T_3 and T_4 showed a slight disadvantage, with a reduction of approximately 90% compared to the control, treatments T_1 and T_2 consistently exhibited the highest percentage reduction in aphid populations (>95%) in both years. In comparison, T_5 and T_6 were less effective than the earlier treatments, with a reduction of about 80–87%. According to the pooled data, the overall effectiveness of the various insecticidal treatments against aphid incidence was ranked as $T_2 > T_1 > T_3 > T_4 > T_5 > T_6 > T_7$. The results also indicated that the most effective treatment was thiamethoxam 25 WG at 125 g a.i./ha, which reduced the aphid population by 95.93% compared to the control, performing similarly to T_1 (95.08%).

These results align with those of Khan *et al.* (2012), who found that foliar spraying of thiamethoxam and imidacloprid significantly reduced *M. persicae* infestations. Similarly, the findings are consistent with Sarwar *et al*. (2011), who reported that thiamethoxam and imidacloprid were equally effective in controlling aphids.

The data show that all insecticidal treatments outperformed the untreated control (T_7) with a yield of 28.66 t/ha. Among the treatments, T_2 thiamethoxam 25 WG at 125 g a.i./ha achieved the highest tuber production (40.50 t/ha), making it the most successful. It was comparable to T_1 spiromesifen 240 SC at 96 g a.i./ha, which yielded 38.87 t/ha. However, it differed significantly from T_3 thiacloprid (48 g a.i./ha; 36.93 t/ha), T_4 imidacloprid (40 g a.i./

Table1. Schedules of insecticidal treatments against potato aphid (*Myzur persicae*)

Treatment	Insecticides with dose and time of application
T_1	Foliar spray of Spiromesifen 240 S.C. at 3rd week of January @96 g a.i./ha (400ml/ha) and 2nd spray at 30days after spraying of 1st spray
T_2	First spray with thiamethoxam 25 WG @125 g a.i/ha at 3rd week of January and and 2nd spray at 15days after spraying of 1st spray
T_3	Foliar spray to thiacloprid @ 48 g a.i./ ha at 3rd week of January and 2nd spray at 15 days after spraying of 1st spray
T_4	Foliar spray with Imidacloprid @ 40 g. a.i/ha at 3rd week of January and 2nd spray at 15 days after spraying of 1st spray
T_5	Foliar sprays with Cartap hydrochloride 50 SP @ 1 g/l of water at 3rd week of January) and 2nd spray at 30days after spraying of 1st spray
T_6	Foliar sprays with chlorpyriphos 20 EC @ 2.5 ml/lit of water at 3rd week of January and 2nd spray at 15 days after spraying of 1st spray
T_7	Control

Table 2 The efficacy of insecticides against potato aphid

Treatment	Mean number of aphid population/ 30 compound leaves								
	2020-21			2021-22			Pooled data of 2020-21 and 2021-22		
	Pre-treatment	Post-treatment	% reduction over control	Pre-treatment	Post-treatment	% reduction over control	Pre-treatment	Post-treatment	% reduction over control
T_1	15.66	3.66	94.54	16.24	3.46	95.51	15.95	3.56	95.08
T_2	15.00	3.00	95.33	15.66	2.66	96.42	15.33	2.83	95.93
T_3	16.33	6.33	90.95	17.64	6.00	92.83	16.98	6.16	92.00
T_4	17.66	7.33	90.31	18.33	8.66	90.04	17.99	7.99	90.21
T_5	18.00	10.33	86.60	19.66	11.66	87.50	18.83	10.99	87.14
T_6	18.66	15.33	80.82	21.86	19.33	81.36	20.26	17.33	81.15
T_7	22.33	95.66	-	27.33	129.66	-	24.83	112.66	

Table 3. The cost-effectiveness of various insecticide treatment plans against potato aphid (pooled data of 2020-21 and 2021-22).

Treat-ment	Marke table Yield (t/ha)	Increased yield over control (t/ha)	Added benefit over control (Rs/ha)	Cost of treat-ment (Rs/ha)	profit Net (Rs/ha)	BCR
T_1	38.87	10.21	104142	14821	89321	6.02:1
T_2	40.50	11.84	121360	15424	105936	6.87:1
T_3	36.93	8.27	84354	14388	69966	4.86:1
T_4	36.09	7.43	75786	14050	61736	4.39:1
T_5	34.96	6.3	64260	13814	50446	3.65:1
T_6	32.45	3.79	38658	13956	24702	1.77:1
T_7	28.66	-	-	-	-	-

*Selling price of potato was Rs. 10200/t (Average value of 2021 and 2022)

ha; 36.09 t/ha), T_5 cartap hydrochloride 50 SP (1 g/l of water; 34.96 t/ha), and T_6 chlorpyriphos 20 EC (2.50 ml/liter of water; 32.45 t/ha). Treatment T_2 produced the highest incremental benefit (Rs. 121,360.00) compared to the control, while treatment T_6 generated the smallest benefit (Rs. 38,658.00). Following T_2 (Rs. 6.87:1), the benefit-cost ratios (BCR) for the treatments were T_1 (6.02:1), T_3 (4.86:1), T_4 (4.39:1), T_5 (3.65:1), and T_6 (1.77:1). According to Akashe *et al.* (2009), thiamethoxam yielded the best output and benefit-cost ratio, making it the most effective treatment for aphids. Similarly, Gavkare *et al.* (2013) identified thiamethoxam as the most effective insecticide against aphids, followed by imidacloprid. These findings align with those of Biswas *et al.* (2004), while Kachot *et al.* (2018) reported that spiromesifen effectively reduced aphid incidence.

In the current study, both spiromesifen and thiamethoxam showed the highest benefit-cost ratios and were the most effective in controlling sucking pests..

CONCLUSIONS

Compared to the other treatments, thiamethoxam (T_2) and spiromesifen (T_1) were the most effective in reducing aphid infestations and boosting tuber yield, resulting in the highest financial returns. The impact of the different insecticides on the aphid population was moderate, though it varied. In this context, the findings support the use of thiamethoxam and spiromesifen as both efficient and cost-effective methods for managing aphids.

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EFFECTIVE INTROGRESSION OF qDTY3.1 AND qDTY2.1 TO GENETIC BACKGROUND OF A MODERN RICE VARIETY (ADT37) FOR FLOWERING STAGE DROUGHT TOLERANCE BASED ON DROUGHT TOLERANCE DEGREE

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ABSTRACT

Dry spell pressure is one of the overwhelming abiotic burden in downpour took care of low and upland rice framework. In the current review, a generally cultivable present day rice assortment (ADT37) was improved for dry spell resilience at conceptive stage by consolidating qDTY3.1 and qDTY2.1 locus through marker helped backcross technique during the extended period of 2021-23. At sub-atomic level, polymorphism was affirmed between beneficiary (ADT37) and giver parent (IR 81869 B-195) with assistance of straightforward arrangement rehash marker. Here, the quality of leaf rolling and leaf drying was utilized to choose positive dry spell plants from backcrossed populace of every age utilizing IRRI's scale. Plus, plants which are like intermittent parent (RP) at morphological level were additionally browsed chosen positive plants to backcross with RP at every age. Thusly, various ten, eight and nine positive plants were chosen from F1, BC1F1 and BC2F1 populace separately, in view of its elevated degree of dry spell resilience degree (DTD) and heterosis for the quality of leaf drying followed by dry season pressure at vegetative stage. Finally, various two positive plants vagabond ring both qDTY3.1 and qDTY2.1 with heterozygous allelic condition was distinguished from BC3F1 populace utilizing forefront marker (RM520 and RM521) at before self-fertilization. In future, the created and near isogenic lines (NILs) of ADT37 rice assortment for the dry season resilience at regenerative stage in view of serious level of dry spell resistance and heterosis would be more powerful under startling high water shortage circumstance to build the grain yield of rice.

Keywords: ADT37, backcrossing, dry season pressure, dry spell resilience degree, Heterosis, Leaf drying, qDTY3.1 and qDTY2.1.

INTRODUCTION

Rice (*Oryza sativa* L.) crop confronting a troublesome condition as a result of climbing temperature and environmental change it turns out to be profoundly delicate to numerous abiotic stresses like dry season, heat, flood, low temperature, and so on. Among these burdens, dry season is a serious limitation to the development of rice plants up to the blooming stage (Hao *et al.,* 2018; Oladosu, *et*

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al., 2019). It is liable for the development of the plant to become smaller than usual (Zhu *et al.,* 2020; Panda *et al.,* 2021) and yield exceptionally unfortunate grains. Adverse consequence of dry season pressure because of diminishing water supply by expanding power of the changing climatic condition in downpour took care of low and upland districts is exceptionally huge. Simultaneously, rice reproducers need to expand the rice creation rate for the developing rice eating individuals all over the planet. Up to this point, there are such countless reports for the distinguishing proof of quality/QTLs connected with agronomic characteristics which are related with dry season resistance and these hereditary sources have been utilized for the advancement of dry spell lenient rice assortments around the world (Singh, *et al.,* 2016; Kumar *et al.,* 2016; Vikram *et al.,* 2016; Dixit *et al.,* 2017; Barik *et al.,* 2019;). Be that as it may, further disturbance of environmental change because of persistently raising temperature by exercises of the people prompts successive water emergency in horticulture biological system (IPCC, 2014a). This present circumstance undermines the worldwide food security for developing populace and thus, the rice creation is requested to upgrade by the rice reproducers. In the current review, a famous present day rice assortment (ADT37) generally developing in the southern piece of India is improved for dry spell resilience at blossoming stage by joining of qDTY3.1 and qDTY2.1 in view of drought tolerance degree (DTD) and heterosis through backcrossing.

MATERIAL AND METHODS

Plant material

A little amount of rice seeds of ADT37 from Tamilnadu Rice Exploration Organization (TRRI), Aduthurai, Tamilnadu state and IR81869 B-195 from National Rice Research Institute (NRRI), Cuttack, Odisha state were obtained. In this review, rice assortments, ADT37 as female parent (beneficiary) for further developing dry season resistance at regenerative stage and IR81869 B-195 holding onto qDTY3.1 and qDTY2.1 as male parent (Giver) were utilized. ADT37 is likewise a brief span assortment (110 days) and its creation is assessed to 6.0 t/ha. This assortment is created from cross between BG 280-12/PTB 33. Rice is strong and white in variety. It is impervious to numerous bugs and sicknesses.

Phenotypic selection

In this review, large plastic pots loaded up with fine soil from rice field alongside cow waste were utilized for phenotypic choice. This determination cycle was completed in Net house, Kandaswami Kandar's College (11.1202ºN, 78.0031°E), Velur, Namakkal (Region), Tamil Nadu, India during 2021. Seedlings of giver and beneficiary were brought up in a different plastic cup for 21 days and one solid seedling from each parental line was relocated to each pot. Moreover, three arrangements of pots were relocated and they were considered 30 days to lay out. Dry spell pressure was allowed to 45-days old plants for as long as eight days by emptying the water out of pots. Re-water system was finished to plants in first, second and third arrangement of pot on fourth, sixth, eighth day, separately. Pace of leaf rolling and leaf drying occurrence was noted following the IRRI's scale (2002) (Table-1 and 2).

In another trial, pace of seed setting not set in stone in both parental lines under dry season pressure. For this, dry season pressure was forced on plants during inception of banner leaf (booting stage) by emptying water out of pots. Scoring of seed setting rate was finished by IRRI's scale (2002) (Table-3). For determination of dry season open minded descendants in light of the pace of leaf drying,

Table 1. Drought score for leaf rolling at vegetative stage (IRRI's Scale, 2002).

Scale	Description
0	Leaves healthy
1	Leaves start to fold
3	Leaves folding (deep V-shape)
5	Leaves fully cupped (U-shape)
7	Leaf margins touching (O-shape)
9	Leaves tightly rolled (V-shape)

Determined F_1 plants were oppressed for dry season pressure at seedling stage and dry spell lenient plants were chosen in light of DTD worth and heterosis followed by IRRI's scale for backcrossing with ADT37 as repetitive parent (RP)to create BC_1F_1 seeds during Rabi-2021-22. Created BC_1F_1 plants were forced dry spell pressure in enormous plastic pots as referenced previously. For control, parental lines were developed under flooding condition. Dry spell lenient descendants were chosen in

Table 2. Drought score for leaf drying at vegetative stage (IRRI's Scale, 2002).

Scale	Description	Rate
0	No symptoms	Highly resistant
1	Slight tip drying	Resistant
3	Tip drying extended to ¼ length in most leaves	Moderately resistant
5	¼ to ½ of the leaves fully dried	Moderately susceptible
7	More than 2/3 of all leaves fully dried	Susceptible
9	All plants apparently dead	Highly susceptible

complete length of three leaves from top of the plant of every offspring were estimated and less with the length of dried piece of the leaf and drought tolerance degree (DTD) was scored by Zu *et al.* (2017) and IRRI's scale for leaf drying (2002). At genotypic level, polymorphism study was done in parental lines utilizing basic grouping rehashes (SSR) marker (Table-4).

Development of near isogenic lines (NILs)

After affirmation of parental lines at phenotypic and genotypic level as safe and defenseless to dry spell pressure, we went for cross fertilization step. For undermining of anthers from repetitive parent, we eliminated each of the six pre-developed anthers cautiously with assistance of forceps in the early (in the middle between 6-7 am) and covered the panicle containing castrated blossoms with spread paper cover. Then, we

Table 3. Spikelet fertility under drought stress condition (IRRI's Scale, 2002).

Scale	Seed setting %
1	More than 80%
3	61 – 80%
5	41 – 60%
7	11 – 40%
9	Less than 11%

cut the panicle (between from 9 to 10.30 am) from the giver parent (IR81869 B-195) cautiously at the hour of opening of palea and lemma some portion of the blossom having developed anthers (light yellow in variety) and treatment was finished by cleaning dust grains on padded shame of undermined blossoms and F1 seeds were determined. This hybridization cycle was finished in Nethouse, Kandaswami Kandar's College, Velur, Namakkal (Region), Tamil Nadu, during Kharif season, 2021.

Table 4. Simple sequence repeat (SSR) marker utilized as frontal area marker in this review.

QTL	SSR marker	Forward primer	Reverse primer
qDTY3.1	RM520	5'-AGGAGCAAGAA AAGTTCCCC-3'	5'-GCCAATGTGT GACGCAATAG-3'
qDTY2.1	RM521	5'-TTCCCTTATTC CTGCTCTCC-3'	5'-GGGATTTGCA GTGAGCTAGC-3'

view of dry season resistance degree (DTD) (Zu *et al.,* 2017) and leaf drying (IRRI's scale, 2002). Plants with higher DTD esteem than RP were chosen for backcrossing with RP to create BC_2F_1seeds during Kharif-2022. During Rabi-2022-23, dry season lenient BC_2F_1 descendants chose at phenotypic level were utilized for backcrossing with RP to deliver BC_3F_1 seeds (Fig.1). During Kharif-2023, positive plants were recognized in created BC_3F_1 populace utilizing closer view markers (RM520 and RM521) and they were considered self fertilization to deliver BC_3F_2 seeds.

Genomic DNA isolation and PCR amplification

For sub-atomic marker examinations, the genomic DNA was detached from new leaf of ADT37, IR81869 B-195 and BC_3F_1 descendants utilizing CTAB technique with minor alterations (Drew and Lynch, 1980). Polymerase chain response was finished with the volume of 10µl containing 20-30ng format DNA, 5pmol of every preliminary, 0.05mM dNTPs, 10x PCR cushion (10mM Tris, pH 8.4, 50mM KCl and 1.8mM MgCl2) and 0.5 U of Taq DNA polymerase (Bangalore Genei Pvt. Ltd.,

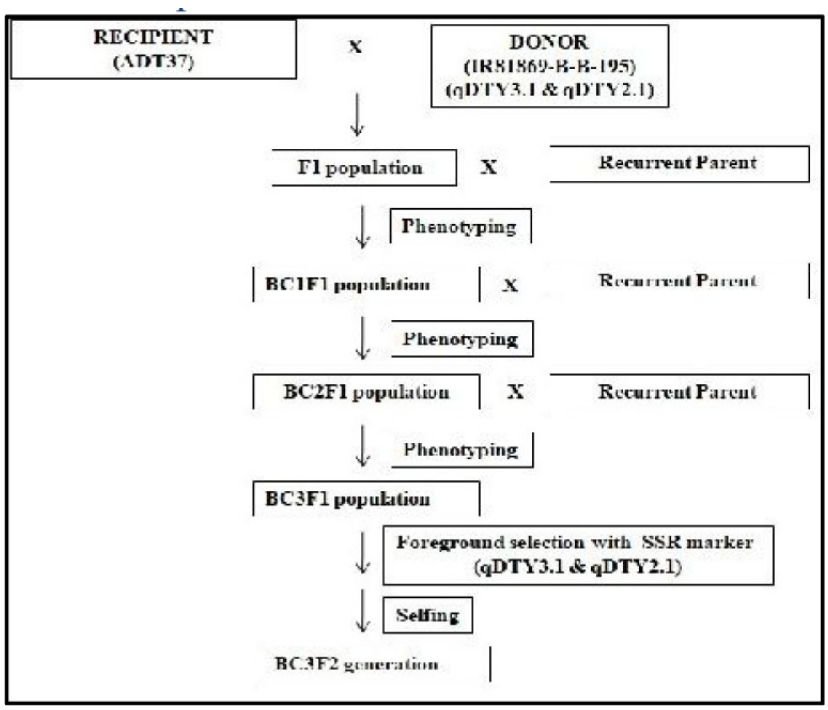


Figure 1. Rearing plan utilized in the marker helped backcross program for introgression of qDTY3.1 and qDTY2.1 into ADT37 rice assortment.

Bengaluru, India), running an intensification profile comprising of one pattern of introductory denaturation at 94°C for 5 min; trailed by 35 cycles containing denaturation with at 94°C for 30s, toughening at 55°C for 30s, expansion at 72°C for 1 min; and a last augmentation at 72°C for 7 min. The intensified PCR items were settled by electrophoresis having 2.5% agarose gel and fluoro-stained with ethidium bromide. The amplicon goal was pictographed utilizing BioRad gel documentation framework. For closer view choice, marker successions for RM521 and RM520 connected with qDTY2.1 and qDTY3.1 (Venuprasad *et al.,* 2009), separately, were downloaded from the marker data set at Gramene (http://www.gramene.org) and the groundworks were specially combined from Sigma-Aldrich (Bengaluru, India) (Table-4).

Drought tolerance degree (DTD)

Drought tolerance degree (DTD) esteem was determined for leaf drying characteristic in parental lines (ADT37 and IR81869 B-195) and descendants of F1, BC_1F_1 and BC_2F_1 age under dry season pressure condition as per Zu *et al.,* (2017). DTD is characterized as the mean of the proportions of green leaf length to add up to leaf length of the best three leaves in each plant after serious dry spell treatment. DTD esteems subsequently shift from zero to one. The green leaf length and the absolute leaf length of the primary leaf are assigned as F1 and F2, individually. Additionally, the green leaf length and the absolute leaf length of the subsequent leaf are independently assigned as S1 and S2, and those of the third leaf as T1 and T2. The untreated control cultivars were taken care of similarly to acquire their DTD values. The DTD worth of every material was determined by the accompanying equation: $N_j = 1/n \sum_{i=1}^{n} [(F_1/F_2 + S_1/S_2 + T_1/T_2)/3]$

Where, X_j represents DTD value of each cultivar.

Heterosis

Heterosis was finished by Turner (1953) for leaf drying characteristic in parental lines (ADT37 and IR81869 B-195), progenies of F_1, BC_1 and BC_2 generation as follows:

Heterosis over mid parent (H1)

$$HMP(\%) = \frac{\bar{F1} - \bar{MP}}{\bar{MP}} \times 100$$

Heterosis over better parent (H2)

$$HBP(\%) = \frac{\bar{F1} - \bar{BP}}{\bar{BP}} \times 100$$

Where, *F1* = mean of *F1,* $\bar{F1}$, $\bar{MP}$ = mean of the two guardians and $\bar{BP}$ = mean of the better parent.

Statistical analysis

In this review, varieties were dissected for DTD worth and heterosis of rice descendants between BC populaces in view of mean worth, change, standard deviation, standard mistake, coefficient difference % and relationship coefficient utilizing factual adding machine accessible on https://www.socscistatistics.com.

RESULTS AND DISCUSSION

Dry spell pressure hampers the rice development through restricted leaf development, diminished leaf region, leaf rolling, leaf drying, thickened leaf size, early senescence, stomatal conclusion and cutinized layer on the leaf surface because of water pressure (Zhu *et al.,* 2020 and Panda *et al.,* 2021). Dry season's effect impacts rice plant at any development stage, especially conceptive stage is extremely touchy. In this association, rice researchers of International Rice Research Institute (IRRI), Philippines have recognized many significant drought tolerance

at yielding (DTY) QTLs (qDTY1.1-qDTY12.1) for regenerative stage dry spell resilience and these QTLs have been integrated into numerous uber rice assortments like IR64, MTU1010, Swarna, Sabitri, TDK1 and Vandana (Sandhu *et al.,* 2014). In this review, we consolidated two DTY QTLs (DTY3.1 and DTY2.1) related with dry spell resilience at conceptive stage, from IR81869 B-195 rice genotype into the hereditary foundation of a cutting edge rice assortment (ADT37) in view of higher DTD and heterosis esteem through backcrossing strategy. Before the course of consolidation of these QTLs, we noted safe response at vegetative and conceptive stage in giver parent, IR 81869 B-195 harboringqDTY3.1 and qDTY2.1 and powerless response in beneficiary parent, ADT37 having no DTY QTLs for dry season resilience at regenerative stage in parental polymorphism at phenotypic level. In ADT37 (beneficiary) and IR81869 B-195 (giver), leaf moving occurrence was recorded to score 5 and score 1, separately submerged pressure condition. After re-water system, scale for leaf drying was score 1 (safe) in both parental lines on fourth day. On sixth day, leaf drying rate

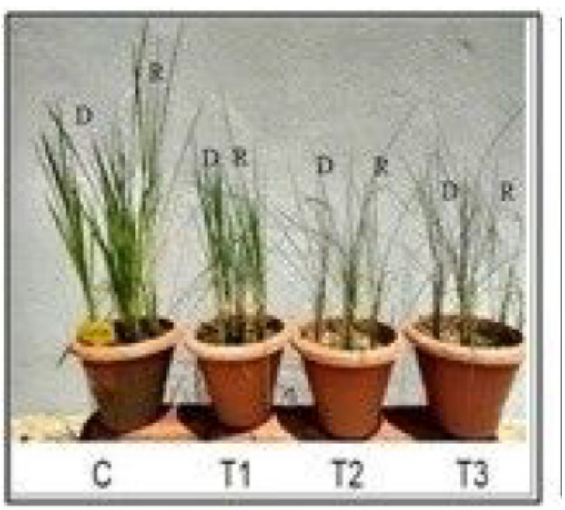


Figure 2. Study of polymorphism between ADT37 (R) and IR81869-B-B-195 (D) at phenotypic level.

was enrolled as score 1 in giver line and score 9 in beneficiary line. On eighth day, both parental lines showed profoundly vulnerable response (score 9) (Fig.2).

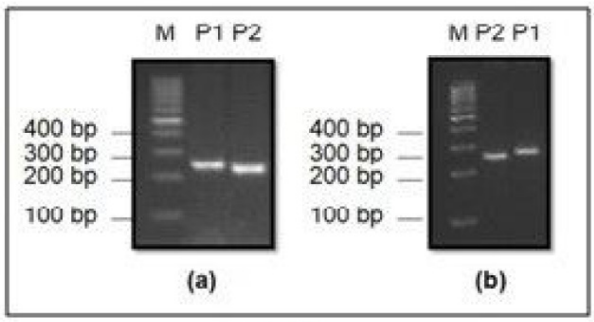
C- Control under flooding **T**- Treatment under drought stress at **T1**- 4th day; **T2**- 6th day;

T3- 8th day drought stress after leaf rolling.

Under flooding, both parental lines were profoundly safe (score 0) to both rate of leaf rolling and leaf drying. Additionally, drought tolerance degree yielded more (0.61) and less (0.31) DTD esteem in ADT37 and IR81869 B-195, separately. In charge (flooding), DTD esteem was higher (1.0) in both parental lines. During dry season pressure at the hour of generation, the pace of seed setting in ADT37 was score 7 (11 - 40%) and score 3 (61 - 80%) in IR81869 B-195. In charge, the pace of seed setting was noted to score 1(more than 80%) in both parental lines. Subsequently, we noticed the differential responses of contributor and beneficiary parent under dry spell pressure condition during vegetative and conceptive stage at phenotypic level. At genotypic level, we reported a polymorphic banding design somewhere in the range of ADT37 and IR81869 B-195 in PCR enhancement for qDTY3.1 and qDTY2.1. In contributor and beneficiary line, PCR band size was around 280 base matches and 290 base sets for RM520 marker connected with qDTY3.1 while for RM521 connected with qDTY2.1, the PCR band size was 280 base sets in beneficiary and 250 base matches in giver (Fig.3 a, b).

(a) RM 520 (DTY 3.1) and **(b)** RM521 (DTY 2.1).**M-**100 bp DNA ladder.**P1-** ADT37(Recipient); **P2-**IR81869-B-B-195 (Donor).

Consequently, we could separate the parental lines from one another at genotypic level additionally 1using QTL-connected SSR



2b

Figure 3. Parental polymorphism at genotypic level with simple sequence repeat (SSR) marker.

markers. As of now, these markers, have been accounted for as connected markers of enormous impact QTLs, DTY3.1 (RM520) and DTY2.1 (RM521) under extreme marsh dry season pressure (Venuprasad *et al.,* 2009). These QTLs have been recognized in Apo rice assortment and qDTY3.1 and qDTY2.1 are situated on chromosome 3 and chromosome 2 with 31% and 13-16% of hereditary difference for grain yield, respectively. Of these QTLs, qDTY3.1 has been integrated into the hereditary foundation of many rice assortments due to its significant job in dry spell resilience in swamp and direct seed planting upland regions (Sandhu *et al.,* 2014). Recently, these SSR markers have been utilized in closer view choice for introgression of qDTY3.1 and qDTY2.1 into the hereditary foundation of Pusa 44 rice assortment (Dwivedi *et al.,* 2021). From F1 populace, just 40 F1 descendants were forced dry spell pressure at vegetative stage. In the perception of leaves of these descendants following dry season pressure for leaf drying rate, first (from top of the plant) and second leaf displayed differential reactions to dry spell pressure in the scope of exceptionally impervious to profoundly vulnerable response and third leaf showed just profoundly powerless response. It shows the limit of descendants at different degrees. In dry season screening, DTD esteem was higher in giver (0.62) and lower in beneficiary (0.31). Higher and lower level of leaf drying among benefactor and beneficiary are relied upon the degree of cell demise which is brought about by creation of responsive oxygen species (ROS) under dry season pressure (Panda *et al.,* 2021). Besides, the higher pace of leaf drying is connected with lower level of proline creation. Here, the pace of DTD worth of 40 F1 descendants went from 0.13 to 0.74 with mean worth, difference, SD and SE of 0.45, 0.02, 0.02 and 0.003, individually. In heterosis study for leaf drying character, we noted positive and negative qualities for either mid-parent or better parent in the scope of - 71.73 - 60.86 and - 58.06 - 138.70, separately. In this examination, we noticed that positive and adverse aftereffects of heterosis agree with higher and lower worth of dry spell resistance degree separately. More elevated level of heterosis in rice descendants demonstrates protection from dry season pressure (Michael and Rangasamy, 2002). As of late, positive heterosis is accounted for the characteristics of number of powerful turners, spikelet ripeness, grain yield, and 100-grain weight, featuring the potential for upgraded efficiency under dry spell pressure (Priya *et al.,* 2024). Here, 10 plants (# F1-9, 11, 14, 17, 20, 21, 22, 23 and 39) with higher DTD values at the pace of 55.07%, 58.10%, 56.31%, 53.73%, 47.45%, 55.71%, 44.64%, 56.31% and 41.50% over the RP (ADT37) were chosen (Table-5).

We could separate the dry tolerant open minded lines of from intolerant lines plainly founded on DTD an incentive for leaf drying character. DTD is a basic technique to distinguish dry spell open minded rice genotype at early development stage (Zu *et al.,* 2017). Moreover, DTD is related with water potential, endurance rate, panicles per plant, spikelet's per panicle, seed setting rate, yield per plant, content of proline, chlorophyll and malondialdehyde (Kumar *et al.,* 2009). Chosen plants were backcrossed with its RP and

Table 5. Selection of drought tolerant F_1 progenies based on drought tolerance degree and heterosis.

