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Development of plant-based meat analogue using jackfruit a healthy substitute for meat

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Abstract
In order to create protein-based meat replacements with a rich, fibrous structure resembling flesh, interactions between the protein and starch molecules should be crucial. In this current study, we used jackfruit and cashew nut as significant ingredients for developing a meat analogue. While developing a meat analogue, cold extrusion was carried out. The proximate colour and Sensory parameters of the developed sample were studied in detail. Two formulations were developed, M1 and M2, varying their jackfruit and cashew nut content. We found that sample M1 with 70% jackfruit gave a nutritional assessment of 14.99% protein, 3.51% fat, 3.43% fibre, 55.16% moisture and 21.89% carbohydrate. M1 and M2 show good customer acceptance in the sensorial analysis sample, whereas samples demonstrated desired appearance, taste, chewiness, flavour, and overall acceptability in sensory evaluation. It emphasized that a jackfruit and cashew nut flour complex would make a suitable meat analogue.

Keywords: Meat analogue, jackfruit, plant based protein, cold extrusion, sensory analysis, texture analysis

1. Introduction
Plant based meat substitute is created to suit customer needs as well as security of global food production, and this sector had risen rapidly in last decades. Though progress has been undertaken to make plant protein-based fibres sensory characteristics equivalent to those of an entire muscle cut, it is still tough to mimic the complex arrangement of the muscle cells which play a vital role in sensory characteristics. As of now, the business tactics are mostly centered on reformed or else formed meat mimetics. The acceptance of an plant based vegan diet has expanded substantially in the developed World, owing mostly to a better knowledge of carbon pollution from the meat livestock and dairy business (Ramos Diaz *et al*., 2022) [20]. Additionally, meat is constituted of triglycerides and mainly saturated fatty acids which are high in concentration as compared with polyunsaturated fatty acids (PUFAs). These saturated fatty acids related with several chronic illnesses. Hence, excess amount of intake of the meat products cannot be encouraged from health standpoint (Kumar, 2016) [16]. Among these, major concerns for plant-based meat analogue are consumers disinclination to the dietetic variations due to the nutritional and sensory acceptance of the meat based alternative products, as well as ease of access is a concern (Corrin & Papadopoulos, 2017) [9]. The development of vegan based meat market is anticipated to upswing to $85 billion in 2030 (UBS, 2019) from $4.6 billion in 2018 also, as a breakthrough, by the year 2026 achieve $30.9 billion. This emerging market is currently to be well-positioned for additional innovation and development. Impossible Foods introduced plant-based whoppers without beef in May 2019 in collaboration with Burger King (Sha & Xiong, 2020) [24].

Intense processing is required to create the meat alike fibrous structures, such as cross-linking, thermos-extrusion, spinning and shear (Sha & Xiong, 2020) [24], high moisture and low moisture extrusion methods (Samard *et al*., 2019) [23]. Cultured meat and plant-based meat analogues are the two key categories of meat alternatives. Plant-based proteins with parallel organoleptic and healthful qualities to bovine meat make up the majority of plant-based meat products. (Sun *et al*., 2021) [25]. The principal of developing plant based replacements is the protein. Several suitable ingredient is also essential to produce and mimic based protein products which influence the texture, appearance, flavour, and mouthfeel. Consumer looking plant-based meat alternatives to replace animal-based meat since it represents sustainable animal protein sources and evades ethical questions of animal slaughtering (Dekkers *et al*., 2018; McClements *et al*., 2021) [10, 17]. Consequently, low-cost as well as less energy concentrated processing methods are essential to fulfil the developing market.

