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Evaluation of textural and sensory properties of jackfruit, soybean and amaranth based vegan meat

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Abstract
This study uses texture profile analysis (TPA) and sensory evaluation to examine the textural and sensory characteristics of vegan meat derived from jackfruit, soybean, and amaranth. TPA plays a crucial role in objectively evaluating physical attributes by mimicking masticatory movements. When evaluating cooked vegan meat, texture factors like adhesiveness, cohesion, gumminess, hardness, and springiness are crucial. Samples differ significantly in terms of firmness (measured by the force required to compress the sample), with T_2 having the maximum firmness. There are also noticeable variations in springiness, cohesion, and chewiness that are impacted by the amounts of ingredients. When it comes to the sensory evaluation, vegan meat samples show slight variations in appearance scores, with T_2 closely matching the control. All samples see colour in the same way, although T_2 and the control are preferred. T_2 is rated as having the best flavour and taste, outperforming the control. Texture examination confirms T_2's superiority over the control, closely matching it. In terms of taste, texture, and all-around appeal, T_2 is evaluated favorably and is comparable to the control, according to the acceptance scores. Interestingly, the most sensory-acceptable composite flour blend is a 30:50:20 mixture of jackfruit, soybean, and amaranth. These results demonstrate how ingredient ratios affect the texture and sensory characteristics of vegan meat, providing information that can be used to create plant-based substitutes that are as tasty as possible.

Keywords: Jackfruit, soybean, amaranth, vegan meat, texture profile analysis, sensory evaluation

Introduction

The jackfruit (*Artocarpus heterophyllus*), is a popular tree that is frequently found in home gardens in Bangladesh and India. It is a member of the Moraceae family, which is related to the mulberry family. As per (Baliga *et al*., 2011) [1]. Since ancient times, jackfruit has been a widely consumed meal in Sri Lanka. This is a seasonal fruit that provided a significant portion of the people's and their livestock's nourishment during a period when staple food grains were scarce. It is called poor man's food as a result. (Ranasinghe *et al*., 2019) [15]. The three components of the jackfruit compound fruit are the skin (five to five5%), the seeds (18%), and the pulp (30–32%). The underutilized jackfruit portions, such as the rind and seed, have been discovered to offer excellent nutritional contents in addition to its pulp. It is said that the nutritional makeup of jackfruit seeds is comparable to that of cereals. Starch and dietary fibre, which make up 22% and 3.19% of the jackfruit seed, respectively, are two of the seed's main nutrients. Furthermore, the main protein in jackfruit seeds, jacalin, has immunological qualities. In addition, lignans, isoflavones, saponins, and other phytonutrients found in jackfruit seed have a wide range of health advantages, including anti-cancer, antihypertensive, anti-aging, antioxidant, and anti-ulcer properties. Conversely, the rind of jackfruit has a high pectin concentration. It was discovered that the jackfruit's inedible parts (pulp) have a higher pectin content than the edible section. Pectin yields from jackfruit rind varied from 14.8–18.5 percent (w/w), whereas pectin yields from chempedak rind were between 17.6-20.5 percent (w/w). Furthermore, the rind of the jackfruit adds to the fruit's antioxidant capacity. It was observed that the polyphenol and flavonoid content of jackfruit rind extracts was higher than that of the fruit's spine and skin. (Hamid *et al*., 2020) [5].

Soybean (Glycine max), are an especially good source of fat (16–27%) and protein (35–42%). Because of this, soybeans rank among the most valuable and widely grown crops. The soybean and many other plants in the Fabaceae family have the same problem. (Kuzniar *et al*., 2016) [7].