	Drought stress					
	Leaf Position				Heterosis	
Geno type	1st Leaf score	2nd Leaf Score	3rd Leaf score	DTD Value	MP	BP
Donor	5	7	9	0.31		
Recipient	0	5	7	0.62		
F_{1-1}	7	7	9	0.27	-41.30	-12.90
F_{1-2}	3	9	9	0.37	-19.56	19.35
F_{1-3}	5	5	9	0.46	0.0	48.38
F_{1-4}	1	7	9	0.48	4.34	54.83
F_{1-5}	3	7	9	0.44	-4.34	41.93
F_{1-6}	3	7	9	0.43	-6.52	38.70
F_{1-7}	5	7	9	0.37	-19.56	19.35
F_{1-8}	5	7	9	0.27	-41.30	-12.90
F_{1-9}	1	3	7	0.69	50.00	122.58
F_{1-10}	5	5	9	0.34	-26.08	9.67
F_{1-11}	1	3	7	0.74	60.86	138.70
F_{1-12}	5	5	7	0.53	15.21	70.96
F_{1-13}	1	7	9	0.47	2.17	51.61
F_{1-14}	1	5	7	0.71	54.34	129.03
F_{1-15}	5	5	9	0.41	-10.86	32.25
F_{1-16}	1	5	9	0.52	13.04	67.74
F_{1-17}	1	7	7	0.63	36.95	103.22
F_{1-18}	5	5	9	0.38	-17.39	22.58
F_{1-19}	1	7	9	0.45	-2.17	45.16
F_{1-20}	1	5	7	0.67	45.65	116.12
F_{1-21}	1	5	9	0.59	28.26	90.32
F_{1-22}	0	5	7	0.70	52.17	125.80
F_{1-23}	0	5	9	0.56	21.73	80.64
F_{1-24}	0	5	9	0.52	13.04	67.74
F_{1-25}	5	5	9	0.41	-10.86	32.25
F_{1-26}	1	3	7	0.67	45.65	116.12
F_{1-27}	0	1	9	0.70	52.17	125.80
F_{1-28}	9	0	7	0.18	-60.86	-41.93
F_{1-29}	3	9	9	0.35	-23.91	12.90
F_{1-30}	9	1	9	0.34	-26.08	9.67
F_{1-31}	3	5	9	0.51	10.86	64.51
F_{1-32}	7	9	9	0.13	-71.73	-58.06
F_{1-33}	7	7	9	0.23	-50.00	-25.80
F_{1-34}	7	9	9	0.24	-47.82	-22.58
F_{1-35}	3	9	9	0.32	-30.43	3.22

	Drought stress					
	Leaf Position				Heterosis	
Geno type	1st Leaf score	2nd Leaf Score	3rd Leaf score	DTD Value	MP	BP
F_{1-36}	5	3	9	0.42	-8.69	35.48
F_{1-37}	5	7	9	0.39	-15.21	25.80
F_{1-38}	5	7	9	0.31	-32.60	0.00
F_{1-39}	5	0	9	0.53	15.21	70.96
F_{1-40}	5	3	9	0.48	4.34	54.83

Table 6. Selection of drought tolerant BC_1F_1 progenies based on drought tolerance degree and Heterosis.

	Drought stress					
	Leaf Position				Heterosis	
Geno type	1st Leaf score	2nd Leaf Score	3rd Leaf score	DTD Value	MP	BP
Donor	5	7	9	0.42		
Recipient	0	5	7	0.62		
$F_{1-9.1}$	**1**	**3**	**7**	**0.73**	**60.86**	**138.70**
$F_{1-9.2}$	5	5	7	0.52	15.21	70.96
$F_{1-9.3}$	1	7	9	0.48	2.17	51.61
$F_{1-9.4}$	**1**	**5**	**7**	**0.73**	**54.34**	**129.03**
$F_{1-9.5}$	5	5	9	0.43	-10.86	32.25
$F_{1-11.1}$	1	5	9	0.54	13.04	67.74
$F_{1-11.2}$	**1**	**7**	**7**	**0.62**	**36.95**	**103.22**
$F_{1-11.3}$	5	5	9	0.36	-17.39	22.58
$F_{1-11.4}$	1	7	9	0.48	-2.17	45.16
$F_{1-11.4}$	**1**	**5**	**7**	**0.65**	**45.65**	**116.12**
$F_{1-11.5}$	**1**	**5**	**9**	**0.60**	**28.26**	**90.32**
$F_{1-14.1}$	**0**	**5**	**7**	**0.72**	**52.17**	**125.80**
$F_{1-14.2}$	0	5	9	0.54	21.73	80.64
$F_{1-14.3}$	0	5	9	0.53	13.04	67.74
$F_{1-14.4.}$	5	5	9	0.42	-10.86	32.25
$F_{1-14.5}$	**1**	**3**	**7**	**0.68**	**45.65**	**116.12**
$F_{1-17.1}$	**0**	**1**	**9**	**0.71**	**52.17**	**125.80**
$F_{1-17.2}$	9	0	7	0.19	-60.86	-41.93
$F_{1-17.3}$	3	9	9	0.36	-23.91	12.90
$F_{1-17.4}$	9	1	9	0.35	-26.08	9.67
$F_{1-17.5}$	3	5	9	0.52	10.86	64.51
$F_{1-20.1}$	7	9	9	0.15	-71.73	-58.06

$F_{1\text{-}20.2}$	7	7	9	0.24	-50.00	-25.80
$F_{1\text{-}20.3}$	7	9	9	0.26	-47.82	-22.58
$F_{1\text{-}20.4}$	3	9	9	0.31	-30.43	3.22
$F_{1\text{-}20.5}$	5	3	9	0.41	-8.69	35.48
$F_{1\text{-}21.1}$	5	7	9	0.40	-15.21	25.80
$F_{1\text{-}21.2}$	5	7	9	0.33	-32.60	0.00
$F_{1\text{-}21.3}$	5	0	9	0.52	15.21	70.96
$F_{1\text{-}21.4}$	5	3	9	0.46	4.34	54.83
$F_{1\text{-}21.5}$	5	7	9	0.38	-15.21	25.80
$F_{1\text{-}22.1}$	3	5	9	0.45	-4.34	41.93
$F_{1\text{-}22.2}$	5	9	9	0.18	-65.21	-48.38
$F_{1\text{-}22.3}$	3	7	9	0.41	-13.04	29.03
$F_{1\text{-}22.4}$	7	9	9	0.23	-54.34	-32.25
$F_{1\text{-}22.5}$	9	5	9	0.24	-50.00	-25.80
$F_{1\text{-}23.1}$	5	7	9	0.35	-30.43	3.22
$F_{1\text{-}23.2}$	7	9	9	0.24	-56.52	-35.48
$F_{1\text{-}23.3}$	1	9	9	0.34	-30.43	3.22
$F_{1\text{-}23.4}$	1	7	9	0.51	8.69	61.29
$F_{1\text{-}23.5}$	7	9	9	0.13	-69.56	-54.83

Table 7. Selection of drought tolerant BC_2F_1 progenies based on drought tolerance degree and heterosis.

	Drought stress					
	Leaf Position				**Heterosis**	
Geno type	**1st Leaf score**	**2nd Leaf Score**	**3rd Leaf score**	**DTD Value**	**MP**	**BP**
Donor	5	7	9	0.30		
Recipient	0	5	7	0.59		
$F_{1\text{-}9.1.1}$	1	7	9	0.49	4.34	54.83
$F_{1\text{-}9.1.2}$	3	7	9	0.43	-4.34	41.93
$F_{1\text{-}9.1.3}$	3	7	9	0.42	-6.52	38.70
$F_{1\text{-}9.1.4}$	5	7	9	0.38	-19.56	19.35
$F_{1\text{-}9.1.5}$	5	7	9	0.28	-41.30	-12.90
$F_{1\text{-}9.4.1}$	**1**	**3**	**7**	**0.68**	**50.00**	**122.58**
$F_{1\text{-}9.4.2}$	5	5	9	0.33	-26.08	9.67
$F_{1\text{-}9.4.3}$	**1**	**3**	**7**	**0.72**	**60.86**	**138.70**
$F_{1\text{-}9.4.4}$	5	5	7	0.54	15.21	70.96
$F_{1\text{-}9.4.5}$	1	7	9	0.46	2.17	51.61
$F_{1\text{-}11.1.1}$	**1**	**5**	**7**	**0.72**	**54.34**	**129.03**
$F_{1\text{-}11.1.2}$	5	5	9	0.43	-10.86	32.25
$F_{1\text{-}11.1.3}$	1	5	9	0.55	13.04	67.74
$F_{1\text{-}11.1.4}$	**1**	**7**	**7**	**0.62**	**36.95**	**103.22**
$F_{1\text{-}11.1.5}$	5	5	9	0.39	-17.39	22.58

Geno type	Drought stress				Heterosis	
	Leaf Position					
	1st Leaf score	2nd Leaf Score	3rd Leaf score	DTD Value	MP	BP
$F_{1\text{-}14.1.1}$	1	7	9	0.44	-2.17	45.16
$F_{1\text{-}14.1.2}$	**1**	**5**	**7**	**0.66**	**45.65**	**116.12**
$F_{1\text{-}14.1.3}$	**1**	**5**	**9**	**0.60**	**28.26**	**90.32**
$F_{1\text{-}14.1.4}$	**0**	**5**	**7**	**0.70**	**52.17**	**125.80**
$F_{1\text{-}14.1.5}$	0	5	9	0.55	21.73	80.64
$F_{1\text{-}17.1.1}$	0	5	9	0.53	13.04	67.74
$F_{1\text{-}17.1.2}$	5	5	9	0.43	-10.86	32.25
$F_{1\text{-}17.1.3}$	**1**	**3**	**7**	**0.68**	**45.65**	**116.12**
$F_{1\text{-}17.1.4}$	**0**	**1**	**9**	**0.71**	**52.17**	**125.80**
$F_{1\text{-}17.1.5}$	9	0	7	0.15	-60.86	-41.93

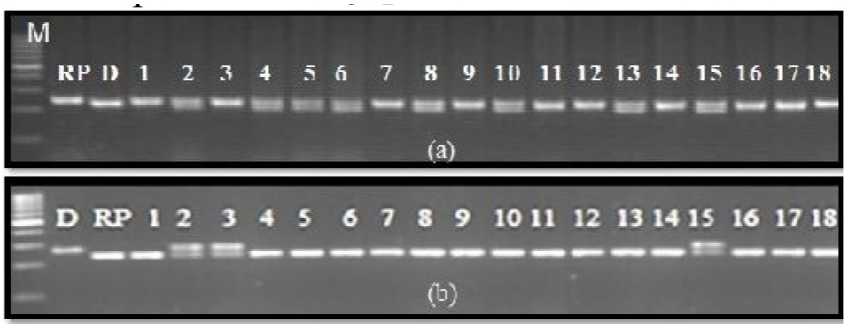


Figure 4. PCR amplification of BC_3F_1 population using SSR marker, (a) RM520 and (b) RM521 linked with qDTY3.1 and qDTY2.1, respectively. M: 100 base pair DNA ladder; D- IR81869-B-B-195; RP- ADT37; Lane 1&2: # F_1-9.4.1; Lane 3&4: # F_1-9.4.3; Lane 5&6: F_1-11.1.1; Lane 7&8: #F_1-11.1.4; Lane 9&10: #F_1-14.1.2; Lane 11&12: #F_1-14.1.3; Lane 13&14: #F_1-17.1.4; Lane 15 &16: #F_1-17.1.3; Lane 17&18: #F_1-17.1.9.

created 62 seeds for BC1F1 age. In the BC1F1 populace, DTD upsides of 40 rice descendants were noted in the scope of 0.13-0.73 with mean worth, change, SD and SE of 0.43, 0.02, 0.02, 0.003, individually. Pace of MP and BP was in the scope of - 71.73 to 54.34 and - 58.06-129.03, separately. From these, various eight descendants (plant # F1-9.1, 9.4; 11.2; 11.4; 11.5; 14.1; 14.5 and 17.1) were chosen in light of higher DTD esteem which is 54.79%, 54.79%, 46.77%, 49.23%, 45.0%, 54.16%, 51.47% and 53.52% higher than that of RP (0.42) (Table-6).

Following the backcrossing, 51 seeds were delivered for BC2F1 age. In this populace, the base and greatest worth of DTD, MP and BP esteem was 0.28 and 0.72, - 41.30 and 60.86, - 12.90 and 138.70, separately. Mean worth, range, fluctuation, SD and SE for DTD worth of these descendants was 0.51, 0.15-0.72, 0.02, 0.02 and 0.004, individually. From these, 9 descendants (#F1-9.4.1; 9.4.3; 11.1.1; 11.1.4; 14.1.2; 14.1.3; 14.1.4; 17.1.3 and 17.1.9) were chosen as dry season lenient with 55.9%, 58.3%, 58.3%, 51.6%, 54.5%, 50.0%, 57.1%, 55.9% and 57.7% predominant than RP(Table-7).

Table 8. Analysis the variations of drought tolerance degree (DTD) among the BC population.

Rice progenies	Mean	Variance	Standard Deviation	Standard Error	Coefficient variance %
F_1 generation	0.45	0.15	0.02	0.003	0.04
BC_1F_1 generation	0.43	0.17	0.02	0.02	0.04
BC_2F_1 generation	0.51	0.10	0.03	0.006	0.05

At long last, they chose descendants were utilized for backcrossing with RP and delivered 73 seeds for BC3F1 age. At sub-atomic level, various eight plants (#F_1-9.4.1; #F_1-9.4.3; #F_1-11.1.1; #F_1-11.1.4; #F_1-14.1.2; #F_1-17.1.4; #F_1-17.1.3) and three plants (#F_1-9.4.1; #F_1-9.4.3; #F_1-17.1.4) were recorded as certain for qDTY3.1 and qDTY2.1 in light of heterozygous allelic condition utilizing frontal area marker (RM520 and RM521) from BC3F1 populace in PCR enhancement (Fig. 4 a, b). From these plants, various two plants holding onto both QTLs (DTY3.1 and DTY2.1) were recognized QTLs were self-pollinated and created BC_3F_2 seeds.

In measurable review, varieties were dissected for DTD worth of rice descendants between BC populace (Table-8). Mean worth, fluctuation, standard deviation, standard blunder and coefficient change % of rice descendants of F_1 age was 0.45, 0.15, 0.02, 0.003 and 0.04 individually. In rice descendants of BC_1F_1 age, the mean worth, fluctuation, standard deviation, standard blunder and coefficient change % was noted to 0.43, 0.17, 0.02, 0.02 and 0.04, separately. For the rice descendants of BC_2F_1 age, the mean worth, fluctuation, standard deviation, standard blunder and coefficient change % was enlisted to 0.51, 0.10, 0.03, 0.006 and 0.05, individually. Here, the most noteworthy and least mean worth was noted in rice descendants of BC_2 and BC_1 age, separately. The pace of difference was high in BC_1 age and low in BC_2 age. The degree of standard deviation was same in F_1 and BC_1 age yet BC_2 age is veered off from them. The degree of standard blunder was extremely low in BC2 age when contrast with F_1 and BC_1 age. The level of coefficient difference was high in BC_2 age and low in F_1 and BC_1 age.

In straight connection examination, critical positive connections were seen between DTD worth and heterosis in F_1 (r=0.54 for MP; r=0.20 for BP) and BC_2 (r=2.21 for MP; r=1.0 for BP) age. In BC_1 age, a non-huge negative relationship was found between DTD worth and heterosis (r = - 0.58 for MP; r=0.05 for BP). These outcomes recommend that the positive connection between DTD worth and heterosis increments with expanding hereditary foundation of RP.

CONCLUSIONS

In the current review, two significant quantitative trait locus (DTY3.1 and DTY2.1) connected with dry season resistance at conceptive stage are consolidated with the dry spell helpless genome of ADT37 rice assortment effectively through cross-fertilization. The hereditary foundation of ADT37 assortment is recuperated through a resulting mindful backcrossing the BC populace with its intermittent parent up to BC_3F_1 age. Simultaneously, the degree of dry season resilience of rice descendants of each BC age is kept up with in view of serious level of dry spell resistance and heterosis for the quality of leaf drying. Finally, effective joining of both DTY3.1 and DTY2.1 QTLs was recognized in two rice descendants of BC_3F_1 populace from PCR enhancement utilizing SSR marker (RM520 and RM521) connected with these

QTLs. Also, it is accounted for that the dry spell open minded descendants created through cautious cross-fertilization and phenotypic choice are related with positive heterosis and high DTD esteem. Here, we have given a due significance for phenotypic determination as opposed to genotypic choice to choose unrivaled rice lines under dry spell pressure condition for environment strong rice source. Accordingly created NILs for ADT37 rice assortment would be assessed for the predictable impact of these loci in grain yielding under dry spell pressure in future.

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ANALYSIS OF ANTICANCER POTENTIAL OF JACKFRUIT FLOUR COMPOUNDS: A COMPARISON WITH TAMOXIFEN FOR BREAST CANCER THERAPY

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ABSTRACT

Tamoxifen effectively prevents and treats estrogen-dependent breast cancers, tamoxifen therapy carries a risk factor of developing endometrial tumors. *Artocarpus heterophyllus Lam*, popularly referred to as jackfruit, is a widely available fruit rich in natural bioactive compounds with promising anticancer potential. LCMS analysis of a methanolic extract from raw jackfruit flour revealed 563 compounds. Computational modeling simulations were conducted for these compounds using the glide docking panel within maestro 11.9 (Schrödinger Suite) to evaluate their binding affinity to the human estrogen receptor alpha ligand-binding domain (ERá LBD), with the structure of the GW5638-ERa LBD complex (PDB ID: 1R5K) serving as the reference. Fifty-two compounds successfully engaged with the human estrogen receptor alpha, surpassing a glide score threshold of -5 (kcal/mol), with 48 of them achieving a Glide score equal to or higher than -5 (kcal/mol). Among these, fluvastatin sodium (Lescol), pravastatin sodium, and 1,7-bis(4-hydroxyphenyl)-5-[(2R,3R,4S,5S,6R)-3,4,5-trihydroxy-6-(hydroxymethyl)oxan-2-yl]oxyheptan-3-onedemonstrated impressive binding energies of -10.791,-10.063 and -10.005, respectively, surpassing tamoxifen's binding energy of -9.856 in docking experiments. Besides, in ADME analysis fluvastatin sodium exhibited superior ADME properties compared to tamoxifen.This advantageous solubility profile and its promising docking scores position fluvastatin sodium as a robust candidate warranting further consideration in breast cancer drug development.

Keywords: Breast cancer, Jackfruit, LCMS analysis, Molecular docking, ADME analysis

INTRODUCTION

Noncommunicable diseases emerge as a significant threat to global health(WHO, 2022). Cancer is one of the main noncommunicable diseases with more than 277 different types of cancers being identified so far (Hassanpour and Dehghani, 2017). Breast cancer continues to be a major global health concern. It is a heterogenous disease and is the main cancer found in women with 2.6 million cases worldwide in 2020, with a significant death rate among women across the globe (Wilkinson and Gathani, 2022; Yerushalmi *et al.,* 2009). While conventional therapies remain the mainstay of breast cancer treatment, the exploration of natural products with potential anti-cancer properties holds promise. Although tamoxifen has been the mainstay of treatment, there are

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possible adverse effects. Investigating complementary or alternative therapies with fewer side effects is essential. An achievable option is jackfruit flour, which is high in antioxidants and other possibly advantageous ingredients.

Jackfruit fruit scientifically known as *Artocarpus heterophyllus Lam* is a powerhouse of nutrition, boasting an abundance of vitamins and minerals and packed with phytochemicals and antioxidants, helping to ward off chronic diseases (Gupta *et al.,* 2023; Haleel *et al.,* 2018; Sidhu, 2012). Since jackfruit is abundant in nature, anticancer activity is helpful in the cancer research field.

Although jackfruit's nutritional value and abundance are widely known, research into its possible anti-cancer effects is still in its infancy. Studies conducted *in vitro* and *in vivo* are required to confirm the preliminary promise that the bioactive compounds in jackfruit suggest. In this initial phase, molecular docking simulations can be a useful tool for researchers to find chemicals produced from jackfruit that may interact with proteins involved in the development of breast cancer. The combination of high-throughput screening methods and in silico technologies are a very useful approach in the current study, facilitating the drug discovery process and concurrently curtailing both time and costs (Lage *et al.,* 2018; Vijayababu and Kurian, 2021).

This study explores the potential of compounds found in jackfruit flour and juxtaposes their efficacy with that of tamoxifen. It compares various methods to determine the possible benefits and drawbacks of employing compounds from jackfruit flour as a breast cancer treatment and offers important vital insights for the development of innovative and potentially safer therapeutic options for breast cancer.

MATERIAL AND METHODS

Sample preparation

Soft variety fully matured jackfruits were harvested, and jackfruit bulbs were separated and dried. After drying bulbs were powdered using mechanical blenders and kept in airtight plastic bags for further study.

LCMS analysis

It was performed on Xevo G2-XS QT and Acquity UPLC. Methanolic extract of the flour was

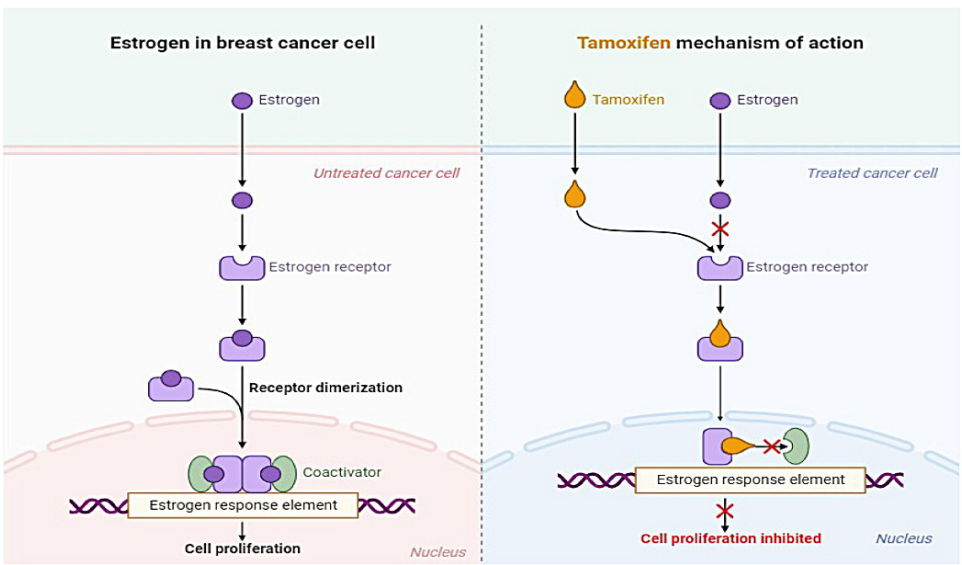

Figure 1.Tamoxifen mechanism of action in breast cancer image recreated with BioRender and the source of Schuurman, *et al.,* 2019.

used to conduct the LCMS analysis. Based on the compounds identified through LCMS analysis, ligand molecules were retrieved from the PubChem database which provided information on properties like the molecular formula, canonical smiles, molar mass, and both the two-dimensional and three-dimensional structures of each compound found in raw jackfruit flour.

Selection of target protein

Estrogens have been widely recognized for their pivotal role in fostering the growth of a substantial proportion of breast cancers. Over half of all breast cancer cases demonstrate over expression of estrogen receptor alpha (ER alpha), with approximately 70 percent of these cases exhibiting positive responses to anti-estrogen therapies like tamoxifen (Rusidzé *et al.,* 2021). However, tamoxifen therapy carries a risk factor of developing endometrial tumors.

The 3-dimensional arrangement of the estrogen receptor alpha (ER alpha) ligand-binding domain (LBD complexed with compound GW5638) has already been reported. GW5638 is a structurally similar compound to tamoxifen. The structure of GW5638-ER alpha LBD, represented by the human estrogen receptor alpha ligand-binding domain complex with GW5638 (PDB ID: 1R5K), was obtained from the Protein Data Bank (Wu *et al.,* 2005) for this current study. The Protein Data Bank is the global repository for 3D structural information about crucial biological macromolecules and nucleotides.

Molecular interaction studies

In cancer research, Insilico docking is a powerful filter for the drug discovery process. Docking studies support biomarker identification and help to identify the mechanisms underlying cancer progression and drug discovery (Fan *et al.,* 2019). In this study glide v11.9 module was used to find out the binding affinity between the target protein and ligands.

Swiss ADME

Swiss Institute of Bioinformatics developed SwissADME is a versatile tool within the Swiss Drug Design workspace. This tool facilitates seamless access to various computer-aided drug design (CADD) applications, including bioisosteric design, virtual screening of ligands, target identification, molecular docking, and molecular dynamics. Swiss ADME streamlines the evaluation and optimization of drug-like properties, accelerating the drug development process.

Ligand preparation

The compounds found in raw jackfruit, identified through Liquid Chromatography-Mass Spectroscopy (LCMS) analysis, were incorporated into the current study. From the PubChem Database, their 3-dimensional structural coordinates were obtained in SDF format. LigPrep, in conjunction with EpiK, was employed to expand the number of hydrogens attached and tautomeric states at pH 7.0±2.0 for every molecule with the help of the LigPrep wizard. Three-dimensional arrangements were used to examine the chirality of the ligands.

Target protein retrieval and preparation

Based on the literature, the crystal structure of the human estrogen receptor alpha ligand-binding domain complex with GW5638 (PDB ID: 1R5K) was sourced from the Data Bank of Protein (Wu *et al.,* 2005). Given the polymer nature of the protein, the investigation concentrated specifically on chain A. However, the initial state of the protein structure retrieved from the PDB database is not compatible with molecular docking (Pinzi and Rastelli, 2019). To rectify this issue, the protein structure underwent optimization using Schrödinger's protein preparation wizards. This optimization procedure involved correcting bond orders, adding hydrogen atoms and missing residues, adjusting

formal charges to hetero groups, and generating ionization states at physiological pH (7.0), following the guidelines outlined by Samykannu *et al.* (2018). Although the initial instance of water molecules in the protein was systematically removed to ensure precision in subsequent molecular docking studies. Subsequently, the protein structure underwent minimization using the OPLS_2005 force field.

Target protein grid generation

A precise grid box within the binding and catalytic site of the macromolecule is important in molecular docking. Accordingly, a primary grid box with dimensions of 36×36×36Å centered on GW5638, a molecule crystallized with human estrogen receptor alpha was created. By using the receptor grid generation wizard automatically generated a secondary grid box centered on the docking site. (Samykannu *et al.,* 2018). The van der Waals radii scaling factor was set to the default value of 1.0Å, and partial atomic charges with a cutoff of less than 0.25 were used. The grid-box generation process excluded rotatable groups and constraints.

GLIDE (Grid-based Ligand Docking with Energetics)

Molecular docking predicts how small molecules bind to specific sites on protein targets which plays a crucial role in structure-based drug design, in addition, it helps to predict both binding strength and biological activity (Kandakatla and Ramakrishnan, 2014).The potential interaction between target protein and ligands was assessed using a software module, glide v11.9 (Friesner *et al*., 2006). Standard precision (SP) mode was used for the molecular docking simulation. The glide score (G-score) reflects the interaction energies between the receptor and the phytochemical. The glide score is calculated based on the following equation

Glide score = 0.065 × vdW + 0.130 × Coul + Lipo + Hbond + Metal + BuryP + RotB + Site

Swiss ADME

The SwissADME software is a tool useful in drug discovery accessible at www.swissadme.ch. The Swiss Institute of Bioinformatics (SIB) molecular modeling group created this software in 2017(Daina *et al.,* 2017). This software allows users to create and modify 2D chemical structures on the submission page powered by ChemAxon's Marvin JS(*Chemaxon*, n.d.) which incorporates a molecular sketcher. These edited structures were then automatically added to the right side of the submission page to serve as the data for calculations. The Swiss ADME accommodates multiple input molecules through a simplified molecular input line entry system (SMILES). Results for the analysis can be generated in a table format, graphical representations, or in an Excel spreadsheet for calculations.

RESULTS AND DISCUSSION

Molecular Interaction

Utilizing a glide score threshold of -5 (kcal/mol) and higher, Table 1 encompasses compounds with the lowest energy among 543 compounds from raw jackfruit flour. Of these, 52 compounds successfully engaged with the human estrogen receptor alpha, with 48 attaining a Glide score of -5 (kcal/mol). Among these 3 compounds possess a glide score threshold of above -10 (kcal/mol). The compilation of these compounds, demonstrating binding energies to tamoxifen's results, along with detailed information such as docking scores, hydrogen bond count, interacting residues, and the distances of these hydrogen bonds, is systematically arranged and summarized in Table 1 and Figures 2A & 2B, 3A & 3B, 4A & 4B and 5A & 5B.

In Figure 2 A human estrogen receptor alpha protein with the established compound (tamoxifen) Residues are color-Coded for emphasis, and notable Interactions are

Table 1. The list of compounds with binding energies compared to Tamoxifen's results from the docking experiments.