In current research we used Extrusion technique for developing a meat analogue at ambient temperature, where we used Jackfruit and cashew nut flour as major ingredients in addition with Flaxseed, pea protein, spices, binding agents, and natural colour. The objective of this research is to determine and study the physicochemical, proximate and sensory analysis of the developed product. by utilizing optimum resources like Jackfruit and cashewnut. Jackfruit (*Artocarpus heterophyllus*) is primarily grown in Asia, with Bangladesh and India beings the world's largest producers averaging 1.25 million metric tons of fruit yearly (Balamaze *et al*., 2019; Rajput *et al*., 2022) [5, 19]. Researchers found that whole jackfruit only 60-65% is edible from which only 35% is utilized (Hamid *et al*., 2020) [12] therefore, to make proper utilization of jackfruit in food industry jackfruit was selected. addition to that while developing a plant-based meat protein is considered as centre element. To full fill this need we utilized Cashew nut (*Anacardium occidentale*) flour which is prominant source of essential amino acids, proteins as well as minerals. According to Aremu *et al*., (2006) [2] cashewnut contains a rich protein source that includes essential amino acids and possess a good antioxidant property.

2. Material and methods

2.1 Raw material

Meat analogue was developed using a raw and matured jackfruit procured from local farmers, the ingredients used for developing meat analogue include pea protein isolates (urban platter brand, Maharashtra, India) and cashew nuts, flaxseed, xanthum gum, were bought from the local market in Thanjavur, India. The analytical-grade chemicals utilized during the investigation were all purchased from Hi-media. (Nashik, Maharashtra).

2.2 Extruder

The extrusion and texturizing processes were carried out using a single screw extruder (la monfera Italy). The description of a single screw extruder was 8:1 length and diameter ratio (L/D), 40.0 cm barrel length, 5.0 cm screw diameter and 3.0 cm pitch diameter of the screw. The maximum speed was 100 RPM. And die used for shaping was 10.0 mm in diameter with two mould openings of rectangular shape with dimensions of 40.0 mm in length and 5.0 mm in height. Which was attached to the extruder's other end; while extruding the temperature of the extruder was kept ambient near 23±2°C. And dough fed through a hopper while mixing blade speed was set at 70 RPM, along with that extruder screw speed was set to 100 RPM.

2.3 Preparation method

Meat analogue was created using a mixture of jackfruit bulb and cashew nut flour combinations. A total of two formulations were prepared, as depicted in the table (1). The procedure followed to develop a meat analogue was similar to (Samard *et al*., 2019) [23], with certain modifications. Tender jackfruit (JF) was initially soaked and blanched in 100°C water for one minute with 0.3% citric acid added (K P *et al*., 2012) [13]. After blanching JF was sliced open and the rinds, bulbs, seeds, and inedible outer peel were separated. From that jackfruit bulbs were utilized for further processing. The dough was prepared by directly grinding jackfruit bulbs with pea protein. Furthermore, the prepared dough was kept for a resting period of 15 minutes. After the resting period all the remaining ingredients were added in their proportions. And the dough was transferred to the extruder for texturization. While extruding the extruder speed was set at 110 RPM, and the temperature was kept at room temperature. then extruded strips chopped down in (L×B×H) 10 cm × 5 cm × 0.5 cm and product were then packed in bags and stored in a deep freezer. The samples were named on their formulations M1 and M2. Later the developed meat analogue cooked by following the method of marinating. Sample dipped in previously prepared spices and salt mixture then deep fried in sunflower oil. And used for sensory, proximate and physicochemical analysis.

2.4 Proximate analysis

The meat analogue was analyzed for the moisture and protein following the protocols (950.46B) (981.10) in AOAC 2000. And for fat, followed the protocol stated in the (960.39A) AOAC 1995. And for ash content protocol followed was (920.153) AOAC 1990. Furthermore, the fibre analysis was followed by weendes protocol (978.10) AOAC 1995. Carbohydrates were estimated with difference method calculations.

2.5 Colour

A colorimeter was used for the determination of colour values. 45/0° Colourflex EZ hunter Lab spectrophotometer (Hunter associates laboratory Reston, Virginia, USA) was used. To evaluate cooked VPMA after calibration with black and white standard plates with values (L^*= 97.83, a^* = -0.43, b^*= 1.98). Colour values were analyzed by the methodology followed by Rajput *et al*., (2022) [19] with few modifications. The samples were kept for analysis by cutting them in a 4 cm square shape inside the measuring glass and then covered with dark lead to obtaining L* (lightness), a* (redness), and b* (yellowness) values.