Most major agricultural production systems, including those in the USA, China, Brazil, Argentina, and India, place a significant emphasis on soybeans. Over the past 20 years, its productivity and output have increased significantly as a result of its significant inclusion in significant crop development programmes. (Pagano *et al.*, 2015) [11]. A large percentage of foods in the Western diet come from animals, and the excessive consumption of meat has generated discussions about its effects on the environment and human health. A high meat diet has been associated with a higher risk of heart disease, type 2 diabetes, and many cancers. Furthermore, the production of cattle accounts for 14.5% of greenhouse gas emissions worldwide. One potential way to lessen the influence on the climate and promote a healthy lifestyle is to switch to a more plant-based diet. Consequently, the plant-based food industry is experiencing phenomenal growth as more and more people choose to live vegan, vegetarian, or flexitarian lifestyles. Products made from plants can be used as dairy alternatives or as meat substitutes. Although now somewhat tiny, the market for meat alternatives is expected to grow in the next years. (Zahari *et al*., 2020) [16].

Amaranth (*Amaranthus*) is a pseudo-cereal that has been widely grown by the Aztecs, Incas and Mayas in Latin America since pre-Columbian times for millennia. The tiny seeds are deserving of a spot on the shelves of health food stores since they have significant amounts of high-quality protein (rich in lysine) and low levels of saturated fatty acids in their oil moiety. (Mendonça *et al*., 2009) [10]. Grain amaranth is gaining increasing interest as a grain crop because of its high biomass output into product, high nutritional content, and tolerance to the both biotic and abiotic stressors. (Kong *et al*., 2009) [6]. According to Market Research Report (2021), The amaranth product industry is predicted to grow robustly in North America, moderately in Europe, and significantly in the Asia Pacific area due to rising consumer demand for organic food and a focus on plant-based goods as part of a healthy lifestyle. Amaranth is grown throughout America, Asia, and Africa. Since the 1990s, it has also been grown in numerous European nations, including Latvia. There are several ways to use amaranth in nutrition: as whole seeds, flour, bran, and oil. The nutty flavour of amaranth seeds can be extracted by boiling, roasting, crushing, or grinding them. Amaranth seeds can be included in a gluten-free diet and are a good source of high-quality fat (5.6–10.9%), uncommon type starch (48–69%), and nutritionally significant proteins (13.1–21.0%). With a lysine level ranging from 4.9 to 6.1 g per 100 g of protein and limited in other cultures, amaranth seeds set themselves apart from conventional cereal grains. Amaranth is a superb cereal grain substitute since it has high levels of lipids, carbs, fibre, sugars, and vitamins A, B, C, and E. In terms of potassium (3498 mg kg−1), phosphorus (4360 mg kg−1), and magnesium (2550 mg kg−1), amaranth outperforms conventional cereals. Amaranth seeds have a possible health benefit due to its components, which include nicotiflorin, rutin, and ferulic acid. A 100 g sample of the seeds contains 173 mg of calcium, 35 mg of iron, and 3 mg of zinc. The scientific literature reports several health benefits of amaranth, including its ability to lower blood glucose, boost immunity, inhibit cancer growth, lower plasma cholesterol, and improve anaemia and hypertension. Amaranth's health-promoting attributes also include anti-allergic and antioxidant characteristics, which may help people with celiac disease, allergies to common cereals, and chronic illnesses. (Beitane *et al*., 2023) [2].

Materials and Methods

Materials

A study named "Evaluation of textural and sensory properties of vegan meat based on jackfruit, soybean, and amaranth" was conducted at the Food Chemistry and Nutrition Department at the College of Food Technology VNMKV Parbhani.

Jackfruit powder, deoiled soybean flour, and roasted amaranth flour are the ingredients used to make vegan meat. LDPE, HDPE bags, and HIPS boxes were used for packaging. These items were purchased at the local market.