Sl.No.	Name of the compound	G-Score (kcal/mol)	Number of H bond	Interaction residues	Distance (Å)
1	Tamoxifen(known Compound)	-9.856	1	THR 347	2.38
2	Fluvastatin sodium (Lescol)	-10.791	2	LEU 536 ASH 351	2.44 1.74
3	Pravastatin sodium	-10.063	3	LEU 536 TYR 537 ASH 351	2.08 2.62 1.68
4	1,7-bis(4-hydroxyphenyl)-5-[(2R,3R,4S,5S,6R)-3,4,5-trihydroxy-6-(hydroxymethyl) oxan-2-yl]oxyheptan-3-one	-10.005	1	GLU 353	1.80

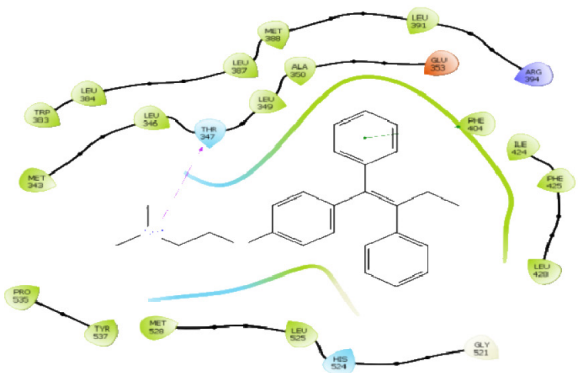

Figure 2A: Human estrogen receptor alpha protein with the established compound (tamoxifen).

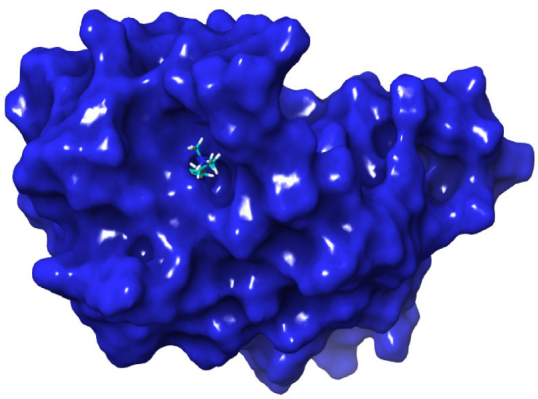

Figure 2 B: Human estrogen receptor alpha protein when interacting with the established compound tamoxifen.

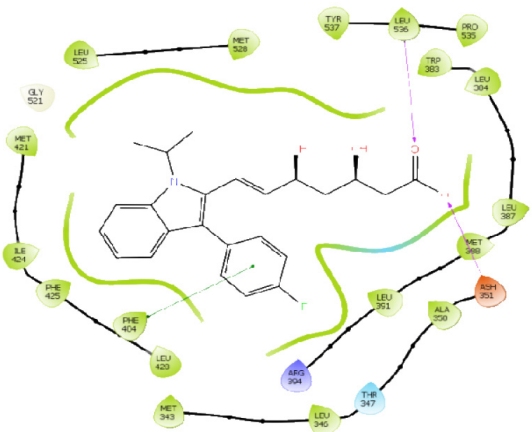

Figure 3A: Human estrogen receptor alpha protein with fluvastatin sodium.

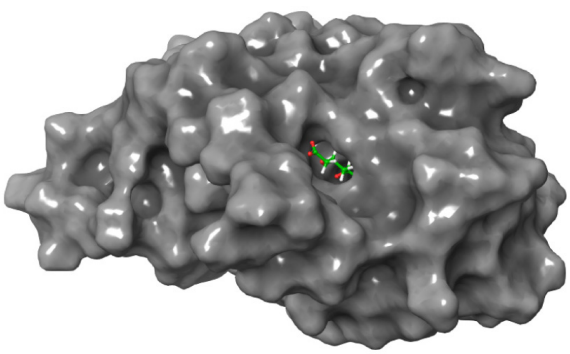

Figure 3 B: Human estrogen receptor alpha protein interacting with fluvastatin sodium.

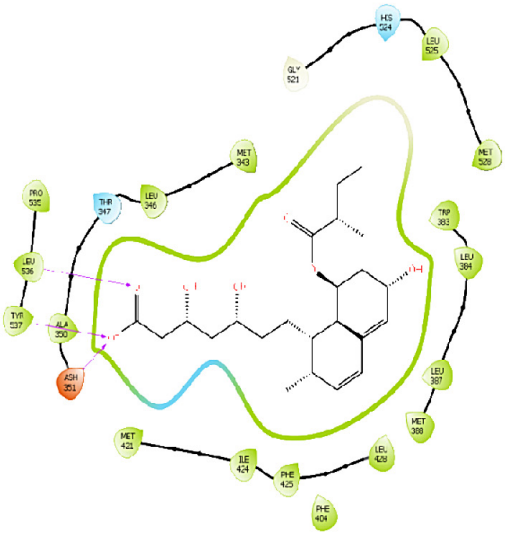

Figure 4A:Human estrogen receptor alpha protein with pravastatin sodium.

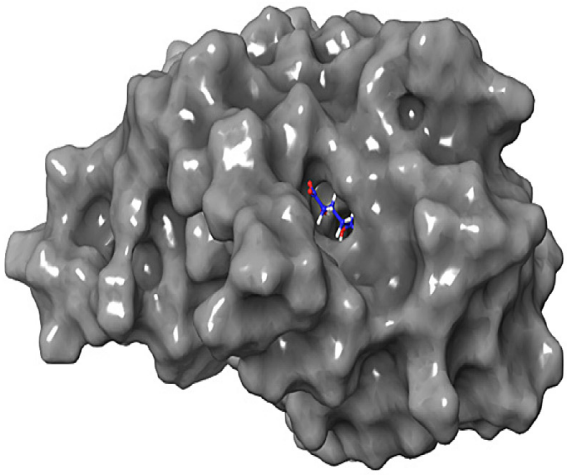

Figure 4B: Human estrogen receptor alpha protein when interacting with pravastatin sodium.

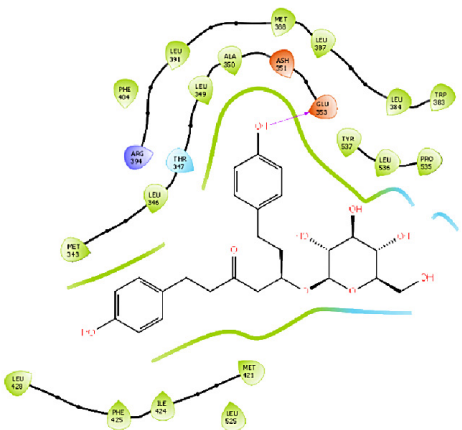

Figure *5* A: Human estrogen receptor alpha protein with 1,7-bis(4-hydroxyphenyl)-5-[(2R,3R,4S,5S,6R)-3,4,5-trihydroxy-6-(hydroxymethyl)oxan-2-yl]oxyheptan-3-one.

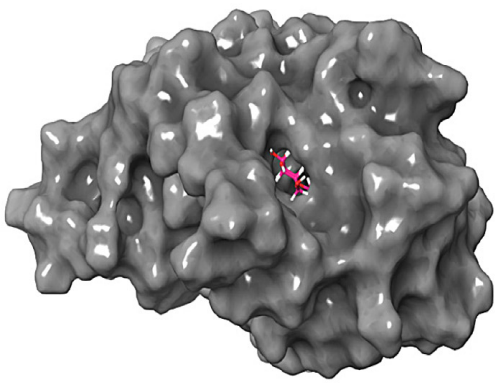

Figure 5 B: Human estrogen receptor alpha protein interacting with1,7-bis(4-hydroxyphenyl)-5-[(2R,3R,4S,5S,6R)-3,4,5-trihydroxy-6-(hydroxymethyl) oxan-2-yl] oxyheptan-3-one.

Highlighted. A hydrogen bond is evident at 2.38 Å to THR 347, represented by a pink Arrow line. Furthermore, a Pi-Pi stacking interaction is bbservable at 5.35Å to PHE 404, marked by a green line. Figure 2 B illustrates the three-dimensional representation that visually depicts the surface characteristics of the human estrogen receptor alpha protein when interacting with the established compound tamoxifen. This representation highlights tamoxifen on the protein surface, facilitates the identification of particular binding sites and regions of interaction.

In Figure 3A human estrogen receptor alpha protein with fluvastatin sodium. Distinct residues are emphasized through varied colors, featuring an H-Bond established at 2.44Å to LUE 536 and 1.74Å to ASH 351, Represented by a pink arrow line. Pi-Pi stacking interaction to PHE 404, marked by a green line. Figure 3 B visually depicts the surface characteristics of the human

estrogen receptor alpha protein when interacting with fluvastatin sodium.

Figure 4 A illustrates the analysis of the human estrogen receptor alpha protein with pravastatin sodium. Three H-bonds were established and represented by a pink arrow line. Figure 4B depicts the three-dimensional representation of the surface characteristics of the Human estrogen receptor alpha protein when interacting with pravastatin sodium.

Figure 5 A shows the 2D interaction analysis of human estrogen receptor alpha protein with 1,7-bis(4-hydroxyphenyl)-5-[(2R,3R,4S,5S,6R)-3,4,5-trihydroxy-6-(hydroxymethyl) oxan-2] oxyheptan-3-one.H-bond established and represented by a pink arrow line. Figure 5 B: is a three-dimensional representation that visually depicts the surface characteristics of the human estrogen receptor alpha protein when interacting with 1, 7-bis(4-hydroxyphenyl)-5-[(2R,3R,4S,5S,6R)-3,4,5-hydroxy-6-(hydroxymethyl) oxan-2-yl] oxyheptan-3-one.

Fluvastatin sodium (Lescol) exhibits a higher docking score of -10.791 than tamoxifen, which has a docking score of -9.856, suggesting a potentially stronger binding affinity in computational simulations. Fluvastatin sodium forms hydrogen bonds with LEU 536 and ASH 351 residues and shows closer interaction distances with all two residues whereas tamoxifen only interacts with a THR 347 residue and has a larger interaction distance with THR 347 (2.38Å) compared to fluvastatin sodium. The docking results suggest that fluvastatin sodium might have a stronger binding affinity to the target molecule than tamoxifen due to more hydrogen bonds with the target, which generally contributes to stronger and more specific binding. Also, shorter distances between the compound and the target residues suggest a tighter fit and potentially more favorable interactions.

Pravastatin sodium interacts with LEU 536, TYR 537, and ASH 351 residues at distances of 2.08Å, 2.62Å, and 1.62Å respectively, while tamoxifen interacts with THR 347 at a distance of 2.38 Å.Pravastatin sodium interacts with more residues than tamoxifen (3 vs 1) and forms a closer interaction with THR 347 (2.08 Å vs 2.38Å). These results suggest that pravastatin sodium may have a stronger binding affinity to the target molecule than tamoxifen due to more hydrogen bonds with the target, which generally contributes to stronger and more specific binding.

Unlike Tamoxifen, which interacts with THR 347 at a distance of 2.38Å, 1,7-bis(4-hydroxyphenyl)-5-[(2R,3R,4S,5S,6R)-3,4,5-trihydroxy-6-(hydroxymethyl) oxan-2-yl] oxyheptan-3one binds to a different residue, GLU 353. Notably, this interaction occurs at a significantly shorter distance of 1.80 Å. In docking simulations, shorter interaction distances often suggest stronger and more specific binding between a ligand and a receptor. Therefore, these results imply that 1,7-bis(4-hydroxyphenyl) -5-[(2R,3R,4S,5S,6R)-3,4,5-trihydroxy-6-(hydroxymethyl) oxan-2-yl] oxyheptan-3-one might have a stronger binding affinity to the target molecule compared to tamoxifen.

ADME analysis

The calculation of essential chemical-physical properties, as well as ADME properties, drug-likeness, and associated features for various molecules, are employed with the help of the SwissADME software. SwissADME emerges as a valuable tool for predicting physicochemical parameters correlated with drug-like properties. Figure 6 represents selected compounds (based on the docking with the least binding energy) from raw jackfruit flour extract. The drug-likeness of each compound was assessed with the help of a bioavailability radar tool. Physicochemical properties considered were affinity for fat, solubility, polarity

size, rotational freedom of bonds, and saturation. Adapted descriptors fix the accepted range for each physicochemical property and are represented on the radar plot as a pink area.For a molecule to be considered drug-like, its property values, represented as a point on the radar, must fall entirely within these pink zones. The ideal values are as follows.

Affinity for fats	: XLOGP3 between “0.7 and +5.0
Drug like size	: MW ranging from 150 and 500 grams per mole.
Polarity	: Total Polar Surface Area (TPSA) ranging from 20 to 130 square angstroms.
Dissolvability	: log S should be under 6
Saturation	: At least 25% of the carbon atoms are sp3 hybridized
Rotational freedom of bonds:	no more than 9 rotatable bonds.

The ideal range for each property is represented through the pink area (affinity for fat, drug-like size, polarity, Dissolvability, saturation, Rotational freedom of bonds). Compared to tamoxifen, fluvastatin sodium (Lescol) is considered a better drug-like compound derived from raw jackfruit flour since it satisfies all six parameters. But, because of the high polarity and excessive flexibility1,7-bis(4-hydroxyphenyl)-5-[(2R,3R,4S,5S,6R)-3,4,5-trihydroxy-6-(hydroxymethyl) oxan-2-yl]oxyheptan-3-one and pravastatin sodium did not possess oral bioavailability. Hence fluvastatin sodium has the potential as a drug candidate for breast cancer, possibly exceeding tamoxifen in some aspects. In support of this Elimam *et al.,* 2020; Kanugula *et al.,* 2014 reported that fluvastatin sodium exhibits anticancer properties and triggers cell death in breast cancer cells through cell cycle death or disrupting protein production. Even though tamoxifen reduces the development of breast cancers, several studies (Emons *et al.,* 2020; Hu *et al.,* 2015) reported an increased risk of developing endometrial

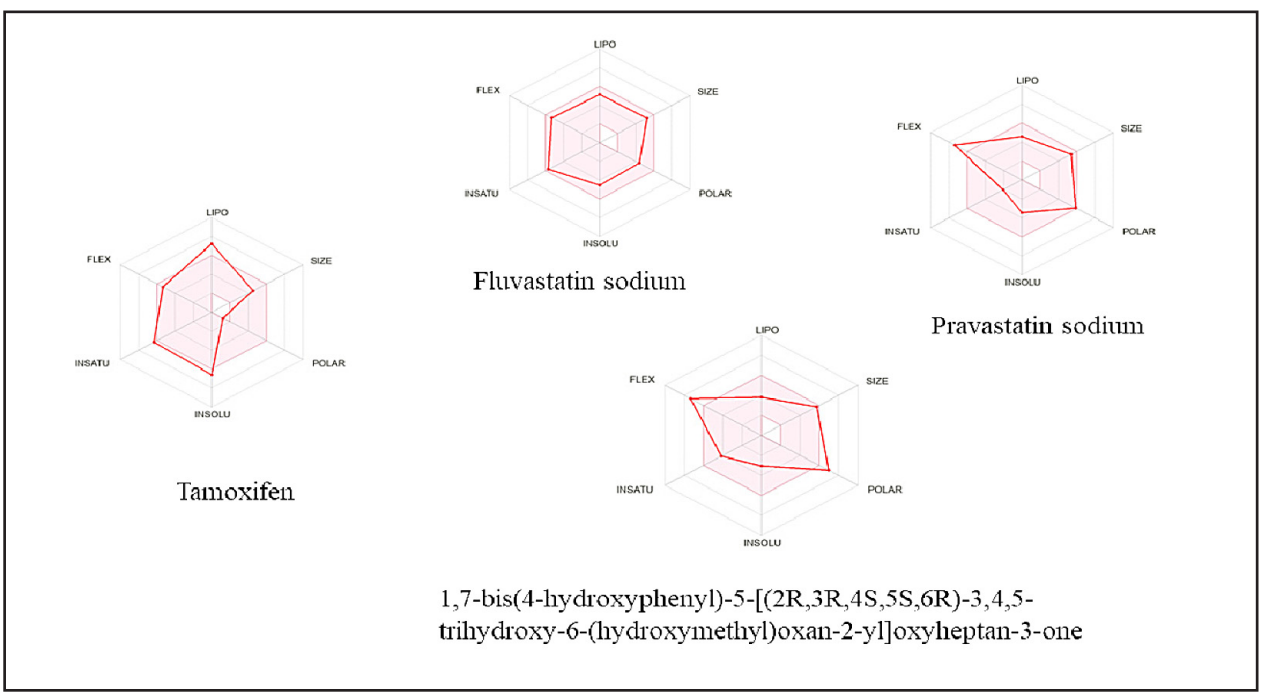

Figure 6: The Bioavailability Radar glances at the drug-likeness and ADME properties of selected compounds from raw jack fruit flour.

cancers due to tamoxifen therapy. Hence, an alternative drug could be lifesaving and beneficial for many people.

CONCLUSIONS

In the present study, compounds found in raw jackfruit flour, fluvastatin sodium (Lescol), pravastatin sodium and 1,7-bis(4-hydroxyphenyl)-5-[(2R,3R,4S,5S,6R)-3,4,5-trihydroxy-6-(hydroxymethyl)oxan-2-yl]oxyheptan-3-one exhibited promising docking scores, suggesting their potential as hit molecules for breast cancer drug design. Moreover, in the ADME analysis, fluvastatin sodium displayed better properties than tamoxifen. This favorable ADME profile, coupled with the promising docking scores, positions this compound as a strong candidate for further consideration in breast cancer drug development. Furthermore, their suitability for oral consumption enhances their potential as viable alternatives to tamoxifen. These findings collectively recommend a comprehensive exploration and validation of these compounds in the hunt for effective and orally consumable breast cancer treatment.

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SPROUTS TIKKI: A NUTRITIOUS RECIPE TO MANAGE FOLIC ACID DEFICIENCY AND OVERWEIGHT

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ABSTRACT

Attempts were made to develop Sprouts Tikki, for supplementation in December 2022 as part of Ph.D thesis, in order to overcome folic acid deficiency and overweight among the population. Bengal gram (whole) and green gram (whole) are rich in folic acid, fibre and sprouting increases their vitamin C content. Hence, these two pulses have been taken up for the development of tikki after sprouting them. According to the nutrient analysis on Sprouts Tikki, the food product contains a good amount of folic acid and fibre.The high fibre content in the Sprouts Tikki will slow down the process of digestion and gives a feeling of fullness.This will reduce the craving for food which will eventually lead to reduction of weight. The high Folic acid content will help to manage its deficiency. An Organoleptic evaluation was performed for three variations of the Sprouts Tikki and ST1 wasthe most accepted one by the sensory panel with a mean of 7.033±1.12903. The storage study revealed that the newly developed Sprouts Tikki remains in good edible condition for a period of one week with TFC reaching $1x10^2$cfu/g and TPC reaching $15x10^2$cfu/g.The amount of phytic acid in the sprouts tikki was determined to be 0.450 mg/100g. The low cost of the product makes it affordable to all the classes of the society.

Keywords: Sprouts Tikki, Recommended Dietary Allowance, Food product development, Triple Burden of Malnutrition

INTRODUCTION

Malnutrition is usually studied under the dimensions of obesity and under nutrition, as dual burden of malnutrition. Recent research, however, has shown that the dual burden of malnutrition is insufficient to address all aspect of malnutrition that are experienced by the population.Thus, in order to make the study more comprehensive, the triple burden of malnutrition, a new dimension of micronutrient deficiency, has been added to the dual burden of malnutrition. The report of World Health Organization (2020) reveals that more than two billion adult population suffer from malnutrition with micronutrient deficiency, globally. In order to address folic acid deficiency and overweight in individuals, the current study was carried out to develop Sprouts Tikki, which are high in fibre and folic acid. Whole Bengal gram was utilised for this purpose since it is a good source of folic acid and fibre. Studies show that sprouting of bengal

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Figure 1. Variations of Sprouts Tikki

gram further increases the Vitamin C and folic Acid content (Dueñas *et al.*, 2015). A study by Mlodzik-Czyzewska *et al.,* (2020) states that folic acid deficieny results in body weight gain and adiposity.The development of product after sprouting the whole bengal gram and making it in the form of tikki is expected to provide subjects with satiety as they are also rich in fibre.

MATERIAL AND METHODS

The current study of developing Sprouts Tikki was carried out in December 2022 in Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore.

Ingredients

Bengal gram (whole), green gram(whole), asafoetida, garlic, chilli powder, and salt were selected for the food product's production and were purchased from the local market.

Method

All the ingredients were weighed on a digital balance to assure accuracy. The whole green gram and whole bengal gram were soaked for twelve hours, overnight. Then the water was drained and the soaked whole green gram and bengal gram were tied in muslin cloth and left overnight for sprouting. On the next day, the sprouts were steamed to soften them and mashed. Further, all the other ingredients viz., chopped garlic, chilly powder, asafoetida and salt were added to the mashed sprouts in a bowl and thoroughly mixed.Then the mix was moulded in to small, flat and round shaped tikkis, which were placed in an oven in combination mode at 350°F for 10 minutes. The Tikkis were baked rather than the conventional method of shallow frying (John *et al.,* 2020). Baking is such a method of cooking which prevents the loss of nutrients from the food to a large extent. Three variations

Table 1. Composition of the Blends

Sr.No	Ingredients(g)	Variation1 (ST1)	Variation2 (ST2)	Variation3 (ST3)
1.	Bengal gram whole	50	40	60
2.	Green gram whole	40	50	30
3.	Garlic	10	10	10
4.	Chilli powder	2	2	2
5.	Asafoetida	1	1	1
6.	Salt	1	1	1
	Total	**104**	**104**	**104**

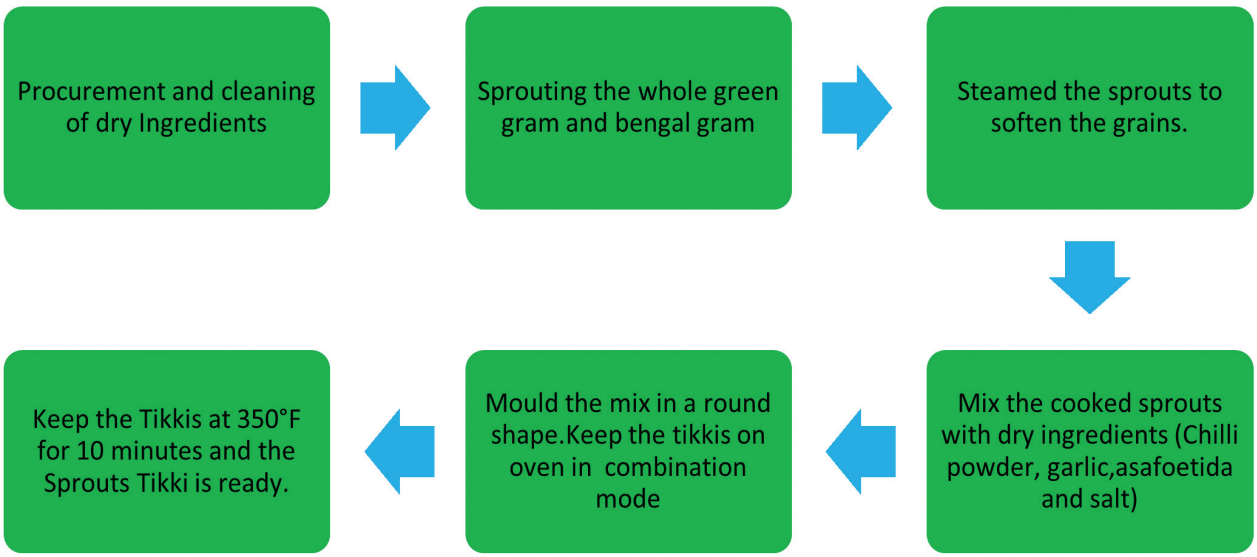

Figure 2. Sprouts Tikki preparation process

of Sprouts Tikki viz., ST1, ST2 and ST3 (Figure 1) were prepared for organoleptic/sensory evaluation. Table 1 lists the specific composition of the three blends of Sprouts Tikki. A total of 100g of Sprouts Tikki was made using 104g of ingredients. Steps involved in the preparation of Sprouts Tikki is detailed in Figure 2.

Cost calculation

Food insecurity and inadequate food diversity have been found to make the economically weaker groups more vulnerable to micronutrient deficiencies than the middle and higher socio economic levels. Therefore, it is imperative that novel products be developed that are both affordable and meet the population's nutritional demands. The ingredients used to make Sprouts Tikki are inexpensive and found in practically every kitchen. The product's final price has been established in order to assess its economic feasibility (Anna Herforth, 2020).

Organoleptic evaluation

An organoleptic evaluation was conducted for Sprouts Tikki. The organoleptic evaluation was performed using the nine-point Hedonic scale. Thirty semi-trained individuals from our own university

S. No	Nutrients	Method
1.	Moisture	AOAC 2015
2.	Total Ash	AOAC 2015
3.	Total Carbohydrate	FSSAI Manual 2016- Anthrone Reagent Method
4.	Energy	FAO Manual 2015-Bomb Calorimeter
5.	Protein	AOAC 2015-Kjeldal Method
6.	Fat	AOAC 2015- Soxhlet Extraction method
7.	Calcium	AOAC 2015 Titration Method
8.	Iron	AOAC 2015-Atomic Absorption Spectrometry
9	Folic Acid	UV-Visible Spectrometry
10.	Fibre	AOAC 2015- Fibroton method

Table 2. Nutrient Analysis

conducted the organoleptic evaluation. For each of the three variations, the developed product's colour, flavour, texture, and overall acceptability were evaluated. The product with the highest sensory score and acceptance was selected for the nutritional and shelf-life study (Fiorentini 2020).

Nutrient analysis

The most accepted Sprouts Tikki (ST1) were subjected to nutrient analysis using standard procedures (Table 2). Moisture, ash, total carbohydrate energy, protein, fibre, fat, calcium, iron, and folic acid were among the parameters that were analyzed (Kamani *et al.,* 2020). The calculated nutritive value for Vitamin C of Sprouts Tikki (ST1) by nutritive value calculation was also recorded.

Anti-nutrient analysis

Pulses contain phytic acid which is an anti-nutrient. The most accepted Sprouts Tikki (ST1) was subjected tophytic acid analysis.The Sprouts Tikki was made from whole bengal Gram and whole green gram which are pulses.

Shelf life study

A shelf life study was conducted to check for any microbiological growth in the most accepted Sprouts Tikki following organoleptic evaluation. The total bacterial and fungal counts of the food product were assessed. A pH meter was utilised to assess the pH of the developed product. The shelf life study also examined the product's changes in colour, smell, and appearance. On the 4th and 7th day of preparation, the developed product was examined for the growth of microorganisms. (Man, 2015).

Statistical analysis

Statistical Analysis was carried out between the 3 variations of the Sprouts Tikki.The data collected after the organoleptic evaluation was set for a one way ANOVA test to evaluate the significance difference and also to reject or accept the null hypothesis (Nunes *et al.*, 2015).

Table 3. Mean and standard deviation for three variations of Sprouts Tikki

Sr.No	Variations	Mean ± Standard Deviation	F-value	p-value
1.	ST1	7.0333 ± 1.12903	4.037	0.021
2.	ST2	4.8667 ± 1.43198		
3.	ST3	4.6000 ± 1.30252		

RESULTS AND DISCUSSION

Organoleptic evaluation

The statistical analysis (i.e.) one-way ANOVA was carried out for organoleptic evaluation of the three variations of Sprouts Tikki and the results are depicted in Table 3.

The statistical test on one way ANOVA was applied to the 3 variations of Sprouts Tikki. The mean value of the 3 variations were considered to assess the overall acceptance of the variation of Sprouts Tikki by 30 semi-trained judges (Figure 3) (O'Mahony, 2017). The p-value 0.021 is less than 0.05. Therefore, there is a significant difference between the 3 variations of sample. Therefore, alternate hypothesis was accepted. The organoleptic evaluation's results indicated that ST1 was the most acceptable of the 3 variations.

Cost Calculation

The cost calculation of Sprouts Tikki is depicted in Table 4. The total cost of ingredients to make 100g of the ST1 Rs 16.44. The product's packaging and electricity were regarded as overhead expenses. 100 g of Sprouts Tikki cost Rs. 1.4 to package, while 1 unit of power required for 20 minutes of baking cost Rs. 4.5. Therefore total cost of 100 g of Sprouts Tikki(ST1) is Rs 22.35.