2.6 Sensory Analysis.

The sensory analysis was carried out using the FIZZ Software (version 2.0 Fizz Biosystems, France) at the School of Sensory Science, NIFTEM-Thanjavur, India. The questionnaire was prepared using FIZZ software which generates the web links for the questionnaire form, and then these links were forwarded to the panel for evaluation. The evaluation was carried out by master's and doctoral students from NIFTEM Thanjavur campus. A total of 30-semi trained panel members were there, of which 16 were male and 14 were female. Samples were freshly cooked and served with the labelling of codes generated by FIZZ software. The temperature of product was between 35-38°C. Semi-train panel member with instructions performed a test in accordance with ISO 8589:2007. Sensorial analysis of developed specimens was analyzed on a 9-point hedonic scale. (9- excessively disliked and 1-excessively like) for characteristics such as colour, mouthfeel, chewiness, overall acceptance, and flavour. During the analysis, temperature inside the lab was kept at 23-24°C, and the lighting was also kept under control.

2.7 Statistical analysis

All experiments were done in triplicate, and all the samples were analyzed using ANOVA in the (Minitab 18.1 statistical analysis tool software USA). Where result shows the significant interaction between the samples and significant main effects at $p<0.05$. A comparison was done with post hoc approach Tukey with a confidence level of 95% for the analysis.

3. Result and Discussion

3.1 Proximate analysis

The proximate analysis of the developed sample was performed with the standard protocols stated in the AOAC and values were stated in the table (2). The moisture content of developed meat analogue was between 55.16 and 77.61 where higher values found in the control sample. It was found that there is no significant change between sample M1 and C (p>0.05), but sample M2 shows significant difference (p<0.05) with other two samples. Researchers found the potential of dietary fibres to bind water was well known. Incorporating nutritional fibre like powdered carrot and wheat bran into chicken sausage improves its moisture content (Fernandez-Gines *et al*., 2003; Yadav *et al*., 2018) [11, 26]. therefore, the reduction in moisture levels throughout this research was attributed to the proportional substitution of meat, using dietary fibre source material of jackfruit and Flaxseed flour.

Protein and fat content of the developed meat analogue was found in good amount as comparing with the control. for protein content highest value 26.25 and lowest will be 14.30 for control so developed meat analogue is rich in good proteins with optimum amount. Where statistically sample M1 and C does not show any significant difference (p>0.05) in their protein values but sample M2 having difference (p<0.05) with compare to C and M2. This change is observed due to the Variation in formulation of protein rich raw ingredients sample M1 contain major amount of jackfruit which is deficient in protein jackfruit possess only 2-3% of protein (Ranasinghe *et al*., 2019a) [21] and other protein sources incorporated in meat analogue was pea protein isolates and flaxseed were in fix amount so it may not make huge difference in the protein content. Where as sample M2 having only 20% jackfruit and all remaining ingredients were rich in protein major ingredients utilized in M2 was cashew nut flour with addition of pea protein isolates and flaxseed flour. So due to incorporation of protein rich raw ingredients in sample M2 shows higher protein content. Furthermore, fat content of the developed meat analogue was between 3.51 to 10.99% sample M1 and C show insignificant difference (p>0.05) in their values but sample M2 having significant difference (p<0.05) with other two samples the highest amount of fat found in Sample M2 due to higher amount of cashew nut flour which resembles good amount of fat content so it's showing a higher value in M2, in case of M1 there was no inclusion of Cashew nut flour which directly affected the fat content of the sample. And control sample resembles 4.30% fat content which naturally found cod fish. Furthermore, Fibre and ash content of the developed meat analogue was mention in table sample M1 and M2 show no significant difference (p>0.05) in the fibre content where as control sample shows no fibre content the total amount of fibre in raw jackfruit was 2.6% (Ranasinghe *et al*., 2019b) [22] and in flaxseed flour was 20.23% (Adam Omer Ishag *et al*., 2020) [1]. leads to the high fibre content in the finished product. furthermore, for ash content M1 and M2 show no significant difference (p>0.05) between them but C shows a significant difference (p<0.05). results were similar to Keerthana Priya *et al*., (2021) [15] included banana floret and tender jackfruit in the vegetarian sausage and there was a significant rise in the sample's ash content and found the ash content might be ascribed to the excess minerals, starch, and fibre. In this study, variations in ash concentration may be attributable to changes in the proximate analysis of raw material.