Methods

Preparation of jackfruit powder

The recently harvested Artocarpus heterophyllus jackfruit was purchased from a nearby market and prepared using the previously mentioned technique (Hamid *et al*., 2020) [5]. The green, soft, thorny part on the skin's outer layer of a ripe jackfruit was removed, leaving only the white area. The rinds of the yellow jackfruit were affixed with the rags or flakes, which were white bands surrounding the fruit. Smaller fragments of rags and rinses were separated. After cleaning, they were blanched in boiling water for two minutes. This stopped the cooking process, and they were then plunged in cold running water. Before settling in, they removed the blanched and used their hands to squeeze water to chill the rigs and linens. After that, dry those rags and rinds for five to six hours at 70 °C in a dryer. Grounded in a micropulverizer after cooling. LDPE bags held the jackfruit powder until it was used to make moist extruded vegan meat.

Preparation of deoiled soybean flour

Defatted soybean flour was created by processing defatted soybeans. To lessen beany smells, the defatted cake was dried in a dryer for 30 minutes at 60±5 °C to evaporate any remaining solvents. After allowing it to reach room temperature, it was finely crushed into flour using a laboratory micropulverizer. The defatted soybean flour was processed into moist, extruded vegan meat and then packaged in LDPE pouches. (Gandhi *et al*., 2009) [4].

Preparation of amaranth flour

The procedure recommended by (Poshadri *et al*., 2023) [13] was used to roast the amaranth grains. to lessen variables that are detrimental to nutrition and enhance the final product's sensory qualities.

We bought the best-quality amaranth from a nearby store. Dirt was washed off the grains. For ten minutes, amaranth grains were roasted at 75 +/- 5 °C in a shallow pan. To ensure even roasting, the pan was kept at that temperature (using a digital thermometer with a laboratory scale) and vigorously stirred. Following the roasting process, the samples were allowed to cool to room temperature before being crushed into a fine flour using a laboratory grinder and sieved through a mesh size 40 sieve. The final flour was sealed in plastic containers to keep it fresh until it was needed for product processing and analysis.

Preparation of composite flour for vegan meat production

According to earlier descriptions by (Penchalaraju 2022; Leelawat *et al*., 2023) [12, 8], vegan meat was made in a lab. Different ratios of defatted soy flour, roasted amaranth flour, and jackfruit powder are included in the composite flour blend, which is designed for the wet extrusion process to yield high-moisture meat-analog shreds. Hot water (70 °C) was used to reduce the moisture content of composite flour to 50% in order to pre-gelatinize the feed mixture. Next, an extruder (Model No. 16009, Kent Noodle and Meat Analogue Maker) was used to turn the various formulas into meat analogues.

Table 1: Formulation of recipe used for preparation of vegan meat

Ingredients	Control	T_1	T_2	T_3
Minced chicken (g)	100%	-	-	-
Defatted soy flour (g)	0	50	50	50
Amaranth flour (g)	0	30	20	40
Jackfruit powder (g)	0	20	30	10
Hot water (70 °C) (ml)	-	100	100	100

Texture profile analysis of jackfruit, soybean and amaranth based vegan meat

The methodology described by (Penchalaraju *et al*. 2023) [13] was followed in the evaluation of the textural characteristics of meat substitutes, particularly vegan meat. Ten grammes of meat analogues were boiled for ten minutes in 100 millilitres of water to assess the textural quality of the meat analogue. After cooling in a strainer for 30 seconds, the cooked meat analogues were left undisturbed for 2 minutes in order to remove any residual water. Using a texture analyzer (TA-XT plus, Stable Micro Systems Ltd., Godalming, UK), analogues for meat to measure the textural profile, pieces of 50 millimetres in length and 5.0 millimetres in thickness were made. For this research, a 36-millimetre diameter cylindrical probe was used. The test parameters included an 80 percent strain, a 50-gram trigger force, and pre- and post-test speeds of one millimetre per second and one millimetre per second, respectively. Firmness, springiness, cohesiveness, gumminess, and adhesiveness were among the factors that were computed. For every treatment, three duplicates of each measurement were made.