Nutrient analysis

Table 5 shows the results of the analysis of the Sprouts Tikki (ST 1) for folic acid,

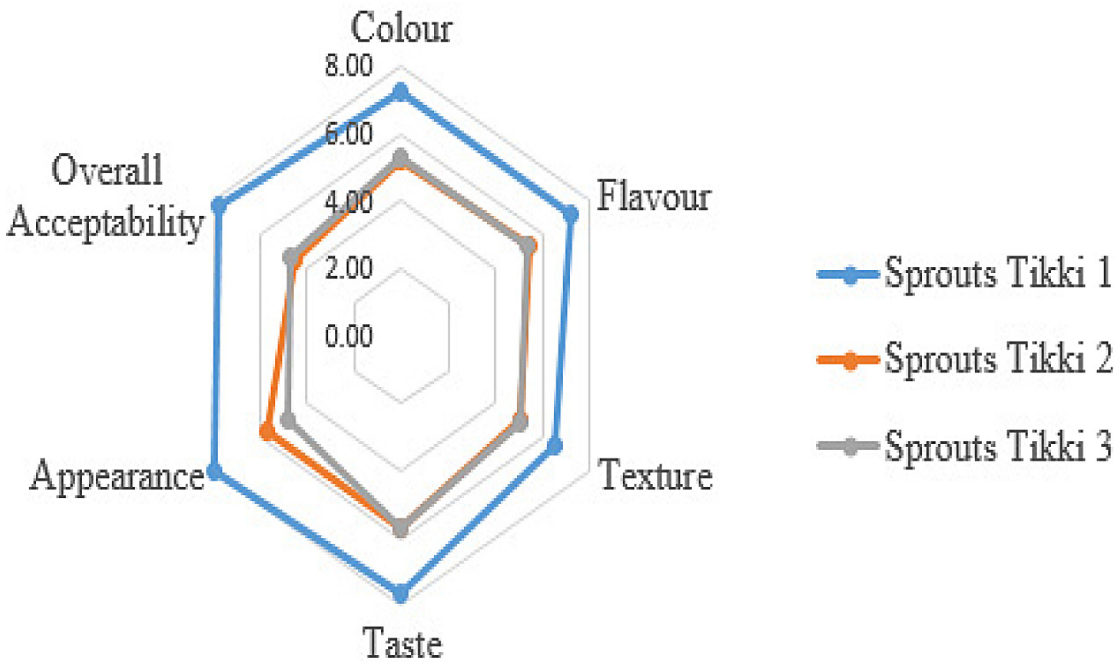

Figure 3.Radar Graph for Sensory Evaluation of ST1, ST2 and ST3

Table 4. Cost calculation of ST1

Sl.No	Ingredients	Amount(g)	Cost(in Rupees)
1.	Bengal gram (whole)	50	5
2.	Green gram (whole)	40	6
3.	Garlic	10	2.5
4.	Chilli powder	2	1.2
5.	Asafoetida	1	1.7
6.	Salt	1	0.05

calcium, iron, protein, fat, energy, and carbohydrates. The moisture and ash content of ST1 are 15.33g and 7.13g respectively. The nutrient analysis reveal that the Sprouts Tikki (ST1) meets one –third requirement of the RDA (Recommended Dietary Allowance) of an average sedentary working woman. The calculated value for Vitamin C was 2.524mg.

Anti-nutrient analysis-phytic acid content

It was found that ST1 had 0.450 mg/100 g of phytic acid. Since sprouting lowers the phytic acid level in pulses, the use of sprouted green gram and bengal gram in Sprouts Tikki may be the cause of the decrease in phytic acid content.

Figure 4. Total plate count analysis of STI using colony count technique on 4th day and 7th day

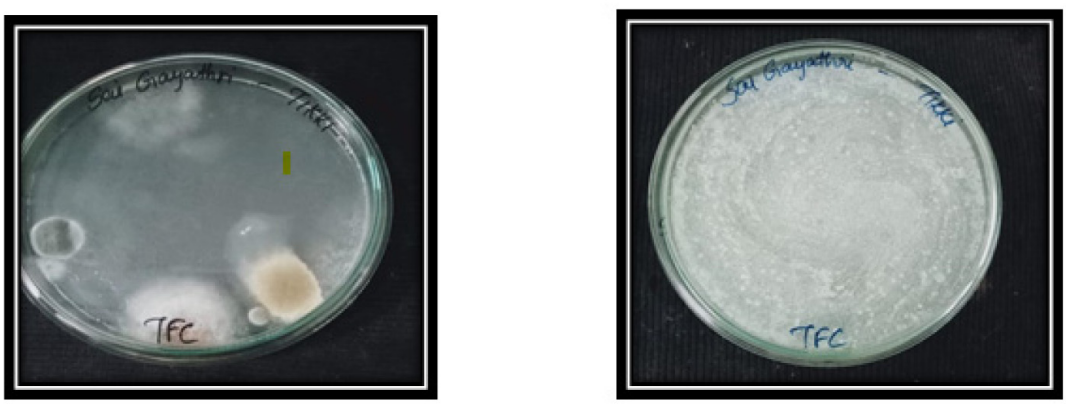

Figure 5. Total fungal count analysis of STI using colony count technique on 4th day and 7th day

Table 5. Nutrient Analysis of ST1

Sr. No	Nutrients	RDA	1/3rd of RDA	Nutritional composition of ST1
1.	Carbohydrates (g)	130	43.3	31.1
2.	Energy (Kcal)	1645	548.3	485
3.	Protein (g)	45.7	15.2	17.6
4.	Fat (g)	20	6.66	5.3
5.	Iron (mg)	29	9.6	3.4
6.	Calcium (mg)	1000	333.3	186
7.	Fibre (g)	25	8.3	7.5
8.	Folic Acid (µg)	220	73.3	81.2

Table 6: Shelf life Analysis

Sr. No	Shelf life study	4th Day	7th Day
1.	pH	6.5	7.0
2.	Total fungal count	Less than 10cfu/g	$1x10^2$ cfu*/g
3.	Total bacterial count	200cfu/g	$15x10^2$ cfu/g

*cfu-colony forming unit

Shelf life analysis

Shelf life analysis was conducted to ascertain the shelf life of Sprouts Tikki (ST1) on the 4th and 7th day of preparation. Table 6 displays the results of the shelf life analysis. The total fungal count in ST1 on 4th and 7t day was less than 10cfu/g and $1x10^2$ cfu/g respectively. The total bacterial count in ST1 on 4th and 7th day was 200cfu and $15x10^2$ cfu/g respectively.The pH values of ST1 on 4th and 7th day were 6.5 and 7 respectively. The product was found to be fit for consumption till 7th day from the day of preparation. The total plate count and total fungal count of ST1 on the fourth and seventh days, respectively, are shown in Figures 4 and 5.

CONCLUSIONS

The Sprouts Tikki is a novel product that uses inexpensive, locally sourced ingredients and requires simple cooking techniques. Among the three variations developed, ST1 was the most acceptable in the organoleptic evaluation. ST1 is a nutritious snack with a folic acid content of 81.2 µg and fibre content of 7.5g, which almost fulfil one-third requirements of the RDA. As a result, the product's high fibre content can help reduce weight and reduce the chance of folic acid deficiency. The Sprouts Tikki is a low cost product with a shelf life of seven days.

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PERFORMANCE ENHANCEMENT OF ATHLETES THROUGH FUNCTIONAL FOOD PRE-GAME SUPPLEMENTS

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ABSTRACT

The research was carried out in 2023. The goal of the current investigation was to assess the impact of two functional food products (Ladoo and Toffee) on athlete performance. The nutrient analysis of the products revealed that both were rich sources of energy (P1: 389 Kcal & P2: 380 Kcal), protein (P1: 12.5 g & P2: 6.5 g), carbohydrates (P1: 41 g & P2: 79 g), and iron (P1: 6.7 mg & P2: 17.4 mg). Sensory evaluation revealed that both products had high acceptance. Eighty middle-distance runners (600m, 800m, 1500m) from Coimbatore District, Tamil Nadu, and the University of Calicut, Kerala, were purposively sampled and equally divided into experimental (n=40) and control groups (n=40). The experimental group was further split into two: Group 1 received Ladoo (n=20), and Group 2 (n=20) received toffees as pre-game supplements for six weeks. The results showed a significant difference in the pre- and post-performance of athletes in both groups ($P<0.05$). Mean Hb levels increased from 15.9 g/dl to 16.1 g/dl among the experimental group that received toffee. There was no significant increase in athletes' body weight, making these two functional food products suitable for enhancing athletic performance without significant weight gain. Therefore, the functional food products developed in the present investigation can enhance the performance levels of middle-distance running athletes.

Keywords: Finger Millet, Functional food, Middle distance runners, Sports performance, Sweet potato, Watermelon Seed

INTRODUCTION

Sports nutrition is a specialization of nutrition that is strongly related to exercise science and the study of the human body. For optimum performance and long-term advantages, athletes and exercisers are very interested in the significance of appropriate nutrition. Successful athletic performance is determined not only by diet but also by lifestyle choices, motivation, training, and social and cultural influences. This article examines the efficacy of pre-game supplementation with specific functional foods made from watermelon seed, ragi, sweet potato and soya, in enhancing athletic performance, focusing on their natural nutrient profiles.

The seeds of watermelon contain vital nutrients that are beneficial for athletes. They are rich in protein, magnesium, zinc and healthy fats. These nutrients are essential for muscle

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repair, energy production, and overall immune function. Research by Kouoimskaand Adamkova (2016) highlights the high protein content in watermelon seeds, which can contribute to muscle recovery and growth. Additionally, antioxidants in watermelon seeds help mitigate oxidative stress from intense physical activity.

Ragi, or finger millet, is an ancient grain revered for its impressive nutritional profile. It is a goodsource of calcium, iron, dietary fibre, and essential amino acids, which are crucial for bone health, haemoglobin production and sustained energy release. High fibre content in ragi, which aids in maintaining stable blood glucose levels and providing consistent energy, preventing fatigue during prolonged physical exertion. (Shobana, 2013)

Sweet potatoes are distinguished for their high carbohydrate content, making them an excellent energy source for athletes. They are also rich in vitamins A and C, potassium, and dietary fiber. Carbohydrates are the primary energy source for high-intensity exercise and the complex carbohydrates in sweet potatoes provide a steady energy release. Burd (2019) noted that the beta-carotene in sweet potatoes enhances immune function and reduces inflammation, aiding in quicker recovery and improved performance.

With all of the essential amino acids and a wealth of vitamins, minerals, and antioxidants, soybeans constitute a complete protein source. Protein is critical for muscle repair and growth, particularly after strenuous workouts. Soy protein significantly enhances muscle mass and strength in athletes. Furthermore, soy isoflavones possess anti-inflammatory and antioxidant properties, promoting recovery and performance enhancement. (Messina, 2016)

The growing dependence on artificial supplements in sports nutrition raises concerns about their long-term health effects and the risk of doping violations. Natural functional foods offer a safer, holistic approach to performance enhancement. Unlike artificial supplements, natural foods provide a complex matrix of nutrients that synergistically improve health and athletic performance. Maughan (2018) emphasized the importance of a balanced diet rich in natural foods for optimal athletic performance and recovery.

Integrating functional foods like watermelon seed, ragi, sweet potato, and soya into pre-game supplementation presents a promising path for enhancing athletic performance. These natural foods deliver a wealth of nutrients that support energy production, muscle repair, immune function, and overall health. As athletes strive to optimize performance while avoiding the risks associated with artificial supplements, the emphasis on natural, nutrient-dense foods becomes increasingly crucial.

MATERIAL AND METHODS

Product Development

Two pre game supplement, were developed and the ingredients chosen for the preparation of product 1(Ladoo) were watermelon seeds, finger millet, honey and ghee. The second product (Toffee) was developed using sweet potato, rice flakes, jaggery, ghee and soy powder.

Acceptability studies

Sensory evaluation of the products was carried out to test the acceptability of the product using semi trained panel members. A Nine -point hedonic scale was used and products were scored for its acceptability. The nine-point hedonic scale, with values ranging from one for severe dislike to ten for extreme liking, is the most often used hedonic scale. (Nicolas, *et al*., 2010).

Nutrient analysis

The laboratory analysis measures the actual levels of nutrients in the prepared food, which providing a high level of accuracy of the analysis. The analysis accounts for the changes in nutritional value that occur due to the cooking and processing of the food. Macro Nutrients like energy, carbohydrates, protein (AOAC, 2023), and fat (AOAC, 2023) were analysed by the standard procedure, and other nutrients like, fibre, iron, antioxidants, vitamins and minerals were computed by Indian Food Composition Table (Longvah *et al.*, 2020).

Identification of Athletes and Assessment of Nutritional Status and Performance of Athletes

Athletes were selected from the Faculty of General and Adapted Physical Education and Yoga (FGAPEdY) at Ramakrishna Mission Vivekananda University in Coimbatore and Calicut University, Kerala. Out of 110 initially screened male athletes, 80 were chosen based on inclusion and exclusion criteria and divided equally into experimental (n=40) and control groups (n=40). The study included 18-25-year-old athletes with normal BMI (18.5-24.9) involved in middle distance running at university, national and state levels. Athletes with severe sports injuries or known deficiency diseases were excluded. Demographic profile was collected through interview and nutritional assessment was conducted using anthropometric, biochemical, and dietary assessments. Athlete performance was analysed pre- and post-intervention based on the time taken to complete the 600m, 800m, and 1500m events.

Supplementation of pre -game snack

The functional food products were supplemented to the experimental group for six weeks as pre-game supplement and nutritional education were given to the control group. Group one was supplemented with 50g of laddu 20 minutes before the training and Group two was introduced with 50 g of toffee 10 minutes before the training period followed by 300-400 ml of water was given. The product was introduced before the morning training session because it was found that they were not consuming any pre-game meal before the training session. A pregame meal is important and its significance lies in providing the necessary nutrients and energy to optimize performance during the upcoming activity. Hence this product was introduced as a pregame supplement among athletes.

Post intervention

The nutritional status and performance of the subjects were analyzed during the 6-week supplementation period. Nutritional screening of the athletes was conducted by anthropometric, biochemical, and dietary assessments, and the post-performance of the athletes was analyzed by an actual performance test (600m, 800 m, 1500m running test).

Statistical Techniques

SPSS version 21 was used for statistical analysis. The statistical difference pre and post endurance level of athletes was analyzed using the dependent 't' test and ANCOVA.

RESULTS AND DISCUSSION

The mean age of the selected subjects was 20–25 years old. They were staying on campus. 50 of the subjects were undergraduates, and 30 subjects were postgraduates.Majority of the athletes were involved in 800 m running. The athlete's parents were farmers with a mean monthly income below Rs. 15000, and the other parents were employed as teachers, factory workers, businessmen, clerks, and officers with a moderate mean income between Rs. 15000 and 50000 per month. Hoque *et al.*, (2018)

Table 1. Background Details of the Athletes

S.No.	Background Information	No of athletes
Age		
1	18-20	-
2	21-23 years	50
3	24-25 years	30
Education level		
1	Undergraduates	50
2	Post graduates	30
Sports /event		
1	600 m	20
2	800m	40
3	1500m	20
Family monthly income		
1	Below 15000	15
2	15000-50000	53
3	Above 50000	12

Indicates that parents' income is a significant factor influencing athletes' knowledge, as they usually consume and experience foods within their parents' income capacity.

Dietary Details of the Athletes

Among the eighty athletes, all of the eighty athletes preferred non-vegetarian foods. All the athletes consumed normal beverages like tea, coffee, and milk. The athletes were not consuming sports drink rather preferred fresh juice more than bottled or aerated drinks. College hostel food was taken by all subjects. The athletes' menus were cyclic, with the inclusion of cereal, pulses, vegetables, milk, and meat products. It was encouraging to note that the daily energy consumption exceeded 3000 kcal. The amount of fat and carbohydrate consumed was enough to satisfy the daily needs. The protein intake was moderate, as their menu included pulses and non-vegetarian food items. Few athletes complained of muscle cramps, giddiness, a feeling of tiredness and minor sports injuries. Athletes should eat a well balanced diet made up of a wide variety of foods in sufficient quantity to cover their daily energy expenditures. Consumption of a variety of foods throughout the day to maintain proper energy and micronutrient intake in sports individuals. (Volpe, 2007).

Nutrient analysis of the product

The figure 1 reveals that the nutrition facts of two functional food products. Products contain 386 kcal and 380 kcal of energy (product1 & product2). Functional products contain 41 g (product1) and 79 g (product2) of Carbohydrate along with 12.5 g (product1) and 6.5 g (product2) of protein and 5.5 g (product1), 1.5 g (product1) of fat. Therefore, these toffee and Ladoo can be better option as an important nutritional supplement. Studies have proven that Carbohydrate-containing foods should provide 60-70% of daily energy

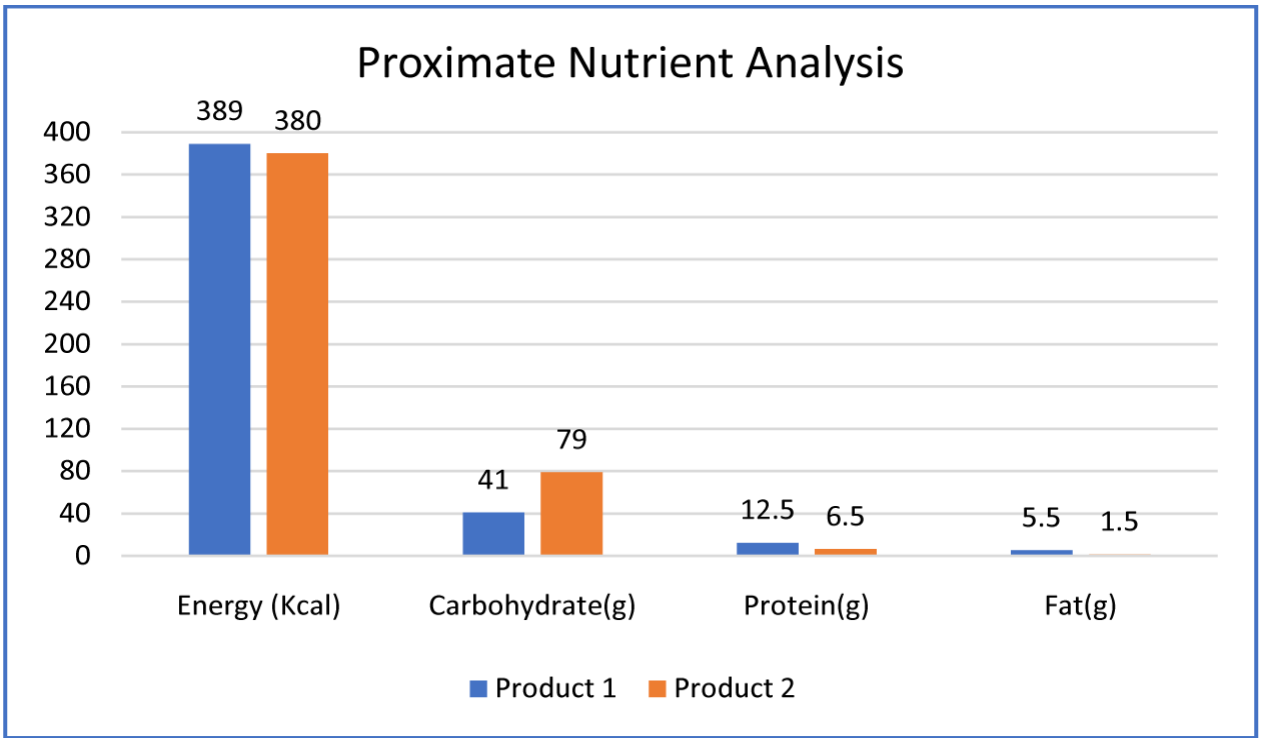

Figure 1. Proximate nutrient analysis of the food products

Table 2.Micronutrient analysis of the products

S.No.	Nutrients	Product 1	Product 2
1	Calcium (g)	162	152
2	Iron (g)	6.7	17.4
3	Fibre (mg)	9.51	2.1
4	Omega 3 (mg)	35.7	30.1
5	Vitamin C (mg)	0.07	1
6	Vitamin A (mcg)	10.29	9.28
7	Vitamin D2 (mcg)	18.87	16.5
8	Vitamin E (mg)	2.72	2.12
9	Vitamin B1 (mg)	0.21	0.1
10	Vitamin B2 (mg)	0.14	0.24
11	Vitamin B3 (mg)	2.32	2.12
12	Sodium (mg)	3.32	2.45
13	Potassium (mg)	248	324
14	Magnesium (mg)	112.8	145
15	Zinc (mg)	1.89	2.45
16	Selenium(mcg)	7.63	6.45
17	Ash content (mg)	2.79	2.23

Table 3. Mean acceptability for the Ladoo and Toffee

S.No.	Characteristics of product (N= 80)	Product 1-Score (Mean)	Product 2-Score (Mean)
1	Appearance	8.2	7.8
2	Flavour	7	5.5
3	Taste	7.8	8.1
4	Mouth feel	7	7.5
5	Texture	8.5	7.9
6	Total (45)	38.5	36.8

intake, protein 12-15%, and the remainder from fat. (Williams, 2008).

The data from table 2 shows that the micro nutrition facts of functional food products. Two Products were the best source of vitamins (B1, B2, B3, E and A) and minerals (P, Mg, Zn and Na). Products were the rich source of iron, especially product 2 which provides 17.4 g of iron Hence, this product will be an ideal functional pre-game supplement to enhance the performance of athletes. Studies suggest that vitamins and minerals are essential for an athlete's health and performance, with no single micronutrient being more significant. Micronutrients are crucial for metabolic activities like energy synthesis, muscle growth, and recovery. Athletes must meet their daily micronutrient intake requirements. (Ghazzawi *et al.,*2023).

Acceptability test of the product was conducted among eighty subjects and semi trained panel members whose results were presented in table 3. They were accepted this product with high acceptability score in terms of appearance, flavour, taste, mouth feel, texture. A related study suggested that a nutritional drink was developed from ragi, soya, jaggery, and dates powder. A nine-point hedonic scale was used for the sensory evaluation, and the product scored highly on the acceptability scale. (Singh *et al.,* 2021)

The normal RDA value of an athlete was compared with the test value of the product as shown in table 4.Eleven per cent of the daily recommended energy was met by these two functional food products. 12.5 per cent (product 1) and 6.5% (product 2) of the recommended protein were met with these

Table 4. Comparison of RDA with test value for products

S.No	Nutrients	RDA	Product 1		Product 2	
			Test Value	to met % the RDA	Test Value	% to met the RDA
1	Energy (Kcal)	3470	389	11	380	11
2	Protein(g)	54	12.5	23	6.5	11
3	Fat(g)	30	5.5	18	1.5	5
4	Carbohydrate(g)	130	41	31	79	60
5	Iron (g)	19	6.7	35	17.4	91

Table 5. Paired sample 't' test and ANOVA for athletic performance for pre and post-test of experimental and control groups-(Product1)

S.No	Group (product 1)	Pre-Test		Post Test		tvalue	p value	f value	p value
		M	SD	M	SD				
1	Experimental Group	2.0610	.02424	2.0460	.02066	4.39	.00	8.07*	.011
2	Control Group	2.0620	.02300	2.0590	.02514	1.15	.27		

*Sig at 0.05 level

Table 6. Adjusted post-test meanvalue comparison for athletic performance of experimental and control groups: (Product 1)

S.No	Experimental	Control	M	SE	Sig	95% Confidence Interval for Difference	
1	2.04	2.05	0.013	0.003	.01	2.052	2.065

products. 18% (product 1) and 5% (product 2) of recommended fat and 31% (product 1) and 60% (product 2) of recommended carbohydrate were met with this product. Product 2 was a dense source of iron, which provided 91% of the recommended daily allowance of iron. Studies have proven that Athletes should consume diets which contain at least the RDA/Adequate Intake (AI) of each micronutrient. Restricted energy intake by athletes, adopt harsh weight-loss procedures, avoid all food groups from their diet, or adhere to other extreme dietary beliefs are more likely to suffer from micronutrient deficiencies (Thomas *et al*., 2016).

Table 5 revealed paired sample 't' test for comparison of pretest and post-test means of experimental and control groups on performance indicates that the t-ratio of 4.39 for the experimental group was significant ($p < 0.05$), whereas the t-ratio for the control group (1.15) was not significant at 0.05 level. The results indicate significant difference between the pre & post-performance in experimental group

The effect of product supplementation on post adjusted mean the experimental and control group was examined by using ANCOVA with pretest score as a covariate. Table-5 shows that there was a significant difference between performance of athletes in experimental and control group ($f = 8.07$, $p = 0.01$, $p<0.05$). Sharma and Sood (2020) discovered that products made from seeds such as watermelon seed, flax, chia, pumpkin, and finger millet are effective in improving athletes' performance.

The comparison of post-adjusted group means for the experimental and control groups of athletes (Table 6) indicates a significant difference between the adjusted post values of the experimental and control groups.

Table 7. Paired sample 't' test and ANOVA for athletic performancefor pre and post-test of experimental and control groups- (Product 2)

S.No	Group (Product 2)	Pre-Test		Post Test		t value	p value	f value	p value
		M	SD	M	SD				
1	Experimental Group	1.58	0.23	1.44	0.45	4.11	0.03	3.47	0.03
2	Control Group	1.65	0.26	1.64	0.47	0.87	0.56		

Table 7 indicated paired sample 't' test for comparison of pretest and post-test means of experimental and control groups on performance indicates that the t-ratio of 4.11 for the experimental group was significant ($p < 0.05$), whereas the t-ratio for the control group (0.87) was not significant at 0.05 level. The results indicate significant difference between the pre and post-performance inthe experimental group

The effect of introduction of pre- game supplement (product 2) on post adjusted mean of experimental and control group was examined by using ANCOVA with pretest score as covariate. Study shows that there was a significant difference between performance of athletes in experimental and control group ($f = 3.47$, $p = 0.03$, $p<0.05$).

The table 8 shows comparison of post adjusted group means for the experimental and

Table 8. Adjusted post-test mean value comparison for athletic performance of experimental and control groups: (Product 2)

S.No	Experimental	Control	MD	SE	Sig	95% Confidence Interval for Difference	
1	1.44	1.64	0.2	0.005	0.03	1.32	1.78

Table 9. Mean body weight (kg) of the athletes before and after supplementation

S.No	Products	Group	Pre-Test		Post Test		t value	p value
			M	SD	M	SD		
1	Product 1	Experimental Group	60.2	6.56	60.5	6.57	2.115	0.52
		Control Group	59.3	5.54	59.4	5.54	0.8764	0.56
2	Product 2	Experimental Group	57.8	5.45	57.9	5.46	2.2609	0.67
		Control Group	61.2	6.1	61.2	6.1	1.0000	0.56

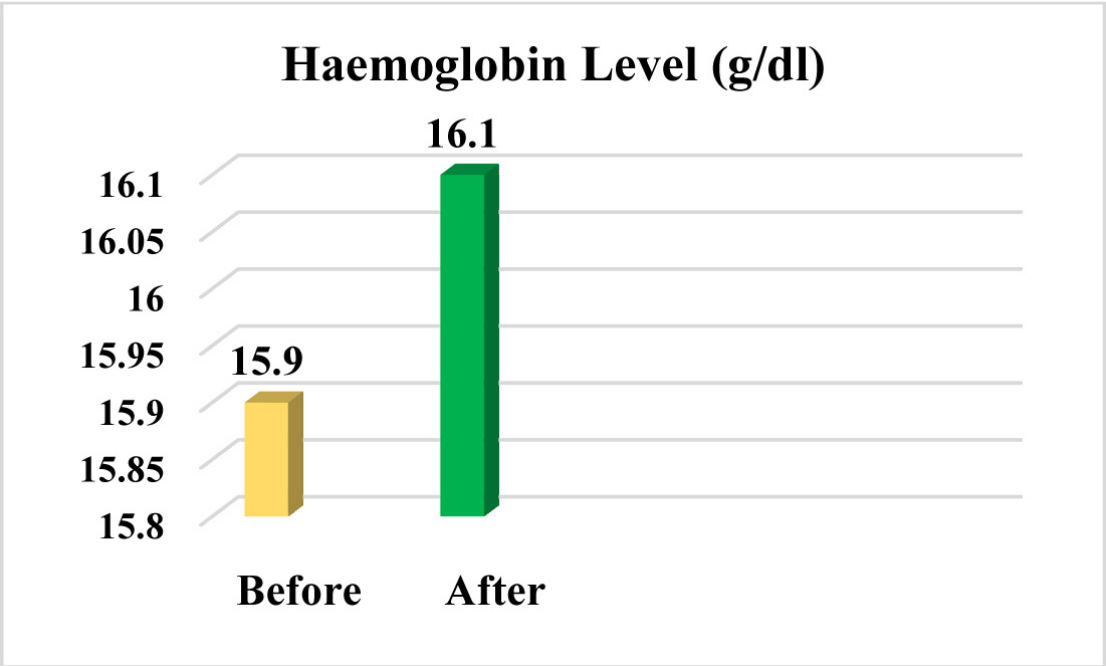

Figure 2. Mean haemoglobin of athletes before and after supplementation among experimental group for Toffee (product 2)

control group for athletic performance indicates significant difference between the adjusted post-test values of experimental and control group. Abdel *et al., (*2022). Formulated and evaluated high energy-protein bars major ingredient was sweet potato, banana, carrot and dates powder. Study revealed that there was significant difference between the adjusted post-test values of experimental and control group performance.

There was no signification difference between the body weight of athletes after supplementation of the functional products among the experimental group (Table-9). The functional food products provided 380 kcal which met 11 per cent of the RDA for this age group but an increase in the body weight was not noticed which may be advantageous wherein the Sports performance can be enhanced by athletes without increasing their body weight. Researchers have pointed out the importance of maintaining appropriate body weight especially by athletes to compete in their appropriate weight category during sports (Peeling *et al.* 2019).