Carbohydrate content in sample C was less than one percent, whereas, in samples M1 and M2, no significant differences were seen c. Ayandipe *et al*. (2020) [3] made a meat imitation composed of cassava flour and coconut composite flour of excellent quality and rich in carbohydrates. Therefore, in the current research we used jackfruit bulb and cashew nut flour having an optimum amount of carbohydrates. Which eventually increased the carbohydrate content.

3.2 Colour values

Colour was the main qualitative factor in processed meat, which affects consumer perception and product approval (Kamani *et al*., 2017) [14]. In current study we discovered that jackfruit incorporated sample shows higher lightness as compare to cashew nut incorporated results showed in the table (3) for control significant difference (p>0.05) was seen. Results were similar to Balqish, (2013) [6] where he found that due to inclusion of jackfruit and wheat flour lightness of their final product was influenced. For redness of the sample M1 and M2 show no significant difference (p>0.05). between them but while comparing with the control it shows that the significant difference(p<0.05) due to the presence natural heme pigments which are responsible for the colour in meat (Cardoso *et al*., 2009) [8]. Furthermore, yellowness of the product b^* values were M1 and M2 show no significant difference (p>0.05) but control having a significant difference comparing with the other two mimicked products. highest yellowness value, which may be due to jackfruit bulb and cashew nut flour percentages on which flaxseed and pea protein isolates also influence b* values.

3.4 Sensory Analysis

The sensory traits of meat analogue shown in fig. (1) the Texture values of the Control sample were high and additionally there is significant difference between overall acceptability, chewiness and juiciness of control sample as compared to the developed one because natural meat texture and flavour. M2 having a high overall acceptability after the control but for the colour M2 and M1 show no significance difference (p>0.05) in figure. Where as after control M1 shows high juiciness and chewiness values. But in terms of flavour M2 getting more acceptance as compare to the control and M1 due to the higher amount of cashew nut According to (Owiredu *et al*., 2014) [18], replacement of wheat flour in biscuit with cashew nut flour had showed increased in sensory metric. There is common disadvantage of using a plant based protein in the meat analogue that compounds from lipid oxidation will form a free radicals of fat which causes the unappealing flavours and odours (Bakhsh *et al*., 2021) [4]. Thus, a wide selection of herbs and spices, counting which is correspondingly functional in meat processing, are used to replicate processed meat flavours. Nevertheless, many plant based substitutes still have an aftertaste. A subsequent lipid oxidation residue, such as methanethiol or hexanal, is suggested to be responsible for the distinctive fragrance of beans (Boatright & Lu, 2007) [7]. Our sensory examination discloses that meat analogue created from jackfruit, cashew nut flour, and supporting ingredients were a good ancillary for traditional meat analogue.

Table 1: Formulations of developed plant-based meat analogue.

Trial	Jackfruit bulb	Cashew nut	Pea protein	Flaxseed	Xanthum	Salt	Total weight
M1	70	0	15	14	0.5	0.5	100gm
M2	20	50	15	14	0.5	0.5	100gm

Abbreviations: M- Formulation [1], M1- Sample with 70% JF[2], M2- 20% JF, C- Control.