Sensory evaluation of jackfruit, soybean and amaranth based vegan meat

A semi-trained panel evaluated the meat analogues made from a composite flour made of jackfruit, defatted soybean, and amaranth. According to the approach described by (Deshpande & Poshadri 2011) [3], the assessment was carried out using a 9-point hedonic rating scale, which ranged from 9 (showing a highly favourable response) to 1 (signifying an exceedingly unpleasant response). The panellists for this sensory evaluation were chosen from among the faculty members at Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, who work in the College of Food Technology.

To give a thorough scientific evaluation of their sensory qualities, the meat analogue samples underwent a rigorous assessment across a range of sensory metrics, including colour and appearance, flavour, taste, texture, and overall acceptability.

Results and Discussion

Evaluation of textural properties of jackfruit, soybean and amaranth based vegan meat

Texture profile analysis (TPA) can be used to analyse the physical qualities of food by simulating human masticatory activity. Analogous texture measuring using an instrument can be a valid and practical substitute for the sensory method described by (Penchalaraju *et al*. 2023) [13]. Textural properties in terms of hardness/firmness, springiness, cohesiveness, gumminess and adhesiveness are main criteria for assessing the quality of cooked meat analogue that determines its consumer acceptance.

Table 2: Texture profile analysis of jackfruit, soybean and amaranth based vegan meat

Sample	Textural parameters				
	Firmness (g)	Springiness (D_2/D_1)	Cohesiveness (A_2/A_1)	Gumminess	Chewiness
Control	3.238	0.923	0.733	2.374	2.192
T_1	2.516	0.886	0.550	1.383	1.226
T_2	4.153	0.869	0.465	1.932	1.678
T_3	3.494	0.906	0.497	1.735	1.572
SE ±	0.0012	0.0012	0.0014	0.0021	0.0007
CD at 5%	0.0036	0.0033	0.0045	0.0061	0.0022

The most crucial factor influencing consumer approval of vegan meat in terms of hardness, stickiness, and mouthfeel is its texture. Firmness is indicated by the force needed to compress the sample with teeth. Sample T_2 (4.153 g) had the maximum firmness, followed by samples T_3 (3.494 g) and T_1 (2.516g). The chicken meat from the control sample (3.238g) was located. The interactions within the protein network may be the cause of the variation in firmness. Higher hardness and elasticity values were understood to be associated with the development of a denser and stronger network. Similar results were published by Gaber *et al*., (2022). When amaranth flour is added to meat analogues at 20, 30, and 40% percentages, the texture of the meat analogues is impacted. The rate at which the sample returns to its original state following finger pressure. The control sample exhibited a notably higher level of springiness in comparison to its plant meat counterparts. Among the vegan meat equivalents, T_3 was the springiest followed by T_1 and T_2. Cohesiveness is the measure of how much of the sample stays together while chewing as opposed to breaking apart. The vegan meat sample showed significantly less cohesiveness than the control sample. The control sample is more cohesive than the vegan meat. The variations in the formulations could be the reason for the variations in the vegan meat sample. Chewiness is the amount of effort needed to chew a sample until it is able to be swallowed. There was a higher chewiness (2.192) noted in the control sample. Compared to vegan meat, its value was nearly twice as high. T_2 was the sample with the highest chewiness among the vegan meat substitutes.

Evaluation of sensory properties of jackfruit, soybean and amaranth based vegan meat

Table 3 presents the data related to the sensory evaluation of vegan meat that included levels of jackfruit powder, amaranth flour, and soybean flour.