Haemoglobin Level of Athletes

The haemoglobin level of the athletes was in the normal range before and after supplementation but there was an improvement noted where by the haemoglobin level increased from 15.9g/dl to 16.1g/dl. Though this is a slight increase in the haemoglobin level, the statistical significance at one percent level was obtained. The performance of athletes, particularly runners, is influenced by a variety of factors. Athletes can enhance their performance with proper nutrition, hydration, and flexibility, which are directly controlled by the athletes. A low iron level is one of the most common conditions among athletes, especially endurance athletes. (Hargreaves *et al.,* 2014). These two product two can be the better option for athletes with iron deficiency (Figure 2).

CONCLUSIONS

Two functional food products were developed and supplemented among the experimental and control groups. The study has shown a difference in the performance of the control group and the experimental group, and there was a significant difference between the preand post-performance experimental groups of product one. The performance of the experimental group was better than the control group in both products. Each product was a rich source of energy, protein, carbohydrate, and iron. Functional food products had a positive impact on the performance of athletes in terms of endurance, speed, and haemoglobin levels. The increase in body weight of the athletes was negligible, hence, these two functional food products can be recommended to improve the performance ability of athletes without increasing their body weight. Hence, the supplementation of functional foods has an profound impact on the performance of sports people.

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OPTIMIZATION AND QUALITY EVALUATION OF SOY MILK BASED NON- DAIRY ICE CREAM

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ABSTRACT

New plant-based alternatives (PBAs) to dairy are being created by the food industry and they are of interest to many consumers. However, some of these PBAs use ingredients that are unfamiliar to consumers. In this context the main aim of the study was to evaluate the sensory, physicochemical and nutritional properties of the gelato prepared with soy beans. Soy milk, made from soybeans, can serve as a healthy alternative to bovine milk, given its nutritional advantage. Results from the study indicated that Soy milk gelato made with a 1:3 (w/v) seed-to-water ratio got the highest score when compared to the other treatments. The soymilk-based gelato had 71.0 per cent moisture, 5.3 per cent protein, 7.6 per cent fat, 1.3 per cent ash, 1.5 per cent crude fiber, 13.3 per cent carbohydrates and 142 kcal per 100g. Soy milk gelatos physicochemical analysis indicated an acidity of 0.18 per cent, pH of 6.5, overrun of 97.0per cent, total soluble solids of 17.9 brix and total solids of 28.0per cent. All physicochemical parameters such as overrun, melt quality, total solids, pH, total soluble solids and acidity were strongly influenced by gelato. A comparison between soy milk gelato with bovine milk gelato demonstrates that the former offers superior protein quality and less calories.

Keywords: Soy milk, Gelato, Proximate composition, Veganism

INTRODUCTION

The production of non-dairy food items has been identified as a new trend in the manufacturing of functional foods. Soybeans are an excellent source of high-quality proteins and carbohydrates but are devoid of lactose and cholesterol. It is a cost-effective source of nutrition for milk allergy patients, lactose-intolerant individuals and also for vegetarians. Soybean protein, because of its undigested pepsin fraction may affect the fecal excretion of bile acids or steroids and also influence the cholesterol metabolism.

The significant influence of soy on human health arises from its comprehensive spectrum of nutrients, including proteins, vitamins, oligosaccharides, dietary fiber and trace minerals. With the presence of oligosac charides, soy fulfils a crucial physiological function and potentially meets prebiotic needs.

Gelatos (ice cream) are globally popularized milk products whose industrial

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demands are rapidly growing day by day. Hence the major share of milk produced across the globe is being employed for the production and marketing of frozen dairy products (Rahila *et al.,* 2024).

During 2020, India produced more than 200 million liters of gelato, showing a significant increase as compared to 2015 gelato is a well-known refreshment for Indians during the country's hot summer months Western parts of the country, in particular, accounted for a high share of gelato consumption within the dairy market. A wide price range of gelato retail products, starting from just a few rupees, allows for consumption across socio-economic groups(Minhas, 2022).

Nowadays, a noticeable trend in society is search for more and more healthy food products. This is also reflected in the interest in plant-based ingredients replacing animal ones. As compared to the dairy-based frozen desserts, the plant-based had nutritional profiles with higher dietary fiber content and also to create functional frozen desserts that are high in protein and energy (Wrobel-Jedrzejewska and Polak, 2023).

Despite efforts over the years to discover better alternatives to cow's milk due to rising prices for bovine milk and its products, the concurrent assessment of gelato formulations using soy milk, fat, emulsifier and stabilizer and sugarin regards to product characteristics, is limited. Efforts have been made over the years to produce cheaper alternativesto cow's milk and its components due to rising pricing, despite their high protein content.

Keeping in view the significance of soy milk and carbohydrate-based polysaccharides, the current research was planned to optimise soy milk gelato and to analyze its effects on the sensory, physico chemical and nutrient parameters.

MATERIAL AND METHODS

The present study was carried out in the Department of Food Science and Nutrition, CCSc, ANGRAU, Lam, Guntur in the year 2023-24. The raw ingredients were brought from the Guntur local market, Andhra Pradesh.

Extraction of soy milk

Five hundred grams of soybeans were washed in distilled water. The cleaned beans

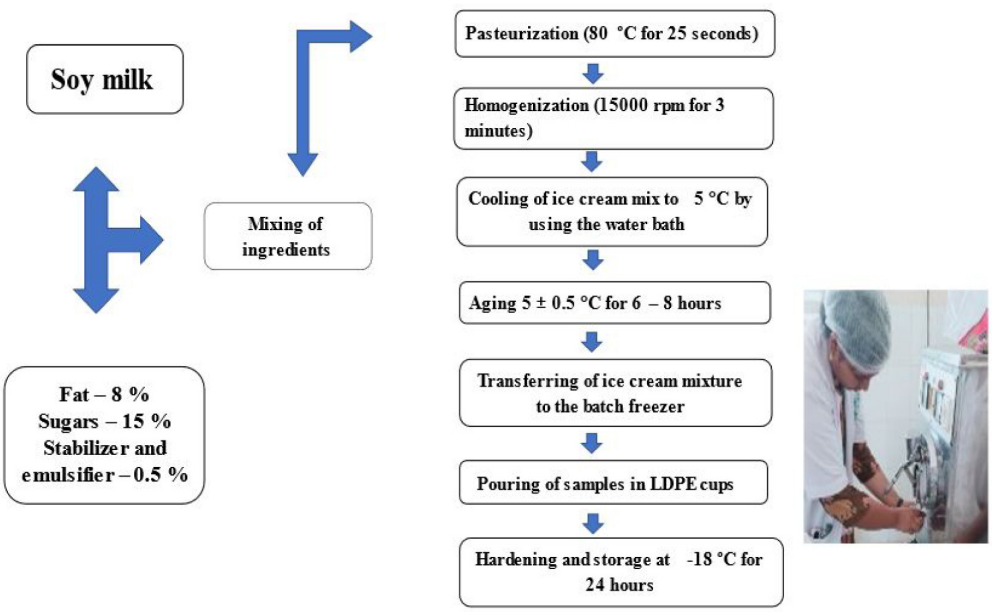

Figure 1: Preparation of soy milk gelato/ice cream

were soaked in water for whole night at room temperature and swollen soybeans were washed, drained and blended with water in the ratios of 1:1(S1), 1:2(S2), 1:3(S3), 1:4(S4) and 1:5(S5) (w/v). Milk was extracted by straining the mixture through a muslin cloth. The extracted milk was pasteurised for 15 seconds at 80°C and kept at 4°C for subsequent analysis (Bristone *et al., 2015*).

Quality Evaluation of Soy milk ice cream

Proximate composition (moisture, protein, ash, fat, fiber, carbohydrate and energy) of raw ingredients and gelato were determined by using AOAC (2005). The sensory evaluation was done by using 9-point hedonic scale for the sample of soy milk gelatos (S1, S2, S3, S4, S5 and C control ice cream).Total solids, percent acidity and melting quality (Perera and Perera, 2021), overrun quality (Ghaderi *et al*., 2021) and total soluble solids (Pon *et al.,* 2015) were analyzed by standard procedures.

Statistical analysis

The data on organoleptic evaluation was subjected to statistical analysis using the Krushkal Walli H-test (one-way analysis and non-parametric) to determine significance (Gopal, 2006).

RESULTS AND DISCUSSION

Proximate composition of soybean was given in Table 1. The soybean had a moisture content of 8.10 per cent, protein 40 per cent, fat 21.4 per cent, ash 4 per cent, crude fiber 5.30 per cent, carbohydrate 18.5 per cent and energy 432 Kcal. Similar findings were published by Bayero *et al*. (2019), who reported values for moisture 8.13 percent, protein 39.2 percent, fat 30.31 percent, ash 4.61 percent, crude fibre 6.84 percent and carbohydrate 5.08 percent.

The moisture content of soy milk was observed to be 93 per cent, protein 3.0 per cent, fat 2.2 per cent, ash 1.4 per cent, crude fiber 1.5 per cent, carbohydrate 4.4 per cent and energy 51 Kcal per 100ml of milk (Table 1). Similar proximate composition values for soymilk were reported by Lumbantobing *et al.* (2020) and Asres *et al.* (2022) who recorded values ranging for moisture 90 to 93 per cent, protein 2.94 to 4.82 per cent, fat 2.0 to 5.7 per cent, crude fiber 0.4 to 0.8 per cent and carbohydrate 3.5 to 4.6per cent.The proximate composition of all the raw materials used in the study depend on the varietal differences, agroclimatic conditions, environmental conditions, geographical conditions, soil types and agronomic production methods.

Table 1. Proximate composition ofraw soybean and soy milk

Samples Proximate Composition (g%)	Soybean	Soy milk
Moisture	8.10 ± 0.03	93.0 ± 0.50
Protein	40.0 ± 2.89	3.00 ± 0.02
Fat	21.4 ± 2.60	2.20 ± 0.10
Ash	4.00 ± 0.30	1.40 ± 0.02
Crude fiber	5.30 ± 1.50	1.50 ±0.02
Carbohydrate	18.5 ± 2.30	4.40 ± 0.01
Energy (Kcal)	432 ± 2.50	51 ± 0.10

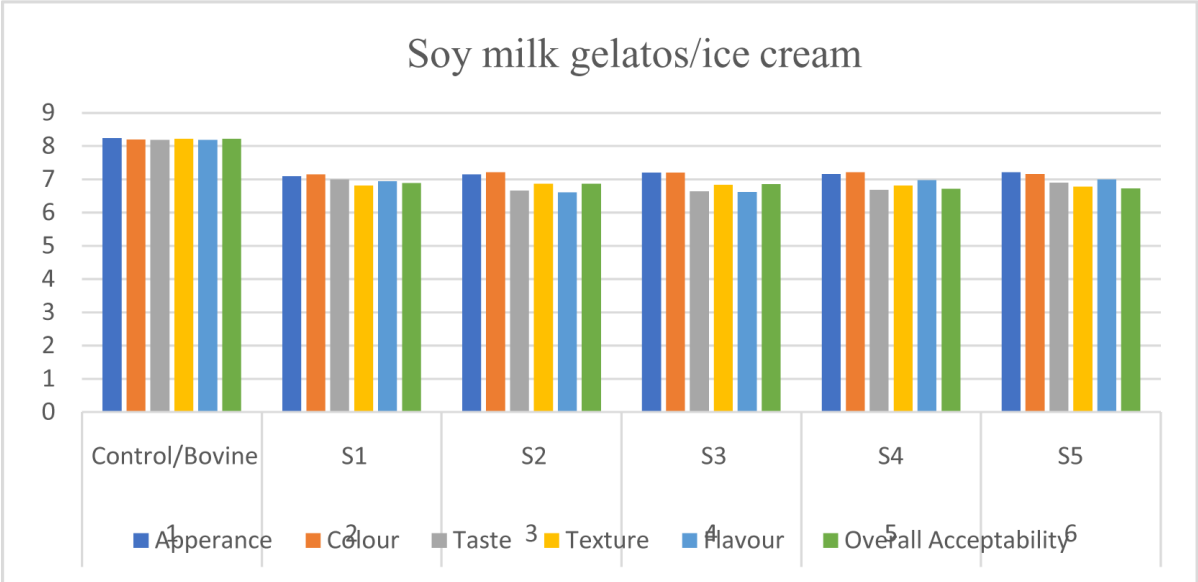

Figure 2. Organoleptic evaluation scores of soy milk gelatos/ice cream

Organoleptic evaluation of soy milk gelato/ice cream

From the results a considerable disparity in degrees of freedom among soy milk gelatos was noted. It was inferred from Figure2, that the control had the greatest scores in all sensory attributes.

The colorscores of soy milk gelatos with various ratios ranged from 7.15 (liked moderately) to 8.2 (liked very much). The S4 had the greatest color score of any of the soy milk gelato versions, while the S1 had the

Figure 3. Best ranked soy milk gelato

Table 2. Ranking of Soy milk gelato vs bovine milk gelato.

Variations of soy milk gelatos	Rank Mean	H value	Chi-square value	C.D
C	13.50	25.95	At 5per cent of	18.25
S1	19.67		Los with 4 dof is	
S2	23.00		9.48	
S3	23.67			
S4	21.25			
S5	19.75			

*C - control/bovine milk gelato, S1-1:1, S2- 1:2, S3-1:3, S4-1:4 and S5 1:5

* The ratio indicates the soybean seed to water composition of milk

Table 3. Physicochemical properties of soy milk ice cream

S. No.	Treatments	Ratio of seed: water	Percent acidity (%)	pH	Overrun (%)	Total soluble solids (Brix's)	Total solids (%)
1.	Soy milk	1:3	0.18 ± 6.6	6.5 ± 0.1	97.0 ± 1.0	17.9 ± 0.4	28 ± 1.1
2.	Bovine milk		0.21 ± 2.8	7.0 ± 0.1	97.0 ± 1.0	27.3 ± 0.9	36 ± 2.3

Table 4. Proximate composition of soy icecream vs bovine icecream

Samples Proximate Composition (g%)	Soy milk gelato	Bovine milk gelato
Moisture	71.0 ± 1.1	62.0 ± 2.3
Protein	5.30 ± 0.02	4.40 ± 0.01
Fat	7.60 ± 0.01	5.40 ± 0.02
Ash	1.30 ± 0.02	1.10 ± 0.02
Crude fiber	1.50± 0.01	0.90 ± 0.08
Carbohydrate	13.3 ± 0.01	24.5 ± 0.01
Energy (Kcal)	142 ± 0.03	164 ±0.05

lowers score.The mean appearance of gelatowith different treatments ranged from 8.24 to 7.1. The S1 of soy milk gelato recorded the highest score, while the S4 ratio had the lowest score.

The lowest score was attained for soy milk gelato with S1. Soy milk gelato made with S3 scored higher than the other treatments. Soy milk gelatos were evaluated using the 9 points hedonic scale and the Kruskal-Wallis H-test was performed to establish which gelato was superior to the ratios and bovine milk gelato. The findings revealed that soy milk gelato with S3 out performed bovine milk gelato. The S3 was significant with other, followed by S2, S4, S5 and S1. At the 5 per cent level of significance and four degrees of freedom, the value 9.48, the H value 25.95 and the CD value 18.25 as shown in Table 2. The finding was in-line with Aboulfazli *et al*. (2014) and Bueno *et al*. (2018), who reported that soy milk gelatos were more acceptable and of excellent quality

Physicochemical properties of soy milk gelatos

The Physicochemical properties of soy milk gelato are shown in Table 3.The table shows that the control group gelato and soy gelato had acidity of 0.21 ± 2.0 and 0.18 ± 6.6 percent, pH of 7.0 and 6.50, overrun of 97 per cent, total soluble solids of 27.3 and 17.9^0 Brix, and total solids of 36 and 28 per cent, respectively. Ahanian *et al*. (2014) and Ahsan *et al*. (2015) reported closervalues ranging from 0.13 to 0.20 percent acidity, pH 6.7 to 7.30, and overrun 85 to 97%.

Proximate composition of soy milk ice cream

Table 4 shows the proximate composition of the highly accepted soy milk gelato with a 1:3 (w/v) ratio and bovine milk gelato. The table shows that soy milk gelato had a higher protein (5.30%), fat (7.60%), lower carbohydrate (13.3%), and energy (142K.cal) content than the control making it a better choice for lactose

intolerant and diabetic individuals. Atallah and Barakat (2017) noted similar protein (5.26 percent) and carbohydrate (19.56 percent) levels in soy milk gelato. Ahanian *et al.* (2014) reported a closer value to fat 7.8 percent and a lower protein content of 4.3%.

CONCLUSIONS

Soy milk, extracted from soybeans, holds promise as a viable alternative to traditional dairy milk owing to its healthful properties. In this context the present study outlines the preparation of non-dairy ice cream using soy milk. Soy milk as the base for ice cream provides various benefits, including being anabudant source of plant-based protein (5.3g/%) and having lower cholesterol levels than standard dairy-based ice creams. Furthermore, soy milk-based ice cream has the potential to become a commercially successful frozen delicacy. Research findings imply that new products with specialized qualities can be developed to reduce the health risks associated with many animal products, such as cholesterol and to replace animal proteins and lipids with plant-based alternatives.

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ASSESSMENT OF NUTRIENT INTAKE AND ANTHROPOMETRIC MEASUREMENTS AMONG IT PROFESSIONALS

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ABSTRACT

The study conducted in 2015 investigated the relationship between nutritional intake and anthropometric measurements among technology personnel, aimed at elucidating their impact on health risks. Utilizing a 24-hour recall approach in the Trivandrum Corporation, the research evaluated food consumption patterns and conducted various anthropometric measurements to assess the risk of metabolic complications. This study examined the nutritional intake and health risks of technology personnel using a 24-hour recall method and anthropometric measurements, and it revealed excessive fat (237.289 % of RDA) and vitamin C (185.863 % of RDA) intake, with iron deficiency (58.782 % of RDA). Health risk assessments based on waist-to-hip ratio and BMI indicated that private sector employees faced higher risks of metabolic complications and disease, with 40 percent at increased risk compared to 30 percent in the government sector. A statistically significant positive correlation ($p < .01$) was found, indicating that higher BMI is associated with greater waist circumference. The study highlighted the need for targeted interventions and lifestyle modifications for technology professionals, considering dietary habits and occupational factors to improve their overall well-being.

Keywords: Health risk, Nutrient intake, Technology personnel, WC, WHR

INTRODUCTION

The Information Technology (IT) sector in India has experienced significant growth as a result of the globalization of the Indian economy and favourable government policies. India has become a prominent service provider in the digital realm through its information technology sector and the country currently boasts an extensive workforce of over 120 million individuals involved in computer-related tasks, with the number of computer users steadily rising each day (Zuniga and Cote, 2017). This industry has increased, creating over 4.14 million jobs and 0.45 million new job opportunities annually and has led to a new work culture and lifestyle changes, increasing their health risk (Banerjee et al, 2023).

In today's digital world, tech professionals play a crucial role across various domains. However, their sedentary work and prolonged stress levels pose significant concerns for their well-being. The isolated nature of their work and extended periods spent staring at computer screens make them

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more susceptible to issues like depression, stress, and back pain. These health problems not only affect their overall well-being but also hinder their professional performance, leading to challenges with concentration and memory retention (Aveline and Kumar, 2018). Long hours spent working on computers by professionals have contributed to wide spread health problems across the globe. Professionals using computers for more than four hours daily are vulnerable to developing eye strain, computer vision syndrome (CVS), and musculoskeletal disorders such as carpal tunnel syndrome (CTS). These individuals also frequently experience neck, shoulder, and stress-related issues (Sudharshini *et al,* 2018).Nutritional intake is also a crucial factor that influences overall health and well- being of these professionals.

The physical and mental wellness of workers, particularly those in sedentary fields like software, is heavily impacted by many elements. Nutrient intake and anthropometric measurements are two such factors that can significantly influence one's overall health and susceptibility to chronic diseases. Analysing anthropometric measurements such as BMI and WC can offer valuable information about an individual's body composition and potential health risks. This research investigates in detail how anthropometric measurements and nutrient intake affect the health hazards that technology workers encounter.

MATERIAL AND METHODS

The study was conducted at Trivandrum Corporation in the state of Kerala. It focused on married women in the IT sector with five hundred samples and thirty sub-samples, categorized as half the respondents from the private and the other half from the Government sector. The study used anthropometric measurements to assess the health risks associated with married women in the technology sector, and a 24-hour recall approach evaluated the quantity and quality of food consumed to determine nutritional intake.

The 24-hour recall method prompted the participants to remember what they had eaten the day before. This method involved gathering data on the respondents' dietary habits using a standard set of cups, spoons, and glasses. The amount of food consumed, and the raw components used in each dishwere recorded, and the participants could recall the quantity of food accurately. The food composition table (Thimmayamma, 1987),

Table 1. Association between BMI and WC for overweight and obese based on disease risk

BMI classification	BMI	Disease risk (Relative to normal weight and waist circumference)	
		Women <=88 cm	Women > 88 cm
Underweight /Normal	<18.5/ 18.5 – 24.9	-	-
Over weight	25.0 – 29.9	Increased	High
Obesity class I	30.0 – 34.9	High	Very high
Obesity class III	35.0 – 39.9	Very high	Very high
Obesity class III	>= 40	Extremely high	Extremely high

(**Source**: NHLBI Obesity Education Initiative, 2000)

which gives the nutritional value for commonly consumed food items, was used to calculate the nutrient content of the food consumed, with the raw ingredients' nutritive value also being assessed.

Anthropometry refers to the study of human body measurements, including weight, height (both standing and lying down), skin fold thickness, circumferences (such as those of the head, waist, and limbs), and limb lengths. In this study, the focus is on measuring height, weight, waist circumference, and hip circumference. Body Mass Index is commonly used to assess body fatness and is calculated by dividing weight in kilograms by the square of height in meters, i.e., BMI = Weight in Kg/ Height in m^2. To determine obesity level, the classification based on BMI from NHLBI Obesity education Initiative (2000) was taken.

The waist-hip ratio (WHR) is a method used to evaluate abdominal fat, which is crucial because increased abdominal fat raises the risk of chronic illnesses, irrespective of weight or BMI. Recent research suggested that measuring waist circumference (WC) alone is more straight forward and superior to assess abdominal fat than WHR. The study adopts risk cut-off points for metabolic complications based on waist circumference from the World Health Organization (2011) expert consultation on obesity reports. The classification of waist-hip ratio is based on Sedodoet al. (2013) guidelines: WHR < 0.80 indicated low health risk, 0.81-0.85 suggested moderate risk, and > 0.85 indicated high health risk. The study also considers combined recommendations of BMI and waist circumference cut-off points for overweight or obesity, aligned with values that assess disease risk. Respondents' risk factors were categorized according to the NHLBI Obesity Education Initiative (2000).

The data collected were coded, classified, tabulated and analysed using SPSS 21; the statistical test used for the present study was percentage analysis, t test, Anova and Co-relation.

RESULTS AND DISCUSSION

The results and discussion of the study "Assessment of Nutrient Intake and Anthropometric Measurements among Technology Professionals" were discussed and interpreted below

Background information on technology personnel

This section presents an overview of the participant's demographic characteristics; the collected personal data includes employment sector, age, and place of residence. The age distribution is categorized into three groups: below 30 years, between 30 to 40 years, and above 40 years. Notably, 58.8 percent of respondents in the private sector are below 30 years old, highlighting the prevalence of younger individuals in IT companies. In the government sector, 60 per cent of respondents fall in the 30 to 40 age group, while 20.8 per cent are above 40.

According to the Census data from Nair (2011), the urban population in Kerala was 47.72 percent. However, in 2011, there was a notable shift, with 52.30 percent of the population being rural, compared to 74.04 percent in the 2001 census. When examining respondents based on their residence, it was found that 65.2 percent of those in the government sector and 76 percent in the private sector reside in urban areas. Conversely, 34.8 percent of government sector respondents and 24 percent of private sector respondents live in rural areas. This information indicates a clear predominance of respondents from urban regions. Regarding educational qualifications, the study shows that 46.8 percent of respondents have obtained a professional degree, while only 5.4 per cent

have completed a plus-two qualification. Additionally, 35 percent of respondents in the government sector have graduated, whereas 72 percent of those in the private sector hold professional qualifications.

Food Combinations and Nutritional Intake

In this section, the study assessed the typical food combinations regularly consumed by the participants. According to (Gopalan *et al.,* 2021), maintaining good health requires a diverse range of nutrients, and the Recommended Dietary Allowance (RDA) defines the nutrient intake that sustains the health of nearly all individuals. In this study the 24-hour recall method determined the nutrient intake of the respondents.

A. Regular food combination

The breakdown of respondents in terms of food combinations illustrated in Table 2 shows that for daily breakfast, 27 per cent of respondents included cereals, pulses, and vegetables. For lunch, 56.2 per cent of respondents consumed a combination of grains, pulses, vegetables, and non-vegetarian items. During tea time, 24 per cent included a combination of cereals and pulses, while 39.2 per cent included all five food groups in their dinner. The use of all five food groups were most predominant at dinner, while

Table 2. Distribution of the respondents based on food combinations

Food combinations	Breakfast	Lunch	Tea	Dinner
Cereals alone	8(1.6)	0(0)	83(20.9)	0(0)
Cereals+ pulses	79(15.8)	0(0)	96(24.2)	4(.8)
Cereals+ vegetables	71(14.2)	22(4.4)	25(6.3)	11(2.2)
Cereals+ non-veg	0(0)	6(1.2)	6(1.5)	4(.8)
Cereals+ fruits	8(1.6)	0(0)	29(7.3)	3(.6)
Cereals+ pulses+ vegetables	135(27.0)	68(13.6)	60(15.1)	30(6.0)
Cereals+ pulses+ non-veg	3(.6)	10(2.0)	24(6.0)	6(1.2)
Cereals+ pulses+ fruits	19(3.8)	0(0)	12(3.0)	2(.4)
Cereals+ vegetables+ non-veg	2(.4)	61(12.2)	9(2.3)	33(6.6)
Cereals+ vegetables+ fruits	10(2.0)	1(0.2)	7(1.8)	10(2.0)
Cereals+ non-veg+ fruits	0(0)	0(0)	0(0)	7(1.4)
Cereals+ pulses+ vegetables+ non-veg	43(8.6)	281(56.2)	19(4.8)	144(28.8)
Cereals+ pulses+ vegetables+ fruits	78(15.6)	13(2.6)	11(2.8)	41(8.2)
Cereals+ pulses+ non-veg+ fruits	4(.8)	0(0)	4(1.0)	9(1.8)
Cereals+ pulses+ non-veg+ vegetables+ fruits	40(8.0)	38(7.6)	12(3)	196(39.2)
Total	500(100)	500(100)	500(100)	500(100)

(The figures in parenthesis denotes per centages)

breakfast, lunch, and teatime showed less engagement with this food combination. Analyzing specific food items, all respondents included cereals in their breakfast, lunch, and dinner, but only 79.4 per cent incorporated them during tea time. Pulses were consumed by 82.2 per cent of respondents at breakfast, 82 per cent at lunch, and 86.4 per cent at dinner, with only 47.6 per cent of respondents included them during teatime.

Vegetables were included by 75.8 per cent of respondents at breakfast, 96.8 per cent at lunch, and 93 per cent at dinner, while non-vegetarian food was consumed by 18.4 per cent of respondents at breakfast, 79.2 per cent at lunch, and 79.8 per cent at dinner. In terms of fruit consumption, 31.8 per cent included them at breakfast, 10.4 per cent at lunch, and 53.6 per cent at dinner. During tea time, among the 79.4 per cent of respondents who consumed snacks, all included cereals, 59.9 per cent included pulses, 18.8 per cent included fruits, 36 per cent included vegetables, and 18.6 per cent included non-vegetarian foods. Ramya et al. (2021) found that most respondents consumed more cereals, sugars, and fats and fewer fruits and vegetables.

B. 24-Hour Recall Method

The study utilized a 24-hour recall method to evaluate the nutritional intake of the participants, comparing the average intake of eight nutrients with the recommended allowances. Table 3 illustrates nutrient intake details, indicating the percentage of Recommended Dietary Allowance (RDA) met. The data shows that fat intake was highly adequate at 237.289 per cent, and vitamin C intake was notably high at 185.863 per cent. However, the intake adequacy for all other nutrients fell below the recommended RDA. Iron was identified as insufficient, meeting only 58.782 per cent of the Recommended Dietary Allowance. On the other hand, protein, calorie, calcium, thiamine, and riboflavin intakes were estimated to surpass 80 per cent of the recommended dietary allowance.