Table 2: Proximate analysis of the Developed meat analogue (mean ± SD)

Trial	M1	M2	C
Moisture	55.16±1.51a	28.93±2.50c	77.61±0.1[a]
protein	14.99±0.96[b]	26.25±1.34[a]	14.3±0.21[b]
fat	3.51±0.38c	10.99±1.21a	4.30±0.11[c]
fibre	3.43±2.44a	2.45±1.63 a	0±0[b]
ash	1.02±0.83 b	1.48±0.02 b	3.95±0.01[a]
Carbohydrate	21.89a	29.9a	<0.1[b]

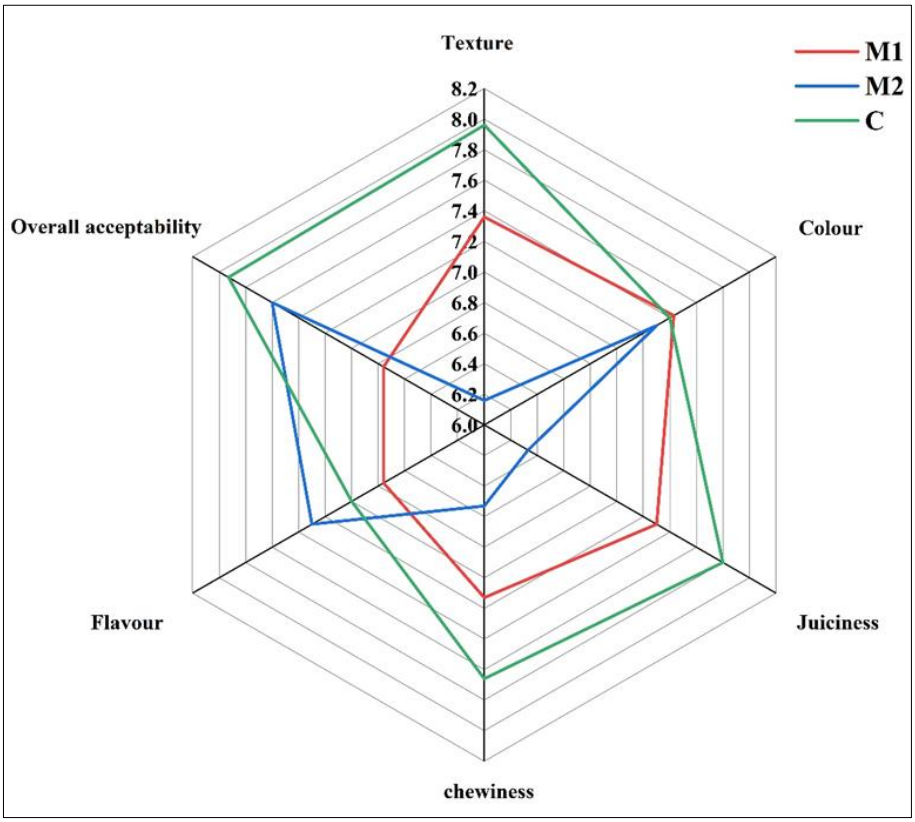
Note: Mean within rows with different superscripts are significantly different (p<.05).

Abbreviations: M- Formulation [1], M1- Sample with 70% JF [2], M2- 20% JF, C- Control.

Table 3: Colour values (mean ± SD)

Colour	M1	M2	C
L*	52.35±0.01a	41.88±0 a	62.01
a*	5.08±0.014 a	5.98±0.01 a	3.01
b*	12.42±0 a	12.25±0 a	20.01

Abbreviations: M- Formulation [1], M1- Sample with 70% JF [2], M2- 20% JF, C- Control.
†M = Formulation.
‡JF = jackfruit.
†M = Formulation.



Abbreviation: M- Formulation, M1- Sample with 70% JF, M2- 20% JF, C- Control.

Fig 1: Spider diagram of sensory analysis.

4. Conclusion

The trend of vegan meat industry is developing fast among the youngsters and health-conscious people which eventually boost up many fresh start-ups finding their place in the market and full-fill the worldwide demand. According to UN the global meat consumption will be triple till 2050. Hence by adopting the sustainable approaches from the plant based meat to full fill this global demand. The outcome of the current study stated that when we compare our sample with control, the proximate and Sensory analysis shown a higher-indices in a their values as well as colour parameters like lightness, redness, yellowness of the developed product was influenced by the key raw ingredients like jackfruit, cashew nut and flaxseed although they added a decent amount of nutrient to developed meat analogue. We also able to utilize underutilized jackfruit fruit, and the to adopt a good amount essential amino acids optimum utilization of cashew nut flour was done. And successfully developed a plant-based meat analogue with jackfruit and cashew nut.