Table 3: Sensory evaluation of jackfruit, soybean and amaranth based vegan meat

Sample	Sensory attributes					
	Appearance	Colour	Flavour	Taste	Texture	Overall acceptability
Control	8.3	8.8	8.3	8.3	8.7	8.8
T_1	7.5	7.3	7.2	7.5	7.8	7.2
T_2	7.8	7.5	7.5	8.1	8.5	8.5
T_3	7.2	7.3	7.1	7.9	8.3	8.0
SE $\pm$	0.061	0.039	0.033	0.057	0.039	0.056
CD at 5%	0.184	0.120	0.100	0.173	0.117	0.170

Appearance

Table 3 displays the average appearance score values for vegan meat items. The control sample (8.3) received a higher score from the judges than the vegan meat samples (7.8), T_1 (7.5), and T_3 (7.2). Though they were evaluated as somewhat appreciated, there wasn't much of a difference in the appearance of the vegan meat made with composite flour. The look of vegan meat samples was not significantly affected by modifications in the blending ratios of the flours in the composite flour, according to the findings. When it came to the look of the vegan meat substitute, the vegan sample T_2, which used conventional blend ratios of soybean flour, amaranth, and jackfruit powder (50:20:30), was comparable to the control group, scoring a 7.8.

Colour

Table 3 can be used to see it. The final product's hue characteristics, which ranged from 7.3 to 8.8, showed minimal variations when it came to vegan meat. The Control sample had a more acceptable colour (8.8), while the T_2 sample's colour (7.5) was scored as being between like moderately and like very much. Interestingly, samples T_1 and T_3, which had the same colour range (7.3), were evaluated similarly.

Flavour

Table 3 displays the average taste score values for samples of chicken and vegan meat. It suggests that sample T_2 (7.5) had a more tolerable flavour character than the control sample (8.3). Additionally, sample T_2 received higher ratings than samples T_1 and T_3. Vegan meats were evaluated as fairly liked, while the control sample was assessed as very much liked.

Taste

Table 3 displays the average score sensory values for taste. When it came to vegan meat, sample T_2 had the best flavour (8.1) when compared to control (8.3), sample T_3 came in second (7.9), and sample T_1 scored lower (7.5) than both control and other samples. It is noteworthy that the current research indicates that the amount of soybean flour, amaranth flour, and jackfruit powder in the composite flour significantly influenced the flavour characteristics. Additionally, judges indicated that the degree of spice adhering to the extrudates affected the aftertaste.

Texture

Table 3 shows that, when compared to the control (8.7) flour combinations in the composite flour, the best texture was seen in the case of sample T_2. The final product's texture character ranged from 7.8 to 8.7 in the case of vegan meat. The panelists gave sample T_2 the highest possible score of 8.5, whereas the control sample received a score of 8.7. Both samples were assessed as very much. It was intriguing to see that the scores for samples T_2 and T_3 were almost identical. Additionally, it was shown that blended flour ratios significantly affected the texture of vegan meat; nevertheless, this impact is preferable when cereals and pulses are combined in a 70:30 ratio.

Overall acceptability

It is seen from the results that variation do exists in overall acceptability score. All the combinations of vegan meat sample prepared from composite flour valued in between like moderately to like very much. Highest score was observed in control sample. The overall acceptability of vegan meat food could be attributed to the different characters of appearance, colour, taste, flavour and texture of the final product. It is revealed from the scores of the overall acceptability that the T_2 sample was rated closely with control sample (chicken meat) in terms of taste, texture and overall acceptability and rated as liked very much. Following an organoleptic evaluation of the product, the following is the product made with Jack fruit flour: In comparison to the other two samples, soybean and amaranth in the ratios 30:50:20, respectively, had the best sensory acceptance.

Conclusion

By carefully examining the texture and sensory qualities of raw amaranth, jackfruit, and soybean, the study laid the foundation for plant-based meat substitutes. Three carefully calibrated vegan meat formulations (T_1, T_2, and T_3) were used; T_3 had the highest protein level (26.5g). The ideal combination of 30% Jackfruit, 50% Soybean, and 20% Amaranth showed great textural qualities and was well-liked by consumers. T_2 preserved microbiological safety while maintaining quality during a 90-day storage period at 5°C. This study highlights the potential of plant-based meat substitutes in satisfying consumer demand for ethical and sustainable food options by offering insightful information on the nutritional advantages, consumer acceptability, economic viability, and shelf life of these alternatives.

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