The average intake of fat, protein, calories, iron, and vitamin C exhibited statistical significance at the 1 per cent level, while calcium showed significance at the 5 per cent level; however, thiamine and riboflavin did not. The data highlights an association between increased consumption of flesh foods, fried items, chocolates, nuts, pizza, and evening snacks with higher fat intake. Conversely, fruits, vegetables, leafy greens, and fruit drinks contributed to an excess Vitamin C intake. It emphasizes that while moderate fat intake is beneficial, an excessive intake of fats may lead to complications.

a. Comparison of nutrient intake based on employment sector, place of residence and age

The Comparison of nutrient intake based on the employment sector in Table 4 observed that individuals in the government sector had comparatively higher intake of nutrients such as fat, calories, and calcium. The data also reveals that both sectors exhibit excess fat and vitamin C intake. However, thiamine and riboflavin meet the Recommended Dietary Allowance (RDA) only among respondents in the private sector. Additionally, despite not meeting the recommendations, calcium and calorie intake were higher among government sector respondents, while iron and protein intake were higher among private sector employees. The results underscore that calorie, thiamine, and riboflavin exhibit significance at the 5 per cent level, indicating a notable difference in nutritional values when comparing employment sectors. This insight helped us understand that the nutritional values observed may be due to various factors related to the nature of work, working

Table 3. Nutrient intake in Comparison with RDA

Nutrient	RDA	Average intake	% of RDA met	Sd	t value	p value
Fat	20 (gm)	47.458	237.289	23.10062	9.207	0.000**
Protein	55 (gm)	47.167	85.759	14.09989	-4.303	0.000**
Calorie	1900 (Kcal)	1603.535	84.397	427.7809	-5.368	0.000**
Calcium	600 (gm)	537.63	89.605	198.7194	-2.431	0.018*
Iron	21 (mg)	12.344	58.782	6.38532	-10.5	0.000**
Thiamine	1 (mg)	0.878	87.809	0.55878	-0.304	0.762
Riboflavin	1.1 (mg)	0.962	87.446	0.68939	-1.552	0.126
Vitamin C	40 (mg)	74.345	185.863	78.61972	3.384	0.001**

** Significant at 1 % level

* Significant at 5 % level

Table 4. Comparison of RDA based on employment sector

Nutrient	Employment sector	RDA	Average intake	% of RDA met	Sd	t value	p value
Fat	Government	20 (gm)	48.65	243.248	16.054	0.397	0.693
	Private		46.266	231.331	28.723		
Protein	Government	55 (gm)	46.379	84.326	10.409	-0.43	0.669
	Private		47.955	87.192	17.171		
Calorie	Government	1900 (Kcal)	1712.993	90.158	361.449	2.034	0.047*
	Private		1494.077	78.636	465.692		
Calcium	Government	600 (mg)	544.492	90.749	211.741	0.265	0.792
	Private		530.768	88.461	188.172		
Iron	Government	21 (mg)	11.683	55.632	3.323	-0.8	0.427
	Private		13.006	61.932	8.426		
Thiamine	Government	1 (mg)	0.734	73.399	0.217	-2.051	0.045*
	Private		1.022	102.219	0.738		
Riboflavin	Government	1.1 (mg)	0.773	70.298	0.267	-2.186	0.033*
	Private		1.151	104.593	0.907		
Vitamin C	Government	40 (mg)	62.691	156.728	60.142	-1.151	0.254
	Private		85.999	214.998	93.152		

*Significant at 5 % level

conditions, sedentary lifestyle, corporate culture, and income disparities prevalent in these sectors.

When comparing nutrient intake based on place of residence, it becomes apparent that fat and vitamin C levels meet the Recommended Dietary Allowance (RDA), while other nutrients fall below recommended levels. Notably, the intake of all specified nutrients is higher among respondents in urban areas than those in rural areas. The data further reveals that iron consumption among respondents in rural areas meets the RDA at less than 55 per cent. Importantly, there is no significant difference in nutrient intake based on place of residence. This finding aligns with Bharathi (2021), who states that calorie, fat, and protein intake tends to be lower among rural participants than their urban counterparts. Not much of a calorie gap was noticed among urban participants.

The study compared the nutrient intake of respondents across different age groups, and the findings indicate that respondents above age 40 exhibited elevated protein and calorie consumption, yet they did not meet the Recommended Dietary Allowance (RDA). Conversely, fat intake was high among respondents aged between 30 and 40 years, with the percentage of RDA intake exceeding 200 for all age groups. Calcium intake was notably high among respondents below 30 years, but it did not meet the recommended requirements. When examining other nutrients such as thiamine, riboflavin, and Vitamin C, the data reveal that the percentage of intake was elevated among respondents below 30 years, meeting the RDA for this age group. However, no statistically significant difference in nutrient intake is based on age. The studies by Mousa *et al.* (2019) and Narici *et al.* (2020) highlight the importance of addressing nutritional needs and physical inactivity across age groups. Mousa et al. emphasize the need for timely identification of malnutrition, with younger individuals requiring balanced fat intake and older individuals needing more protein and calories. By targeting these nutritional gaps and promoting physical activity, we can improve health outcomes and reduce the long-term risks of malnutrition and inactivity.

Anthropometric measurements and health risks

Researchers collected anthropometric measurements using standardized techniques, including body weight, height, and waist and hip measurements. From these measurements, three indices—BMI, WHR, and WC—were calculated to assess the health risk of the respondents. According to Fulgoni *et al.*(2013), understanding a person's body composition and nutritional status is crucial for determining their overall health and anthropometric variables like height, weight, BMI, and skin fold thickness. These measurements offer valuable insights into the well-being of individuals working in technology and help identify those at a higher risk for health issues.

a.Categorization of Body Mass Index

Body Mass Index is a widely accepted measure of body size and a crucial indicator of obesity prevalence in various populations due to its effectiveness in estimating body composition. BMI classification includes six classes: underweight, normal, overweight, obesity class I, obesity class II, and obesity class III. Based on the classification criteria, Figure 1 shows that 6.70 per cent of private sector respondents were underweight, while 30 per cent were classified as overweight. Additionally, 6.70 per cent and 3.30 per cent of respondents were categorized under obesity Class I and II, respectively. The findings also highlight that 50 per cent and 10 per cent of respondents from the government sector fell

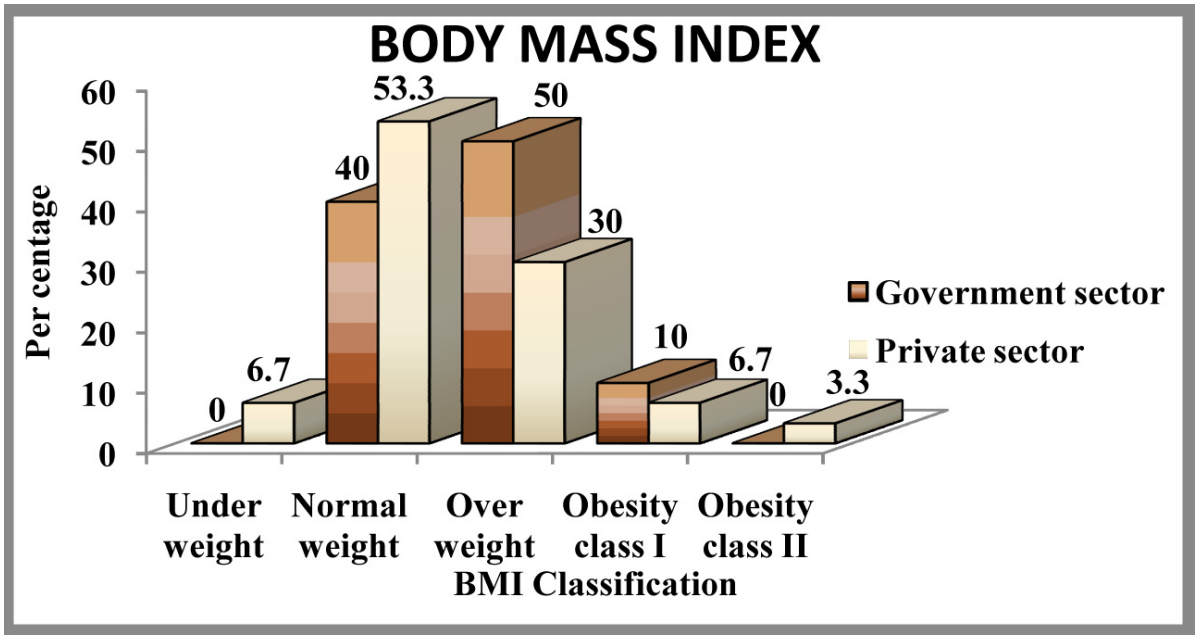

Fig 1 Classification of Body Mass Index

into the overweight and obesity class I categories, respectively.

Mohajan and Mohajan (2023) estimate that obesity and overweight, which are the two primary outcomes of numerous chronic diseases, currently affect approximately one-third of the global population. Obesity contributes to the increased prevalence of various diseases, such as high blood pressure, heart disease, Alzheimer's, asthma, metabolic syndrome, liver steatosis, gallbladder disease, osteoarthritis, obstructive sleep apnoea, some cancers, hypercholesterolemia, musculoskeletal disorders, and type 2 diabetes.

b.Disease risk based on BMI and WC

Abnormal or excessive accumulations of body fat negatively impact health and are characterized as overweight and obesity. According to the NHLBI Obesity Education Initiative (2000), excess abdominal fat is considered a crucial, independent risk factor for disease. Research supports the evaluation of waist circumference to assess the risks associated with obesity and overweight. In women, having a waist circumference greater than 88 cm increases the risk of diabetes, dyslipidemia, hypertension, and cardiovascular disease due to excess abdominal fat. Individuals with waist circumferences exceeding 88 cm should be categorized as having a higher risk than what is indicated by their Body Mass Index (BMI). The disease risk classification based on normal weight and waist circumference, was computed for overweight and obese respondents and is presented in the table.

The data in Table 5 indicates that 61.10 per cent of the respondents belonging to the government sector exhibit an elevated disease risk. Among them, 22.20 per cent are at high risk, and 16.70 per cent show a very high risk. In the private sector, 66.70 per cent of respondents are at increased disease risk, with 16.70 per cent at high risk and another 16.70 per cent facing very high disease risk. This pattern may be attributed to the generally older age of government sector employees, contributing to their higher disease risks. In

Table 5. Association of BMI and WC for overweight and obesity based on disease risk

BMI classification	Disease risk	Employment sector		Total (%)
		Government (%)	Private (%)	
Underweight /Normal	-	-	-	-
Over weight	Increased	61.10	66.70	63.30
Obesity class I	High	22.20	16.70	20
Obesity class II	Very high	16.70	16.70	16.70
Obesity class III	Extremely high	-	-	-
Total	100	100	100	

(The figures in parenthesis denote percentage)

contrast, disease risk in the private sector is likely to increase over time, as most respondents are currently in the increased risk category.

Health risk based on Waist Hip Ratio

In this study, health risks were categorized based on waist-hip ratio, following the guidelines of Sedodo *et al.* (2013).The data revealed that 53.30 per cent of respondents in the government sector were identified with low health risk based on their waist-hip ratio. In contrast, 46.70 per cent of respondents in the private sector exhibited a moderate health risk, with the proportions of high-risk individuals being similar between the two sectors. The health risks among respondents in the private sector may be higher than those in the government sector. Referring to the World Health Organization (2011) expert consultation on obesity reports, recommendations were made regarding abdominal obesity and waist circumference as integral components of metabolic syndrome. The report also established sex-specific waist circumference cut-off points suitable for diverse populations, which were adopted in this study to assess the risk of metabolic complications.

Figure 2 illustrates the increased and significant risk of metabolic complications within the samples. The data indicated that 30 per cent of respondents from the government sector and 40 per cent from the private sector face an increased risk of metabolic complications. Substantial increases in the risk of metabolic complications were observed among 23.30 per cent of respondents from the government sector and 10 per cent from the private sector. According to Dobrowolski *et al.* (2022), obesity, hypertension, and the severity of metabolic disorders elevate cardiovascular risk by contributing to the development of further health conditions.

d. Correlation on waist-hip ratio, waist circumference and BMI

Examining the Correlation between waist-hip ratio (WHR), waist circumference (WC), and body mass index (BMI), the correlation analysis specified in Table 6 reveals a statistically significant relationship ($p < .01$) between BMI and waist circumference. This positive Correlation indicates that these variables tend to increase together, meaning a higher BMI is associated with a larger WC. Ashwell and Gibson (2016) found that the waist-to-height ratio (WHtR) is a more sensitive

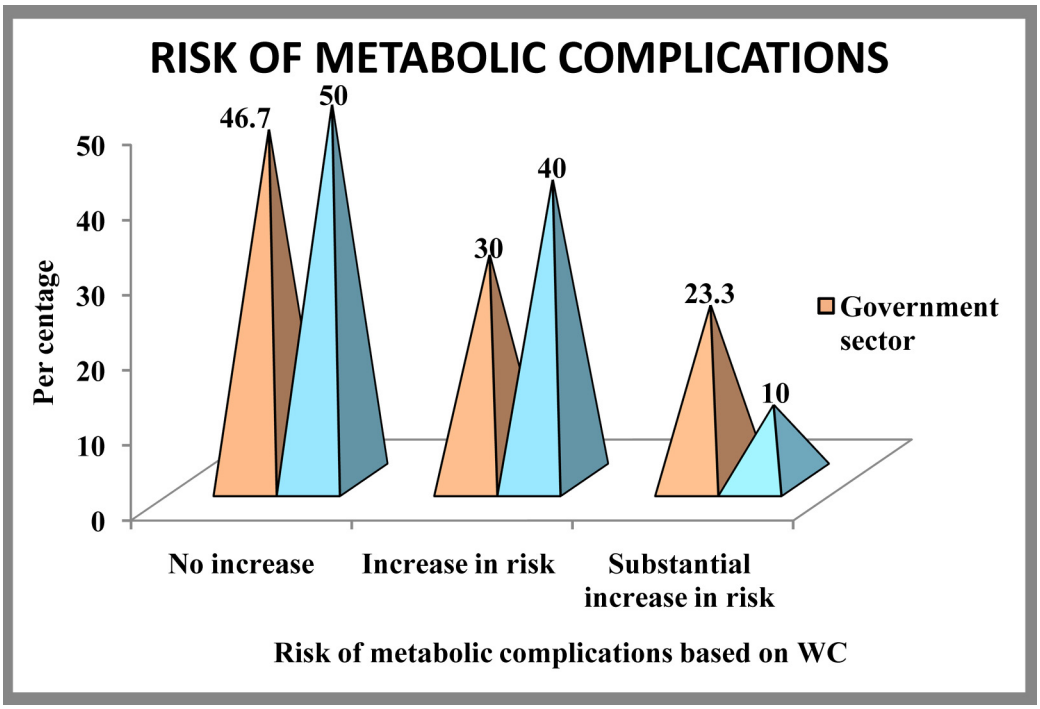

Fig 2 Risk of metabolic complications based on WC

and accurate predictor of early health risks related to abdominal obesity.

Following an extensive review, the World Health Organization (2011) confirmed compelling evidence linking general obesity measures, such as Body Mass Index (BMI), with indicators of abdominal obesity, including waist circumference, waist-hip ratio, and waist-height ratio, to cardiovascular disease (CVD) risk factors. Most cross sectional studies suggested that waist circumference or waist-hip ratio might be more effective CVD risk indicators than BMI.

CONCLUSION

In conclusion, research examining the effects of nutritional intake and anthropometric assessment among technology personnel reveals significant associations between nutrient intake and health outcomes. The study identified excessive fat intake (237.289 % RDA) and vitamin C intake (185.863% RDA), alongside insufficient iron intake (58.782% RDA). Health risks were prevalent, with 61.10 percent of government sector employees and 66.70 percent of private sector employees classified as having an elevated risk. Based

Table 6. Correlation on waist-hip-ratio, waist circumference and BMI

Correlation		Pearson correlation	Significance
Body mass index	Waist circumference	.822**	0.000**
Waist hip ratio	Waist circumference	.514**	0.000**
Waist hip ratio	Body mass index	0.185	0.158

**Significant at 1 % level

on the waist-hip ratio, 53.30 per cent of government employees were categorized as having a low risk, while 46.70 percent of private sector employees were at moderate risk.

This study emphasizes the importance of a thoughtful, balanced approach to nutrition in reducing the potential health risks associated with technology-related work. Evidence suggests that proper nutrient management and regular monitoring of body measurements can improve the well-being of individuals in this field. As technology evolves and job demands increase, it is crucial for technology workers to prioritize their health through informed dietary choices and regular health screenings. The findings highlight the value of proactive health care and underscore the need for personalized nutrition strategies tailored to the specific needs of technologists. By addressing these factors, organizations and individuals can foster a healthier, more resilient workforce, ultimately supporting long-term well-being and productivity in the fast-paced technology sector.

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PERCEPTION OF AGRICULTURE STUDENTS OF MAHARASHTRA TOWARDS FARMING AS AN OCCUPATION

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ABSTRACT

The study examined how 290 agriculture students in Maharashtra perceived farming as an occupation in the year 2024. Researchers looked at various economic, Socio-Cultural, personal, physical, and psychological criteria to gauge how agricultural students felt about farming as a career. The study's conclusions showed that an astounding 50.7 per cent of students believed that farming is associated with poor income, and 78 per cent thought that farmers committed suicide because of their poor income. According to the survey, most students agreed that farming is the occupation with the lowest standing in society, and farmers are not regarded as professionals. Most respondents agreed that farming involves a significant amount of physical work. Because farmers are exposed to extreme weather conditions, a large percentage of respondents (50.7%) agreed and (26.6%) strongly agreed that farmers are always at risk. Many respondents agreed that farmers enjoy working hard. Most respondents agreed that using cutting-edge techniques and technology may boost agricultural income. 53.1 per cent of respondents felt that feeding others is a fulfilling aspect of farming. Students have offered insightful comments on the topic of income sufficiency. Among respondents, 50.7 per cent agreed, and 22.4 per cent strongly agreed that farming generates enough revenue to cover a family's fundamental necessities. In contrast, 50.3 percent of respondents agreed that suicide was a result of unmet fundamental necessities and financial obligations. Therefore, policies that encourage students to work in agriculture and do it in a contemporary manner must be developed.

Keywords: Agriculture, Education, Farming, Occupation, Perception

INTRODUCTION

The agriculture sector is one of the largest sectors in India since ancient times. Most people in developing nations like India reside in rural regions. A sizable section of the Indian populace still relies on agriculture and other sectors for their livelihood, either directly or indirectly (Indwar *et al.,* 2024). Though agriculture is the backbone of the Indian economy, it has been dealing with several difficulties. It is highly vulnerable to the adverse impacts of climate change, including as flooding, droughts, and extreme heat. Because of poor investment, Indian agriculture has continuously seen a drop in relative profitability and job prospects (Kumar *et al.,* 2024). Over the last decade, substantial changes and developments have been aimed

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at improving agriculture productivity to meet the rapidly increasing consumption demand of the growing population. In India, youth constitute a numerically dominant potential, resourceful, and adventurous population segment. Quite 50 per cent of India's current population is below the age of 25 years and over 65 per cent below the age of 35. Most live in rural areas (Mahawar and Neeta, 2021). In 2023, World Bank data underscored the importance of agriculture, agriculture accounting for 4 per cent of the world's GDP and a staggering 25 per cent in the least developed nations. Recent statistics from the Ministry of Statistics & Programme Implementation (MoSPI) shed light on the agriculture sector's robust contribution to India. As per the Second Advance Estimates of National Income, The Gross Value Added (GVA) of agriculture and allied sectors comprised 18.3 per cent of the total economy at current prices during 2022-23.On the one hand, agriculture is an essential sector for India; on the other hand, the agricultural sector of India has been losing a substantial section of its labor force, the youth, particularly males, due to a lack of incentive to take up agriculture as a career and staying in the rural areas, thus leading to migration from rural to urban areas in search of white-collar jobs. More specifically, the youth have developed a negative attitude towards agriculture; therefore, they are no longer interested in careers in agriculture.

Youth are the most vital segment of the population of a country. They have realized the ray of hope for tomorrow's agriculture and will be the backbone of rural communities. Youth is considered a storehouse of energies and innovative ideas, and they are more oriented to adopting technologies due to their enthusiasm, which strengthens the workforce. India, the youngest nation in the world, has massive youth resources to offer to the agriculture sector, but unfortunately, youth participation in agriculture is declining. The migration of rural youth to the cities is around 45 per cent, which is quite alarming. The significant challenges for youth moving to urban centers include lack of basic amenities, unemployment, and lack of interest in farming since agriculture suffers from several factors such as natural disasters, smaller land holdings, and lack of employment opportunities for youth, which is one of the major global economic crises (ATARI, 2020).

Four universities are under the Maharashtra Council of Agricultural Education and Research (MCAER). These universities, 22 government colleges, and 78 non-government colleges collectively offer various degree courses, including B.Sc specializations in agriculture, horticulture, forestry, fishery science, agriculture engineering, community sciences, biotechnology, and agribusiness management. A relatively high rise has been observed in the number of graduates coming out of the agricultural colleges in the recent past. Presently, government agriculture colleges produce about 3,362 graduates per annum, while the graduates from private agricultural colleges are about 12,690 (www.mcaer.org, n.d.2004).

Rural youth are precious human assets who can play an essential role in development activities and agriculture because of their family and community background in agriculture and allied activities. If the talents and abilities of rural youth are appropriately nurtured and systematically guided, agriculture can attain sustained growth and bring prosperity to the country (Bodake *et al.,* 2019). Though, as discussed above, To understand the contradiction, the percentage of graduate students is high, andthe migration of rural youth from villages to cities is also high., it is essential to understand the perception of agriculture students towards farming as an

occupation; the studies by (Sreelakshmi *et al.,* 2024) has made on similar objectives in Rajasthan. The study, hence, keeping this in view, the study was conducted to analyse the factors contributing to the perception of agriculture students towards farming as an occupation.

MATERIAL AND METHODS

The research methodology involved a targeted study within Maharashtra, a leading agricultural state in India. As per the Economic Survey 2023-24 in India, Maharashtra produces tur, gram, total pulses, soybean, sugarcane, and cotton. At the same time, after Rajasthan (6), Maharashtra is the second state with the highest number of agricultural universities (5). Hence, it will be fruitful to study agri students' perception of farming in Maharashtra as an occupation. Stratified random sampling method is used to collect the data in Maharashtra as Maharashtra has a diverse range of agricultural colleges in different regions (e.g., Vidarbha, Marathwada, Western Maharashtra and Konkan).

From an initial outreach to 350 respondents within these areas, 290 valid and pertinent responses were obtained and analysed. The data-gathering process was conducted using a pre-tested interview schedule, ensuring consistency and reliability in the information collected. The scales have been previously used by (Sidhu *et al.,* 2022).

Measurement of the variable perception

It refers to how farming is regarded, understood, and interpreted by farm family members as an occupation on economic, sociocultural, personal, physical, and psychological dimensions. A scale of 10 statements to measure economic factors, 8for sociocultural, 6 for physical, 9 for personal, and 10 for psychological factors, was developed. Thus, a total of 43 statements were constructed for the study. The responses for each statement were rated on a five-point continuum. Positive statements were assigned a score of 5 to 1 for strongly agree to strongly disagree, and negative statements were assigned a reverse score from 1 to 5 for strongly disagree to strongly agree.

Mean Score

To ascertain the perception of Agri students towards farming as an occupation in

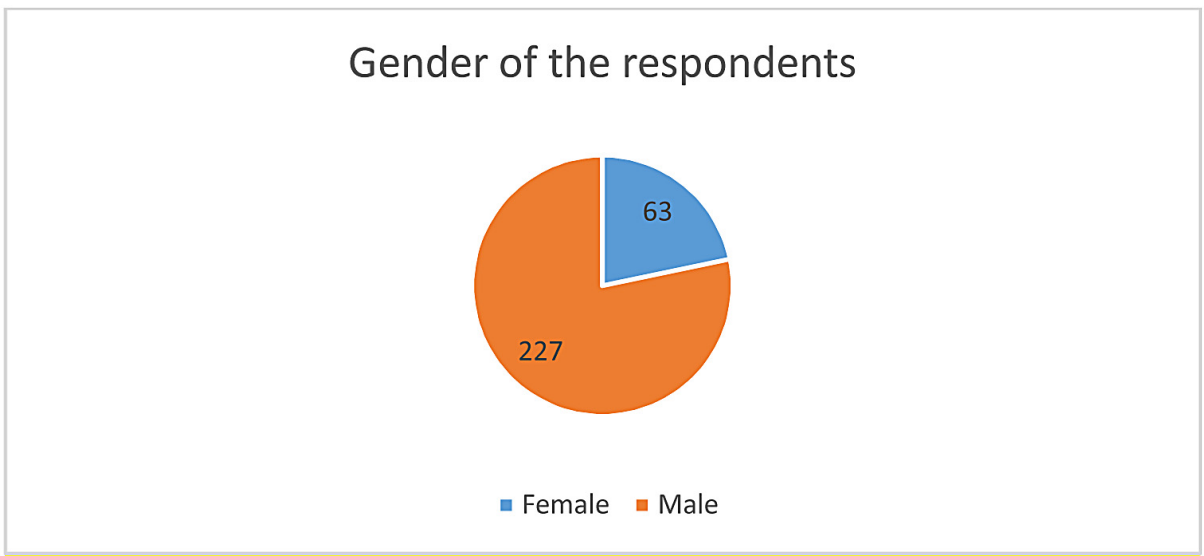

Fig 1:Gender of the respondents

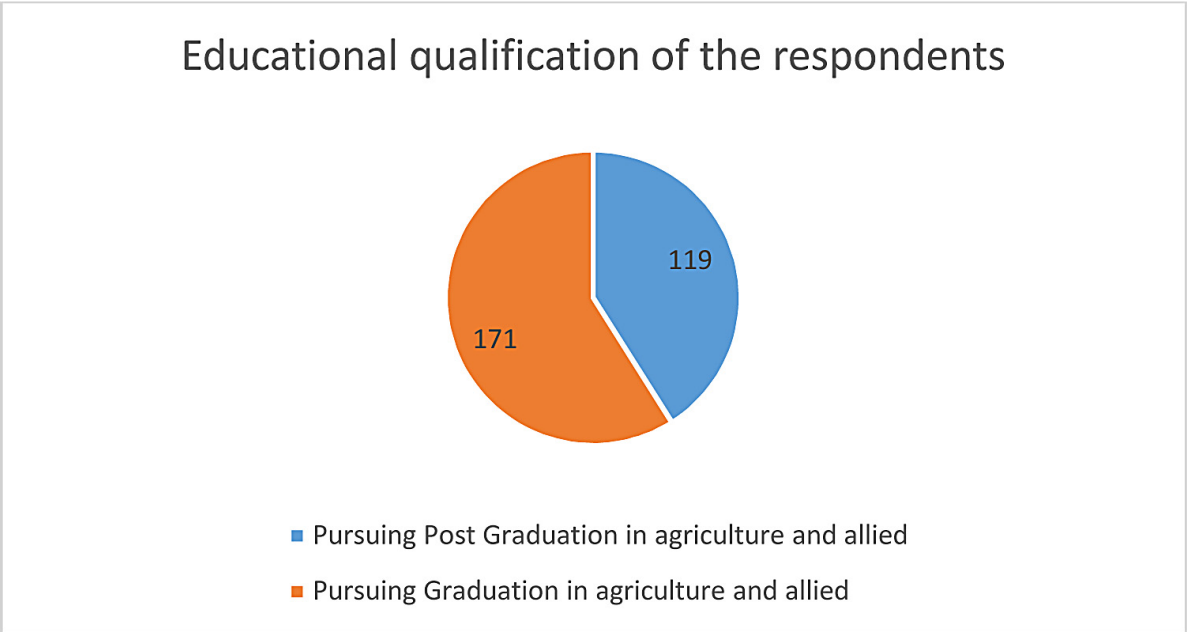

Fig 2:Educational qualification of the respondents

Maharashtra, statistical tools, including frequency, percentage, and mean, were employed for comprehensive analysis. The mean score was calculated by adding the score of each statement for each factor based on agreement and disagreement and dividing by the number of statements. The mean score for each of the factors was also worked out individually. Data were analysed using frequency, mean, and percentages, and ranks were assigned based on mean scores.

RESULTS AND DISCUSSION

Profile of respondents:

As shown in Fig 1. Out of 290 students 227 were male and 63 were female. As shown in Fig 2 out of 290 students 171 were pursuing graduation in agriculture and allied fields and 111 pursuing post-graduation in agriculture and allied fields.

As shown in Table No. 1. Most of the respondents attends community meetings frequently. Out of 290, 175 respondents are members of social organization and most of them volunteered for community and cultural activities. Table No. 2. Revealed Economic orientation of the respondent. Out of 290 respondents 160 respondents are having above 30,000 total monthly income of their household. Many of them having access to educational resources such as Smartphone/ Tablet and Laptop/Computer. All the respondents are having access to the Electricity, Drinking Water, and Toilet. Most of them use public transportation to travel to college. Table No. 3. Revealed mass media exposure of the respondent. It has observed that all the respondents use mass media daily which includes Television, Radio, Newspapers/ Magazines, SocialMedia/Online Platforms, and Podcasts/Streaming Platforms. They have used social media mostly for education/Skill Development purposes. Out of 290, 110 and 150 responded spend 1–3 and More than 3 hours respectively. Remaining 30 spend less than one hour.

Fig 3 has revealed Region & College Wise Spread of Students and Fig 4 has shown

Table 1. Social participation of the respondent

Attended community meetings	**Never**	**30**
	Occasionally	**90**
	Frequently	**170**
		290
Member of social organizations	**Yes**	**175**
	No	**115**
		290
Volunteered for community activities	**Never**	**30**
	Occasionally	**100**
	Frequently	**160**
		290
Participated in cultural activities	**Never**	**30**
	Occasionally	**80**
	Frequently	**180**
		290
Interaction with local leaders	**Never**	**30**
	Occasionally	**100**
	Frequently	**160**
		290

Table 2. Economic orientation of the respondent

Parental/Household Income	
What is the total monthly income of your household?	
Low (Below ¹ 10,000)	**30**
Medium (¹ 10,000–¹ 30,000)	**100**
High (Above ¹ 30,000)	**160**
	290
Access to Educational Resources	
Do you have access to the following resources for education? (Tick all that apply)	
Smartphone/Tablet	
Laptop/Computer	
Internet Connection	
Personal Study Space	
Scoring:	

Access to 1–2 resources	180
Access to 3 resources	80
Access to all 4 resources	30
	290
Household Amenities	
Does your household have access to the following amenities? (Electricity, Drinking Water, Toilet)	
Access to 1 or none	0
Access to 2	0
Access to all 3	290
	290
Mode of Transport for Education	
How do you travel to school/college?	
Walk or public transport	160
Bicycle or shared vehicle	90
Personal two-wheeler or car	40
	290

Table 3. Mass media exposure of the respondent

Frequency of Media Use	
How often do you use mass media (TV, radio, newspapers, and online platforms)?	
Rarely (Once a week or less)	0
Occasionally (2–4 times a week)	0
Frequently (Daily)	290
Diversity of Media Access	
Which of the following media do you regularly use? (Tick all that apply)	
Television	
Radio	
Newspapers/Magazines	
Social Media/Online Platforms	
Podcasts/Streaming Platforms	
Scoring:	
Use 1–2 media types	**50**
Use 3–4 media types	**150**
Use all 5 media types	**90**
	290

Purpose of Media Use	
What is your primary purpose for using mass media?	
Entertainment	50
Information/News	90
Education/Skill Development	150
	290

Time Spent on Media Daily	
How much time do you spend on mass media daily?	
Less than 1 hour	30
1–3 hours	110
More than 3 hours	150
	290

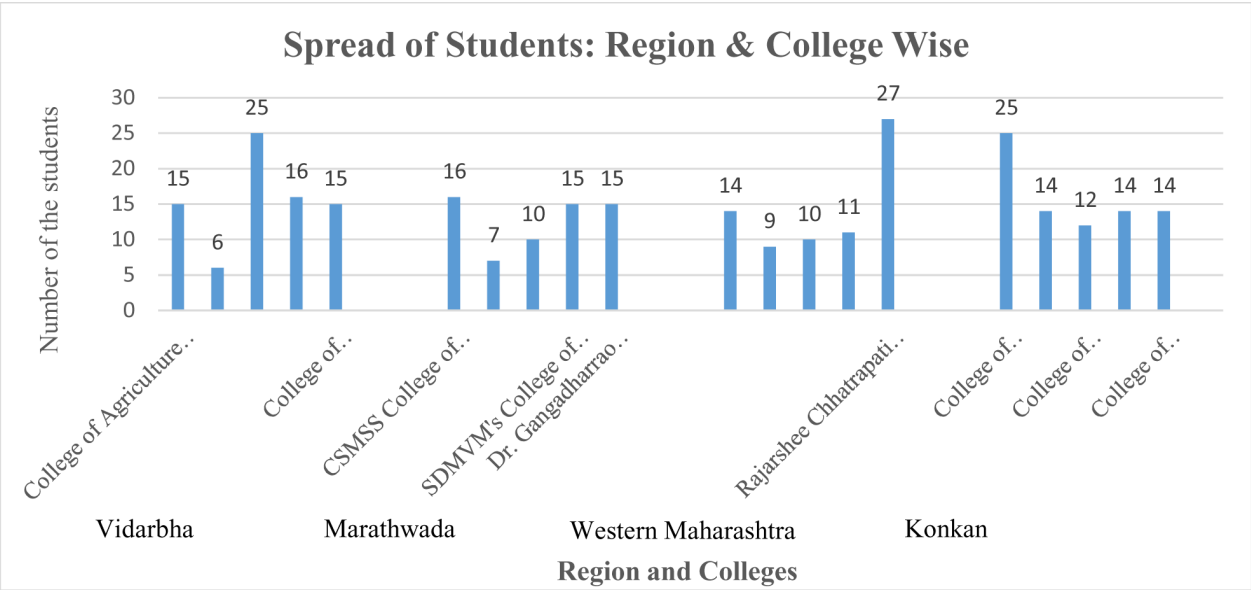

Fig 3. Region & College Wise Spread of Students

region Wise Bifurcation of the Student's Interest after Completing Education. Based on the data from the figures it is observed that students from Vidharbha and Marathwada is having no interest in farming contrast with students from Western Maharashtra and Konkan where students are interested in farming. It can be due to farming is challenging because of climatic change, water scarcity and other factors in those areas. Students from Vidharbha, Marathwada and Western Maharashtra are more interested towards private sector. In Konkan it has been observed that students are more interested in public sector followed by private sector.

In general the interest of students are more towards private sector followed by public sector. In all the regions very few students wants to join their family business. To start a new business more students from the Konkan

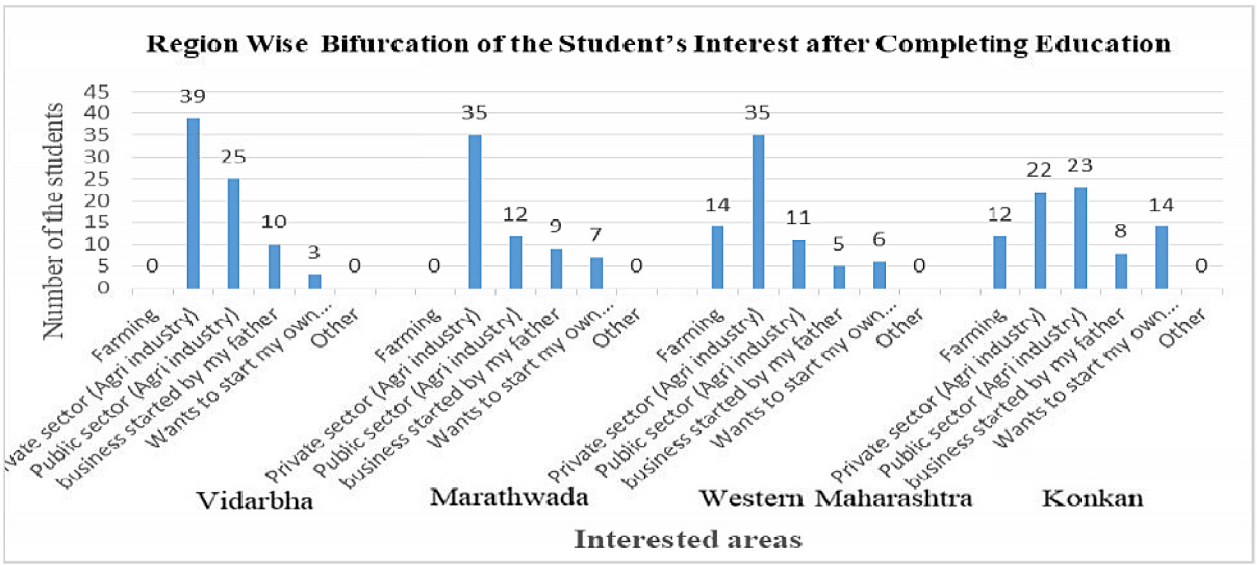

Fig 4. Region Wise Bifurcation of the Student's Interest after Completing Education

followed by Marathwada and Western Maharashtra has shown the interest.

Data from the figure 5 shows alternatives attempted by the students after 12th other than BSc agri. It has observed that out of 290 students, 140 students have applied for Agri and allied sectors such as animal husbandry, milk production industry, dairy farming, horticulture and fishery. It revealed that those who have taken admission in agriculture had keen interest in agriculture that is the reason they have taken their second preference to allied sectors. The data revels that Medical and life sciences is the second choice of the students followed by preparation for competitive exams. Other options explored by the students are Engineering and Technology, Business and Commerce, Arts and Humanities,

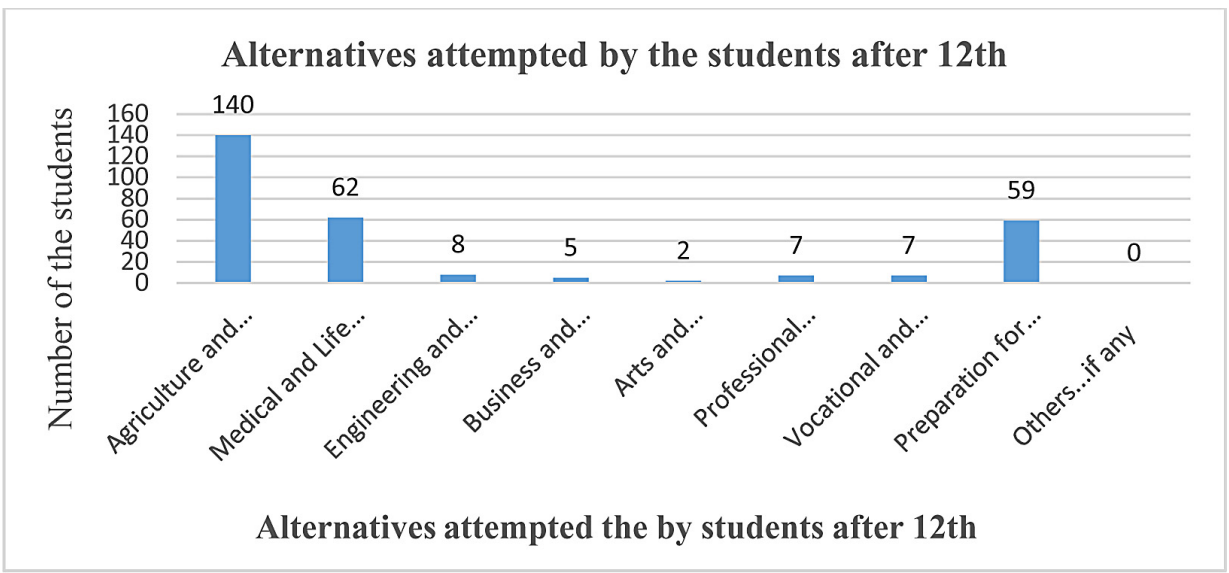

Fig 5. Alternatives attempted by the students after 12th

Professional Courses and Vocational and Skill-Based Courses.

Data shown in figure 6 reveals an understandable explanation of why the agriculture students were to take up their education in agriculture. The study revealed that 239 out of 290 students wish to take agriculture due to their interest in the course. This indicates that most students were intrinsically motivated to take agriculture, which in turn shows that passion and interest are considerations for students' educational choices. These results match the previous study by (Roy and Sanjay Kumar, 2023) where the results revealed that students' intentions to enter agricultural-related careers were predicted by their attitudes toward agriculture. Perceived behavioural control is the strongest predictor. Of the 290 students in the sample, 30 were influenced by their family members to take up farming. It proves that family influences decisions but not as heavily as personal interest. The study by (Panda *et al.,* 2020) also found, 'Parental influence' is one of the factors of enrolment of the student to Agri related course. The other reason was recommendations, as 18 out of 290 students said they were advised to take up agriculture. This seems to suggest that reliance on competency seeking from others in the form of advice or recommendations is irrelevant in a decision such students make. Three respondents, representing one per cent of the sample, have selected agriculture for the following reasons that do not fit the main categories: they wanted to start their own business, and few mentioned that they wanted to take government agricultural exams. Hence, they were admitted to the course.

Perception of youth towards economic factors associated with farming as an occupation:

Table No. 4 shows that 50.7 per cent of students (14.1% strongly agree, 36.6% agree) perceive farming as associated with poor income contributed mostly in negative perception among students. This contrasts with 36.9 per cent (26.9% disagree, 10.0% strongly disagree) who believe otherwise. These results match the previous studies by (Bodake *et al.,* 2019; Gunashekhar *et al*., 2024; Narain *et al*., 2015; Sidhu *et al*., 2022) which reveals Eighty-

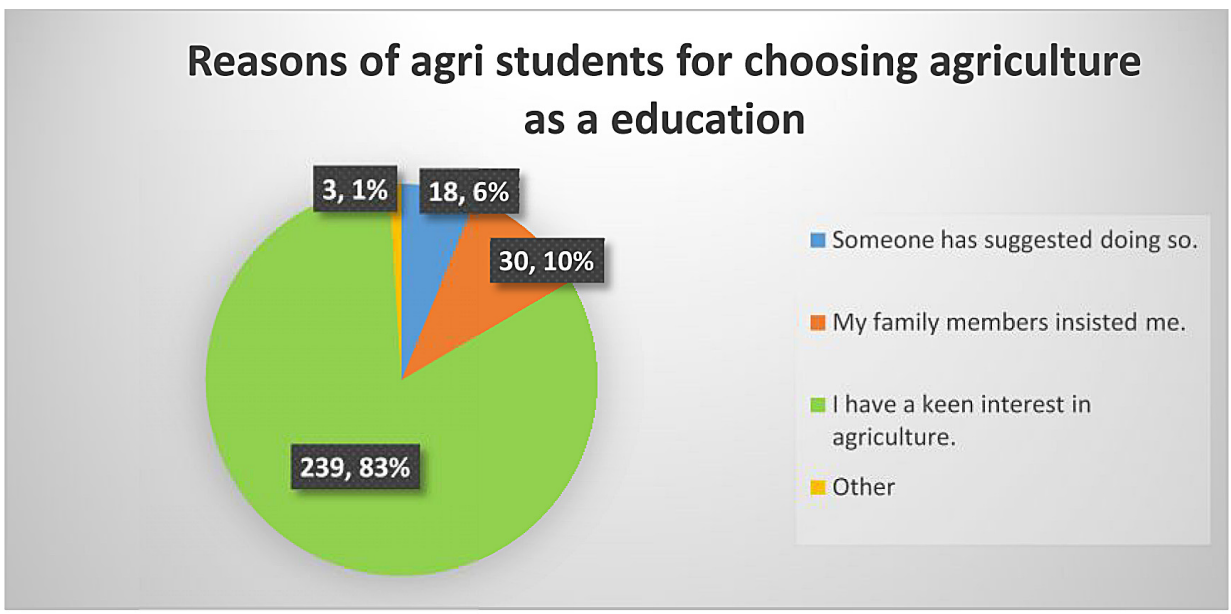

Fig 6: Reasons of agri students for choosing agriculture as an education

eight per cent of farming youth accept that poor income and living standards are responsible for luring rural youth to the non-farm sector. The reason could be that farm returns have decreased due to increased Mechanization and Investment Costs. A significant 82.8 per cent (19.7% strongly agree, 63.1% agree) that the growth of mechanization in farming increases investment costs. A significant majority of the students, 78 per cent (31.4% strongly agree, 46.6% agree), feel that the income from farming is meager compared to other professions. An overwhelming 74.5 per cent (18.3% strongly agree, 56.2% agree) of the respondents feel that farmers are unhappy with their household finances; in contrast, only 12.4 per cent have an opposing view. 78 per cent (31.4% strongly agree, 46.6% agree) believe that low farming income results in suicide cases among the farmers. The unhappiness among farmers or suicidal tendencies could be due to the uncertainty of selling harvest produce; this, too, had the most significant agreement with the statement where 81.7 per cent (30.3 % strongly agree, 51.4% Agree) and only a meager 5.5 per cent disagreed that farmers are uncertain about their income until their harvest is sold in the Mandis. A substantial percentage of 78.3 per cent (25.2 % strongly agree, 53.1 % agree) feel that the farmer organizations are essential if a farmer's interest is to be safe guarded in negotiations with middlemen.

In contrast, the positive side is that 55.9 per cent of the respondent farmers think that farming is a very profitable profession, with a mean score of 3.4. 76.9 percent (17.6% strongly agree, 59.3% agree) believe farming can yield significant profits, and this is second on a score with a mean of 3.8. Seventy percent (13.1% strongly agree and 57.6% agree) agreed that farming farmers can get time for additional occupations, whereas 15.5 percent disagreed (12.4% disagree and 3.1% strongly disagree). The mean score on this statement is 3.7, ranked third.

These results indicate the general agreement among agricultural students regarding their perception of farming. Farming is high-yielding, and it gives time to do other occupations, but at the same time, it also gives economic hurdles related to labor, income, and investment costs.

Perception of youth towards sociocultural factors associated with farming as an occupation:

Perception of the agri students related to sociocultural factors is depicted in data as shown in Table No. 5, reveals that the maximum percentage of the students agreed (34.5% agreed, 11.7%, strongly agreed) that farming is the profession with the lowest status in society. The reason could be that nearly half of the respondents, 46.2%, agreed, and 26.2% strongly agreed that farmers are not considered professionals. In contrast, 50.3% of the respondents agreed, while 26.9% strongly agreed that farming is a prestige symbol in Maharashtra. The mean score was 3.9, ranked first. Also, about 55.5% agreed, and 13.4% strongly agreed that farming is done because previous generations did it. However, most respondents agreed that farming is a prestigious symbol in Maharashtra. A substantial majority (49.0% agreed, and 35.9% strongly agreed) that parents should encourage their children to leave farming to pursue higher-status employment in the city. The reason could be that nearly half (47.2% agreed, 21.7% strongly agreed) that salaried work is more respectable than farming. Concerning girls, 40.3% agreed, and 34.8% strongly agreed that girls avoid marrying farmers to avoid village life. Regarding earnings and matrimonial preference, 40.0% agreed, and 33.1% strongly agreed that girls

Table 4. Perception of Agri students towards economic factors of farming

Economic Factors (N=290)

S.No	Statements	SA		A		U		D		SD		Score	Mean	Rank
		f	%	f	%	f	%	f	%	f	%			
1	Farming is associated with poor income.	41	14.1	106	36.6	36	12.4	78	26.9	29	10.0	818	2.8	5
2	The increasing mechanization of farming leads to higher investment costs.	57	19.7	183	63.1	29	10.0	19	6.6	2	0.7	596	2.1	7
3	The income from farming is insufficient when compared to other professions.	91	31.4	135	46.6	31	10.7	28	9.7	5	1.7	591	2.0	8
4	Farmers are dissatisfied with the state of their household finances.	53	18.3	163	56.2	38	13.1	33	11.4	3	1.0	640	2.2	6
5	Farmers commit suicide as a result of low farming income.	91	31.4	135	46.6	31	10.7	28	9.7	5	1.7	591	2.0	8
6	Farming can yield significant profits.	51	17.6	172	59.3	37	12.8	28	9.7	2	0.7	1112	3.8	2
7	Until their harvest is sold in the Mandis, farmers are unsure of how much money they will make from farming.	88	30.3	149	51.4	37	12.8	14	4.8	2	0.7	563	1.9	9
8	Working in agriculture gives you plenty of time to pursue additional occupations.	38	13.1	167	57.6	40	13.8	36	12.4	9	3.1	1059	3.7	3
9	To protect farmers' interests during negotiations with middlemen, farmer organizations are essential.	73	25.2	154	53.1	41	14.1	19	6.6	3	1.0	1145	3.9	1
10	Farming is a highly profitable profession.	46	15.9	116	40.0	59	20.3	55	19.0	14	4.8	995	3.4	4

* f= frequency and %= percentage

*SA= Strongly Agree, A= Agree, U=Undecided, D=Disagree and SD= Strongly Disagree

Table 5. Perception of Agri students towards Socio - cultural factors of farming

Socio - cultural Factors (N=290)

S.No	Statements	SA		A		U		D		SD		Sc-ore	Me-an	Ra-nk
		f	%	f	%	f	%	f	%	f	%			
1	Farming is the profession with the lowest status in society.	34	11.7	100	34.5	29	10.0	86	29.7	41	14.1	870	3.0	2
2	Farmers are not treated as professionals.	76	26.2	134	46.2	27	9.3	41	14.1	12	4.1	649	2.2	5
3	Parents encourage their kids to leave farming and move to the city in pursuit of high-status employment.	104	35.9	142	49.0	21	7.2	18	6.2	5	1.7	548	1.9	7
4	In Maharashtra, farming is a prestige symbol for farmers.	78	26.9	146	50.3	39	13.4	23	7.9	4	1.4	1141	3.9	1
5	The reason farming is done is because it was done by earlier generations.	39	13.4	161	55.5	37	12.8	45	15.5	8	2.8	692	2.4	3
6	Compared to farming, salaried work is seen as the more respectable career path.	63	21.7	137	47.2	37	12.8	40	13.8	13	4.5	673	2.3	4
7	Girls choose not to marry farmers since it would require them to live in a village.	101	34.8	117	40.3	28	9.7	37	12.8	7	2.4	602	2.1	6
8	Because of his lower income, farmers are not the girl's first option for a husband.	96	33.1	116	40.0	32	11.0	42	14.5	4	1.4	612	2.1	6

* f= frequency and %= percentage

*SA= Strongly Agree, A= Agree, U=Undecided, D=Disagree and SD= Strongly Disagree

Table 6. Perception of Agri students towards Physical factors of farming

Physical Factors (N=290)

S.No	Statements	SA		A		U		D		SD		Sc-ore	Me-an	Ra-nk
		f	%	f	%	f	%	f	%	f	%			
1	Farming requires a lot of physical activity.	109	37.6	145	50.0	17	5.9	18	6.2	1	0.3	1213	4.2	1
2	One who marries a farmer is expects to ready for physical hard work.	47	16.2	139	47.9	40	13.8	55	19.0	9	3.1	710	2.4	5
3	Farmers that do physical work in farming stay healthy	93	32.1	149	51.4	23	7.9	19	6.6	6	2.1	1174	4.0	2
4	Drudgery-laden tasks are no longer a part of agriculture	28	9.7	106	36.6	102	35.2	48	16.6	6	2.1	972	3.4	4
5	Farmers are always at danger because of their exposure to intense heat, cold, and dust.	77	26.6	147	50.7	27	9.3	34	11.7	5	1.7	613	2.1	6
6	Farming poses a health concern since it includes handling chemicals.	60	20.7	173	59.7	28	9.7	24	8.3	5	1.7	1129	3.9	3

* f= frequency and %= percentage

*SA= Strongly Agree, A= Agree, U=Undecided, D=Disagree and SD= Strongly Disagree

Table 7. Perception of Agri students towards Personal Factors of farming

Personal Factors (N=290)

S.No	Statements	SA		A		U		D		SD		Sc-ore	Me-an	Ra-nk
		f	%	f	%	f	%	f	%	f	%			
1	I like being a farmer.	107	36.9	140	48.3	24	8.3	15	5.2	4	1.4	523	1.8	8
2	I'm interested in agriculture.	138	47.6	126	43.4	16	5.5	8	2.8	2	0.7	1260	4.3	1
3	People choose to work as farmers when they have no other options.	60	20.7	116	40.0	45	15.5	57	19.7	12	4.1	715	2.5	7
4	Farming is a way of life, not simply a profession.	115	39.7	133	45.9	14	4.8	23	7.9	5	1.7	1200	4.1	3
5	Farmers take pleasure in working hard.	87	30.0	152	52.4	27	9.3	19	6.6	5	1.7	1167	4.0	4
6	Using innovative methods and technology can boost farming revenue.	121	41.7	133	45.9	22	7.6	14	4.8	0	0.0	1231	4.2	2
7	I am happy and satisfied while I am farming.	89	30.7	156	53.8	20	6.9	20	6.9	5	1.7	1174	4.0	4
8	Farming is for the uneducated people.	18	6.2	56	19.3	23	7.9	82	28.3	111	38.3	1082	3.7	6
9	Individuals working in cities might pursue farming as a passion project and a means of earning additional income.	47	16.2	162	55.9	51	17.6	26	9.0	4	1.4	1092	3.8	5

* f= frequency and %= percentage

*SA= Strongly Agree, A= Agree, U=Undecided, D=Disagree and SD= Strongly Disagree

Table 8. Perception of Agri students towards Psychological factors of farming

Psychological Factors (N=290)

S.No	Statements	SA		A		U		D		SD		Sc-ore	Me-an	Ra-nk
		f	%	f	%	f	%	f	%	f	%			
1	Farming provides enough income to fulfil family members' basic needs.	65	22.4	147	50.7	30	10.3	37	12.8	11	3.8	1088	3.8	3
2	Farmers are being forced to commit suicide due to liability.	59	20.3	119	41.0	63	21.7	36	12.4	13	4.5	695	2.4	6
3	Farmer suffers from poor self-esteem due to his lack of social position.	57	19.7	143	49.3	57	19.7	28	9.7	5	1.7	651	2.2	8
4	Pest and disease attacks on crops are a constant fear to farmers.	104	35.9	147	50.7	19	6.6	18	6.2	2	0.7	537	1.9	9
5	The unpredictability of weather patterns has made farming more hazardous.	101	34.8	139	47.9	37	12.8	11	3.8	2	0.7	544	1.9	9
6	Farming provides a sense of fulfilment since it feeds others.	86	29.7	154	53.1	34	11.7	10	3.4	6	2.1	1174	4.0	1
7	Agriculture is an extremely dangerous career due to fluctuations in agricultural revenue.	55	19.0	114	39.3	47	16.2	56	19.3	18	6.2	738	2.5	5
8	Being a farmer is an extremely stressful job.	48	16.6	106	36.6	42	14.5	79	27.2	15	5.2	777	2.7	4
9	Farmers commit suicide because they are unable to fulfil the basic family needs.	53	18.3	146	50.3	39	13.4	42	14.5	10	3.4	680	2.3	7
10	I prefer to keep farming as a side business and enter a steady profession (private or public sector).	73	25.2	145	50.0	39	13.4	25	8.6	8	2.8	1120	3.9	2

* f= frequency and %= percentage

*SA= Strongly Agree, A= Agree, U=Undecided, D=Disagree and SD= Strongly Disagree

do not prefer to get married to farmers due to lower earnings.

The findings point to the complicated sociocultural dynamics influencing agricultural students' views on farming. The factors that received the highest mean scores identify the concerns on social status, professional recognition, and generational continuity in agriculture.

Perception of youth towards physical factors associated with farming as an occupation:

Table No. 6 reveals the attitudes and beliefs of the students towards physical factors of agriculture. A majority of respondents a whopping 50.0% agreed and 37.6% strongly agreed that a considerable amount of physical activity is involved in farming. This factor had a mean of 4.2, which placed it the highest among all the physical factors. Almost half of the participants, 47.9%, agreed while 16.2% strongly agreed that one who marries a farmer should prepare to get involved in physical hard work.

Most respondents agreed that 51.4% even strongly agreed, farmers that do physical work in farming stay healthy. A substantial proportion of 36.6% agreed while 9.7% strongly agreed, indicating that drudgery-laden tasks are no longer part of agriculture. Many of the respondents, 50.7%, agreed and 26.6% strongly agreed that farmers are always in danger because they are exposed to harsh weather conditions, like intense heat, cold, and dust. Where it ranked as number three.

In addressing the issue of health concerns in handling chemicals, most of them agreed to the statement, at 59.7%, with a further 20.7% saying they strongly agree that farming poses a health concern since it includes handling chemicals. These findings indicated that agricultural students believed that farming involves extreme physical activities and health hazards. The factor of physical activity in agriculture scored highest, showing its importance among students regarding the physical domain of work.

Perception of youth towards personal factors associated with farming as an occupation:

The statement showed that enjoyment towards different individual factors, as far as farming is concerned, have different opinions. Table 7 reveals that 48.3% agreed, while 36.9% strongly agreed that they like being farmers. This is because almost half of the respondents strongly agreed, 47.6% and 43.4% agreed, to be interested in agriculture. This factor has the highest mean score of 4.3 and ranks first. Most respondents opined that farming is their way of life, not just an occupation.

Most respondents (52.4% agreed, 30.0% strongly agreed) said farmers enjoy hard work. Most respondents, 45.9%, agreed, while 41.7% strongly agreed that using innovative methods and technology can increase farming revenue; this is the second-ranked factor, having a mean of 4.2. A majority, slightly over half of all the respondents, 53.8%, agreed, and 30.7% strongly agreed that they were happy and satisfied while farming. A smaller portion of respondents, 19.3%, agreed, and 6.2% strongly agreed, while 28.3% disagreed and 38.3% strongly disagreed that farming is for uneducated people. A vast majority of 55.9% agreed, while 16.2% strongly agreed that the city job person may take up farming as a passion venture and earn extra money.

Though all the above positive opinions students have regarding the personal factors of farming, 40.0% of the respondents agreed, and 20.7% strongly agreed that people choose to become farmers because they have no options. These results clearly show the diverse

personal perceptions of agricultural students toward farming.

Perception of youth towards psychological factors associated with farming as an occupation:

Table No. 8 reveals perceptions of agricultural students towards the psychological factors related to farming, shedding light on the mental and emotional aspects of the profession. Farming's sense of fulfilment from feeding others was acknowledged by 53.1% of respondents who agreed and 29.7% who strongly agreed with the statement. Students have provided valuable insights regarding income sufficiency; 50.7% of respondents agreed, and 22.4% strongly agreed that farming provides enough income to meet basic family needs. In contrast to this, suicide due to unfulfilled basic needs saw 50.3% of respondents agreeing and 18.3% strongly agreeing that this is an issue. The issue of suicide due to financial liabilities saw 41.0% of respondents agreeing and 20.3% strongly agreeing that farmers are compelled to commit suicide because of these pressures. Poor self-esteem due to a lack of social position was also a significant concern, with 49.3% agreeing and 19.7% strongly agreeing that this is a problem for farmers. Fear of pest and disease attacks on crops emerged as a prominent concern, with 50.7% agreeing and 35.9% strongly agreeing that this is a constant fear for farmers.

Similarly, 47.9% agreed, and 34.8% strongly agreed that the unpredictability of weather patterns makes farming hazardous. This result matches the article's results by(Narain*et al*., 2015). Where,they found that the farming sector faces various problems today like indebtedness, climate change, inadequate Govt. support and credit, unregulated markets, land degradation, and infrastructure; this makes youngsters lose interest in agriculture. Concerns about revenue fluctuations were highlighted by 39.3% of respondents who agreed and 19.0% who strongly agreed that agriculture is dangerous due to these fluctuations. The stressfulness of farming was recognized by 36.6% of respondents who agreed and 16.6% who strongly agreed that farming is highly stressful. Finally, the preference for keeping farming as a side business was expressed by 50.0% of respondents who agreed and 25.2% who strongly agreed, leading to a mean score of 3.9 and a second-place ranking.

These results collectively highlight the various psychological factors related to farming, such as income security, mental health concerns, and job satisfaction, reflecting the challenges and rewards that agricultural students perceive.

CONCLUSIONS

The study found that most students chose farming as an education due to their interest in agriculture, but few were expressed willingness to practice farming directly. Students perceive farming as associated with poor income due to high mechanization and investment costs, and as having the lowest social status. However, they also believe that physical work in farming keeps farmers healthy, but they are exposed to harsh weather conditions and chemical exposure. Students believe that farming provides enough income to meet basic family needs, but they suffer from poor self-esteem due to a lack of social position, fear of pest and disease attacks on crops, and unpredictability of weather, leading to suicide due to financial liabilities. The perception of youth towards farming plays a significant role in determining the future of farming and retaining youth in India. Policy formation is needed to create interest among students in working in agriculture and farming in a modernized way. Policies should support farming as a business model, and the

government should encourage students to adopt modern farming practices.

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ARIMA MODEL FOR FORECASTING OF AREA, PRODUCTION AND PRODUCTIVITY OF OILSEEDS IN INDIA

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ABSTRACT

The study conducted in the year 2022-23 applies the ARIMA (Autoregressive Integrated Moving Average) model to forecast the area, production, and yield of oilseeds in India from 2022-23 to 2031-32, based on historical data from 1951 to 2021. The data was tested for stationarity and made stationary through differencing. The ARIMA model was selected using RStudio's Auto ARIMA function, which identified ARIMA (0,1,1) for yield and output, and ARIMA (0,1,0) for area. Diagnostic tests, including the Box-Pierce, Shapiro-Wilk, and White Neural Network tests, confirmed the model's accuracy, with no significant autocorrelation and homoscedasticity in the residuals, though output data showed non-normality. The model forecasted a gradual increase in area (from 291 lakh hectares in 2022-23 to 314 lakh hectares in 2031-32), production (from 345 lakh tonnes to 383 lakh tonnes), and yield (from 1268 kg/ha to 1447 kg/ha), reflecting improvements in agricultural practices. While the ARIMA model is effective for forecasting, the non-normality in output suggests an area for further refinement in future studies.

Keywords: Area, ARIMA, Oilseeds, Production, Yield

INTRODUCTION

Grower and importer of oilseeds, Indian economy is the fourth largest producer in the world. It accounts for 13 percentage of gross cropped area, 3 percentage of national product and 10 per cent value of all agricultural commodities (Directorate of Oilseeds Development). It has recorded an annual growth rate of 2 percentage in yields, 6 percentage in area and 9 percentage in terms of production (2019-2020). The diverse nature of agro-ecological culture favours the cultivation of 9 varieties of crops including 7 edible and 2 non-edible varieties. The total consumption of edible oilseeds was 258.43 lakh tonnes of which domestic production accounts to 116.5 lakh tonnes and imports constituting to 141.93 lakh tonnes. It has 20.8%of total area under cultivation globally accounting for 10% of global production (India Trade Portal).

A wide range of studies has demonstrated the effectiveness of forecasting techniques in analysing oilseed production in India, with a particular emphasis on the ARIMA model. Studies by researchers such as Rathod *et al.* (2018), employed ARIMA in conjunction with Time Delay Neural Networks (TDNN) and Non-Linear Support Vector Regression (NLSVR) to forecast oilseed production. Similarly, Indurupalli *et al.* (2017) conducted a temporal analysis of oilseed performance. In contrast, Kumar *et al.* (2019); Mithiya *et al.* (2019) and Senthamaraikannan and

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Karuppasamy (2020) utilized ARIMA to predict oilseed production based on annual time series data.

More recent research by Devra *et al.* (2023) integrated ARIMA with Artificial Neural Networks (ANN) in a hybrid model to forecast oilseed prices, showcasing the continued relevance of ARIMA in modern forecasting approaches. Goyal *et al.,* (2022) analysed the future trends and growth in oilseed area, production, and productivity in Punjab, demonstrating the ARIMA model's ability to project these key agricultural indicators. Additionally, (Darekar and Reddy, 2018) affirmed the reliability of ARIMA for forecasting mustard prices in India. Ravichandran *et al.,* (2018) further validated the power of ARIMA by combining it with ANN to forecast oilseed production and productivity over a historical period, illustrating the value of hybrid models in time series forecasting for agriculture.

Together, these studies reinforce the pivotal role of ARIMA in predicting and understanding oilseed production dynamics, highlighting its prominence and versatility across various applications. Darekar and Reddy (2017) also emphasized the ARIMA model's strength in forecasting groundnut prices, while (Bannor and Melkamu, 2016) explored ARIMA, ARFIMA, and ECM models to forecast wholesale mustard prices, underscoring the model's wide applicability in agricultural price forecasting.

MATERIAL AND METHODS

The present study has employed the time series analysis to predict the yield, production (output) and area under cultivation of Oilseeds for the period 1951 to 2021 and to forecast the values for next 10 years. Of the various methods of forecasting techniques in time series Autoregressive Integrated Moving Average (ARIMA) model is one of the popular and widely used models. Autoregressive models stem from the concept that future values of a time series can be predicted from the past values and past value of its errors. ARIMA models are relatively easy to implement and interpret, and is a popular choice for both beginner and experienced time series analysts. The model accounts for patterns of growth/ decline (trend), the rate of change and the relationship of 'noise' (error) between consecutive time points.

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$$y_t = c + \phi_1 y_{t-1} + \ldots + \phi_p y_{t-p} + \theta_1 \varepsilon_{t-1} + \ldots + \theta_q \varepsilon_{t-q} + \varepsilon_t$$

where;

y is the differenced series

p is the order of the autoregressive part;

d is the degree of first differencing involved;

q is the order of the moving average part.

The steps to be followed in ARIMA modelling is as mentioned below.

Plot the time series data: Pictorial representation of the data plotted in a graph will help to identify any patterns, trends, or seasonality in the data. Check the stationary: An important aspect of time series is that meaningful interpretation can be done only if the time series data is stationary. It means the mean, variance, and autocorrelation structure of the series remain constant over time. If the data is not stationary, it can be made stationary

by differencing it. Autocorrelation function (ACF) and partial autocorrelation function (PACF): Plotting the ACF & PACF helps to identify the order of the ARIMA model (i.e., the values of p, d, and q). Construct the ARIMA model: This involves fitting a linear regression model to the time series data, incorporating the specified number and type of AR, I, and MA terms. Evaluate the ARIMA model: This involves assessing the model's fit to the historical data and its forecasting accuracy on a holdout dataset. Use the ARIMA model to forecast future values of the time series:

Most of the statistical software packages will calculate the above steps automatically to identify the optimal ARIMA (p, d, q) model. This study uses auto. airma function in RStudio to build the model.

RESULTS AND DISCUSSION

The graphical examination of the data to analyse patterns like seasonality and trends, specifically focusing on the annual yield of oilseeds from 1951 to 2021 was as follows.

Graphic representation of the data set:

Figure 1 displayed the yield per acre of oil seeds from 1950-51 to 2018-19. In the earlier decades, the yield remained relatively low and stable, showing only minor increases. A notable upward trend began around the late 1980s, marking a period of significant productivity improvement. In recent years, the yield levelled off with occasional fluctuations, indicating phases of stability and variability in oilseed production. Overall, the figure illustrated a long-term increase in yield per acre, with substantial growth starting in the late 20th century.

Figure 2 illustrated the output of oilseeds from 1950-51 to 2018-19. In the initial years, the output was remained low and relatively stable, with minimal growth. However, starting in the late 1980s, there was a notable increase, indicating significant growth in oilseed production, with some fluctuations, particularly in the late 1990s and early 2000s. In recent years, oilseed output reached its highest levels, peaking around 2018-19, reflecting substantial improvements in production over the decades. Overall, the figure highlighted a long-term upward trend in oilseed output, with major growth beginning in the late 20th century.

Figure 3 showed the area under cultivation for oilseeds from 1950-51 to 2018-19. Initially, the cultivated area increased gradually, with steady growth from the 1950s through the 1980s. Around the late 1980s and early 1990s, there was a sharper increase,

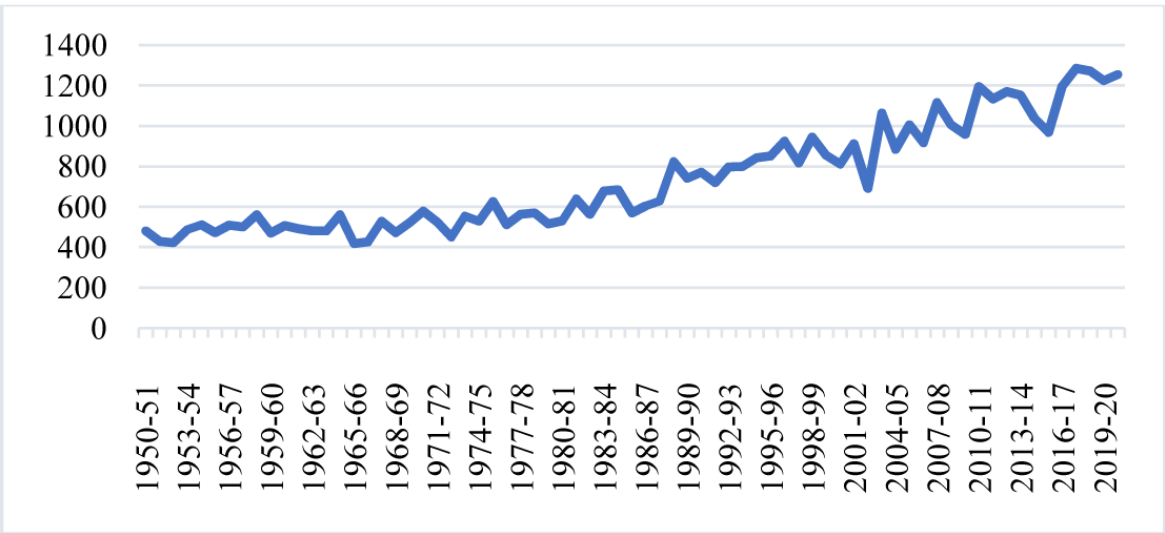

Figure1. Yield per Acre - Oil Seeds

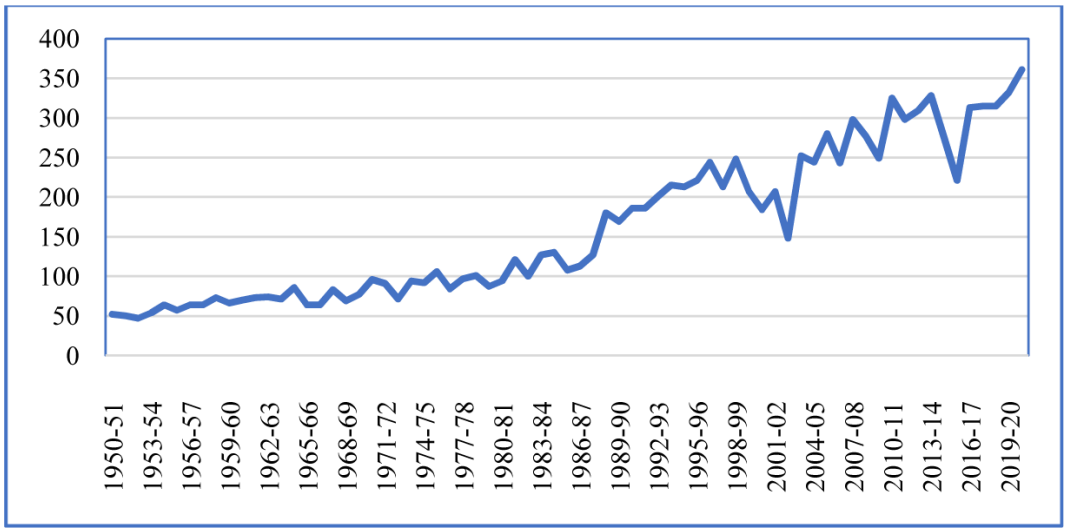

Figure 2. Oilseeds – Output

Table 1. The ADF Test Result Before and After Differencing

ADF Test Result	Yield	Output	Area
Test Static	-2.371	-2.451	-2.950
P-value	0.4243	0.3917	0.1887
Result	Non-stationary	Non-stationary	Non-stationary
ADF Test Results (after differencing)	**Yield**	**Output**	**Area**
Test Static	-6.371	-5.104	-4.369
P-value	0.01	0.01	0.01
Result	Stationary	Stationary	Stationary
Source: Computed			

*Critical value of ADF test for an observation of 100 is –3.45 (5% - with trend)

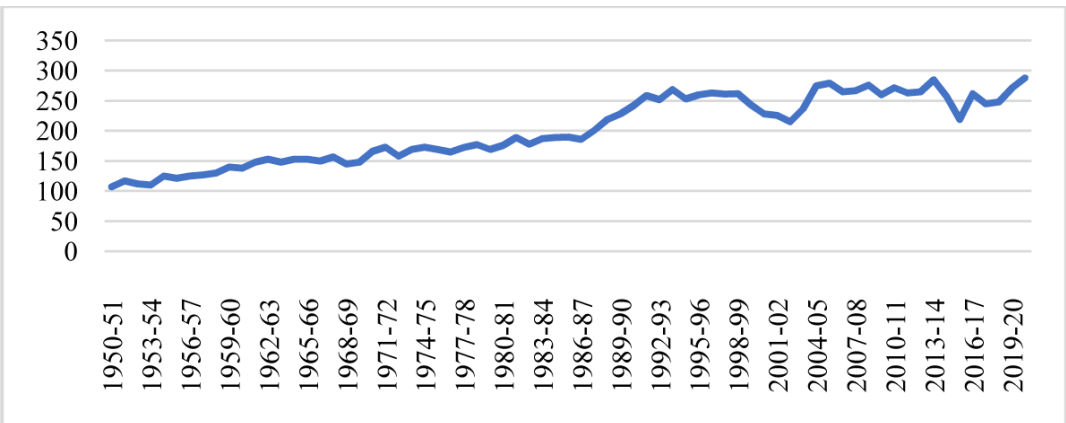

Figure 3. Area under cultivation – oilseeds

Table 2. Best Fit ARIMA Model Selected by Auto Arima Function in R Studio Package

Remark	Yield	Output	Area
ARIMA(p,d,q)	(0,1,1)	(0,1,1)	(0,1,0)
AR	0	0	0
MA	-0.772	-0.580	0
SE	0.068	0.1148	1.60
Variance	0.0019	642.3	181.90
RMSE	0.0434	24.80	13.29

Source: Computed

suggesting an expansion in the area allocated to oilseed crops, possibly due to policy changes or increased demand. After reaching a peak, the cultivated area stabilized, with some fluctuations, from the early 2000s onward, indicating a relatively constant area dedicated to oilseed cultivation in recent years.

An upward trend was visible for all three variables, signalling that the data might not have been stationary. As ARIMA works only with stationary series, the second step was to check for stationarity using the Augmented Dicky Fuller (ADF) test. If it was not stationary, then the series had to be differenced to make it stationary.

It could be seen from Table 1 that the differenced series had become stabilized, and it was observed from the above p-value results that the series was now stationary. As it had been differenced once, the order of integration in the ARIMA model was 1. Next, the order of 'p' and 'q' in the ARIMA model was identified. The Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) were used to determine the order.

However, instead of checking the ACF and PACF, statistical packages like RStudio ran and automatically selected the best model for ARIMA using the auto. arima function. The test results from the auto. arima function are presented below.

Table 2 presented the best-fit ARIMA models for forecasting oilseed yield, output, and area, selected using Auto ARIMA in R Studio. Yield and output followed ARIMA (0,1,1) with MA values of -0.772 and -0.580, respectively, while area followed ARIMA (0,1,0) without AR or MA components. Variance and SE values varied, indicating different prediction accuracies. The RMSE was lowest for yield at 0.0434, suggesting it had the highest predictive accuracy among the three variables.

Once the best model had been selected using the auto. arima function, the next step was to forecast the series. However, before forecasting the series, the residuals had to be diagnosed to identify how well the model fit the data, i.e., whether the residuals were

Table 3. Test Results

Remark	Yield	Output	Area
Box-Pierce Test ResultsP – value	0.761	0.617	0.132
Shapiro-Wilk normality Test Results P – value	Yield	Output	Area
	0.704	0.014	0.222
White Neural Network Test ResultsP – value	Yield	Output	Area
	0.746	0.239	0.897

Source: Computed

uncorrelated, had zero mean, and were normally distributed.

To evaluate the model further, the 'Box-Pierce' or 'Ljung-Box' test was used to check for serial correlation, the Shapiro-Wilk normality test for normality, and the White Neural Network Test for homoscedasticity. The results of these tests identified whether the residuals were IID (independently and identically distributed).

The table presented results from three statistical tests assessing different aspects of the data. The Box-Pierce Test showed no significant autocorrelation in the residuals for yield (0.761), output (0.617), and area (0.132), suggesting that the models did not suffer from autocorrelation. The Shapiro-Wilk normality test indicated that yield (0.704) and area (0.222) followed a normal distribution, while output (0.014) deviated from normality, suggesting a non-normal distribution. The White Neural Network Test revealed no evidence of heteroscedasticity, as all p-values (yield: 0.746, output: 0.239, area: 0.897) were greater than 0.05. Overall, the results suggested that the data for yield and area were well-behaved for modelling, while output required further attention due to its non-normality. The above test results showed that the model fit the data well, and the next step was to forecast the data for the next 10 years.

Given above in Table 4 was the forecast of area, production, and yield in oilseeds for the period 2022-23 to 2031-32. The forecasted values for oilseeds indicated steady growth in the area under cultivation, production volume, and productivity (yield per hectare) from 2022-23 to 2031-32. The area was expected to increase gradually each year, reflecting a potential expansion in land allocation for oilseed cultivation. Production was also projected to grow steadily, with output rising from 345 thousand tons in 2022-23 to 383 thousand tons by 2031-32. This increase in production was supported by gains in productivity, with the yield per hectare expected to improve from 1268 kg/ha in 2022-23 to 1447 kg/ha by 2031-32. The combined rise in area, production, and yield suggested an overall enhancement in oilseed farming efficiency and capacity, likely due to improvements in agricultural practices, technology, and input management.

CONCLUSIONS

The study employed the ARIMA model to forecast the key dimensions of oilseed production in India, specifically focusing on the area under cultivation, production output, and yield. The results indicated a steady growth trend from 2022-23 to 2031-32, with increases in area, production, and yield per hectare. The model forecasted a gradual increase in area (from 291 lakh hectares in 2022-23 to 314 lakh hectares in 2031-32), production (from 345

Table 4. Forecast of Area, Production and Yield

Year	Area	Production	Yield
2022-23	291	345	1268
2023-24	293	349	1287
2024-25	296	353	1306
2025-26	298	358	1325
2026-27	301	362	1345
2027-28	304	366	1365
2028-29	306	370	1385
2029-30	309	374	1405
2030-31	311	379	1426
2031-32	314	383	1447

Source: Computed

lakh tonnes to 383 lakh tonnes), and yield (from 1268 kg/ha to 1447 kg/ha). The diagnostic tests conducted on the ARIMA model, including the Box-Pierce Test, Shapiro-Wilk Normality Test, and White Neural Network Test, confirmed the reliability of the model. The Box-Pierce Test showed no significant autocorrelation in the residuals (p-values of 0.761 for yield, 0.617 for output, and 0.132 for area), suggesting that the models were free from autocorrelation issues. The Shapiro-Wilk Test indicated that yield and area followed a normal distribution (p-values of 0.704 and 0.222, respectively), while output deviated from normality (p-value of 0.014), highlighting the need for further attention to the output data. The White Neural Network Test showed no evidence of heteroscedasticity (p-values of 0.746 for yield, 0.239 for output, and 0.897 for area), ensuring that the variance remained constant across observations. These results suggested that the ARIMA model was well-suited for forecasting oilseed production trends, with steady improvements expected in India's oilseed sector over the next decade. However, the non-normality in output data suggested a potential area for further refinement in the model.

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TECH-POWERED LEARNING IN MIZORAM: EDUCATIONAL APPLICATIONS ON LEARNING OUTCOME AND ACADEMIC ACHIEVEMENT

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Mobile learning (m-learning) has emerged as a transformative tool in education, offering anytime, anywhere access to knowledge. This research investigates how students leverage these apps for optimal learning by studying usage patterns, preferences, and challenges. The study focuses on understanding the impact on learning outcomes across different disciplines, addressing a crucial gap in current research. Mobile apps enhance traditional lectures through gamification and interactive features, which have been shown to improve student engagement and achievement (Pechenkina *et al.,* 2017). Research indicates that gamified elements and personalized learning experiences significantly impact knowledge retention and academic performance (Huang *et al.,* 2020; Klímová, 2019).

The study was conducted in Aizawl, Mizoram, targeting undergraduate students aged 18-26 years. Using purposive sampling, 500 participants were selected with a 95 per cent confidence level and 4.2 percent margin of error. Data collection employed a self-structured questionnaire with established reliability (Cronbach alpha >0.7) addressing demographics, usage patterns, preferences, and perceived learning outcomes. Analysis utilized descriptive statistics and ANOVA for comparing learning outcomes across disciplines.

The data provided in Table 1 offers an overview of the study's participants and insights into the usage of mobile learning applications. The study population comprised predominantly 18-20-year-olds (59.00 per cent), with a balanced gender distribution. Arts & Humanities students constituted the majority (52.00 per cent). Duolingo emerged as the most popular application (51.00 per cent), with language learning being the primary focus (24.00 per cent). Most students used apps within educational institutions (48.00 per cent), showing a "Sometimes" usage pattern (40.00 per cent). These findings align with research by Noor *et al.,* (2022) on digital platform usage patterns among university students.

The study examined user preferences, challenges, and the likelihood of recommending mobile learning apps, as shown in Table 2. Students prioritized engaging content (28.00 per cent) and personalized learning experiences (27.00 per cent). The main challenges were lack of motivation (31.00 per cent) and distractions (27.00 per cent).

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Table 1. Demographics and Usage Patterns

Category	Subcategory	Frequency	Percentage	Mean	S.D
Age	18-20	293	59		
	21-23	170	34		
	24-26	37	7		
Gender	Male	244	49		
	Female	256	51		
Discipline	Science	153	31		
	Arts & Humanities	261	52		
	Commerce	86	17		
Year	1st	166	33		
	2nd	153	31		
	3rd	181	36		
Types of mobile learning applications used	Duolingo	255	51		
	Coursera	80	16		
	Byju's	63	13		
	Quizlet	27	5		
	Udemy	7	1		
	edX	26	5		
	Khan Academy	20	4		
	Vedantu	22	4		
Subjects or topics for mobile learning	Language learning	120	24		
	Test Prep	99	20		
	Professional Skills	88	18		
	Life Skills	95	19		
	Creative Skills	98	20		
Frequency of use	Always	91	18	2.68	1.068
	Frequently	101	20		
	Sometimes	201	40		
	Rarely	91	18		
	Once	16	3		
Context of use	At home	156	31	1.90	0.718
	At college	238	48		
	On the go	106	21		

Table 2. User Preferences

Content	Category	Frequency	Percentage	Mean	S.D
Important Features of Mobile Learning Applications	Ease of use	104	21	2.55	1.076
	Engaging content	138	28		
	Personalized learning experience	135	27		
	Ability to track progress	123	25		
Challenges Faced When Using Mobile Learning Applications	Technical difficulties	107	21	2.47	1.043
	Lack of motivation	155	31		
	Distractions	136	27		
	Difficulty with content	102	20		
Likelihood of Recommending Mobile Learning Applications	Very likely	82	16	2.47	0.983
	Somewhat likely	181	36		
	Neutral	174	35		
	Somewhat unlikely	46	9		
	Not at all likely	17	3		

Table 3. Learning Outcome

Aspects	Descriptive Statistics	Categories SA	A	N	D	SD	Mean	SD
Effective Learning Through Mobile Apps	Frequency	82	296	83	20	19	2.2	0.892
	Percentage	16	59	17	4	4		
Enhanced Course Material Understanding with Mobile Apps	Frequency	85	233	110	52	20	2.38	1.013
	Percentage	17	47	22	10	4		
Boosted Motivation to Learn with Mobile Apps	Frequency	93	265	94	30	18	2.23	0.942
	Percentage	19	53	19	6	4		
Increased Learning Enjoyment with Mobile Apps	Frequency	94	269	84	35	18	2.23	0.954
	Percentage	19	54	17	7	4		
Improved Information Retention with Mobile Apps	Frequency	112	236	98	27	27	2.24	1.032
	Percentage	22	47	20	5	5		
Better Study Habits Through Mobile Apps	Frequency	68	273	129	17	13	2.27	0.833
	Percentage	14	55	26	3	3		
More Effective Exam Preparation with Mobile Apps	Frequency	141	267	62	12	18	2.0	0.91
	Percentage	28	53	12	2	4		
Improved Overall Academic Performance with Mobile Apps	Frequency	111	222	137	16	14	2.2	0.915
	Percentage	22	44	27	3	3		

Table 4. Academic Achievement and Discipline Comparison

Content	Category	n	%	Mean (SD)	Min	Max	Compared to Discipline	Mean Difference (I-J)	Std. Error	Sig.	95% CI
Higher Grades with Mobile Learning Apps	SA	63	13	2.33 (0.862)	-	-	-	-	-	-	-
	A	260	52								
	N	142	28								
	D	19	4								
	SD	16	3								
Mastering More Course Material	SA	110	22	2.15 (0.929)	-	-	-	-	-	-	-
	A	259	52								
	N	94	19								
	D	19	4								
	SD	18	4								
Academic Goals Achieved	SA	67	13	2.37 (0.886)	-	-	-	-	-	-	-
	A	240	48								
	N	150	30								
	D	29	6								
	SD	14	3								
Increased Academic Confidence	SA	57	11	2.40 (0.968)	-	-	-	-	-	-	-
	A	276	55								
	N	104	21								
	D	36	7								
	SD	27	5								
Motivation for Further Learning	SA	94	19	2.19 (0.866)	-	-	-	-	-	-	-
	A	256	51								
	N	122	24								
	D	15	3								
	SD	13	3								
Student Discipline	Science	153	-	17.07 (3.99)	10	33	-	-	-	-	-
Commerce vs Science	-	-	-	-	-	-	1	1.75	0.57	0.002	0.63 - 2.87
Commerce vs Arts	-	-	-	-	-	-	2	1.05	0.53	0.046	0.02 - 2.08

The results of the survey from Table 3, on student experiences with mobile learning apps present a predominantly positive outlook. Notably, 59.00 percent agreed that mobile apps effectively facilitated learning, with 47.00 percent reporting improved course material understanding and 55.00 percent noting better study habits. These results support earlier findings by Ansari and Tripathi (2017) regarding the effectiveness of mobile learning apps in higher education.

The analysis of the data provided in Table 6 offers compelling evidence to refute the null hypothesis (H_0) positing no correlation between a student's discipline and their

reported learning outcomes from mobile learning applications. The results show that Commerce students demonstrated significantly higher learning outcomes (mean=18.83) compared to Science (mean=17.07, p=0.002) and Arts & Humanities students (mean=17.77, p=0.046). This suggests that mobile learning applications may be particularly effective for commerce-related subjects, possibly due to better alignment with learning styles or content relevance. These findings complement research by Salhab and Daher (2023) on university students' engagement with mobile learning across different disciplines.

The study corroborates the positive influence of mobile learning applications on academic performance while emphasizing the need to address motivational challenges and the personalization of content. The enhanced performance observed among Commerce students indicates the significance of designing applications that cater specifically to disciplinary requirements. These findings can inform educators and developers in their efforts to create more effective and targeted mobile learning experiences.

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