4.1 Conflict of interest: Authors declared no conflict of interest for this article.

5. References

1. Adam Omer Ishag O, Khalid A, Abdi A, Yaagoub Erwa I, Babiker Omer A, H Nour A. Proximate Composition, Physicochemical Properties and Antioxidant Activity of Flaxseed. Annual Research & Review in Biology, 2020, 1-10. https://doi.org/10.9734/arrb/2019/v34i230148

2. Aremu MO, Olonisakin A, Bako DA, Madu PC. Compositional studies and physicochemical characteristics of cashew nut (*Anarcadium occidentale*) flour. Pakistan Journal of Nutrition. 2006;5(4):328-333. https://doi.org/10.3923/PJN.2006.328.333
3. Ayandipe DO, Adebowale AA, Obadina O, Sanwo K, Kosoko SB, Omohimi CI. Optimization of High-Quality Cassava and Coconut Composite Flour Combination as Filler in Chicken Sausages, 2020. Https://Doi.Org/10.1080/15428052.2020.1799280, 20(1), 1–32. https://doi.org/10.1080/15428052.2020.1799280
4. Bakhsh A, Lee SJ, Lee EY, Hwang YH, Joo ST. Evaluation of rheological and sensory characteristics of plant-based meat analog with comparison to beef and pork. Food Science of Animal Resources. 2021;41(6):983-996. https://doi.org/10.5851/KOSFA.2021.E50
5. Balamaze J, Muyonga J, Byaruhanga Y. Production and utilization of jackfruit (*Artocarpus heterophyllus*) in Uganda. African Journal of Food, Agriculture, Nutrition and Development. 2019;19(02):14289–14302. https://doi.org/10.18697/ajfand.85.17290
6. Balqish N. Determination of Proximate Composition and Colour Characteristic of Noodles Incorporated, 1985.
7. Boatright WL, Lu G. Hexanal Synthesis in Isolated Soy Proteins. Journal of the American Oil Chemists' Society. 2007;84(3):249. https://doi.org/10.1007/s11746-007-1036-6
8. Cardoso CML, Mendes R, Nunes ML. Instrumental Texture and Sensory Characteristics of Cod Frankfurter Sausages. International Journal of Food Properties. 2009;12(3):625-643. https://doi.org/10.1080/10942910801992959
9. Corrin T, Papadopoulos A. Understanding the attitudes and perceptions of vegetarian and plant-based diets to shape future health promotion programs. Appetite. 2017;109:40-47. https://doi.org/10.1016/J.APPET.2016.11.018
10. Dekkers BL, Boom RM, van der Goot AJ. Structuring processes for meat analogues. Trends in Food Science & Technology. 2018;81:25-36. https://doi.org/10.1016/J.TIFS.2018.08.011
11. Fernandez-Gines JM, Fernandez-Lopez J, Sayas-Barbera E, Sendra E, Perez-Alvarez JA. Effect of Storage Conditions on Quality Characteristics of Bologna Sausages Made with Citrus Fiber. Journal of Food Science. 2003;68(2):710-714. https://doi.org/10.1111/j.1365-2621.2003.tb05737.x
12. Hamid MA, Tsia FLC, Okit AAB, Xin CW, Cien HH, Harn LS, *et al*. The application of Jackfruit by-product on the development of healthy meat analogue. IOP Conference Series: Earth and Environmental Science. 2020;575(1):012001. https://doi.org/10.1088/1755-1315/575/1/012001
13. KPS, Sbabu P, Bindu J. Optimization of blanching process for tender jackfruit (*Artocarpus heterophyllus* L.). Indian Journal of Dairy & Biosciences, 2012, 23.
14. Kamani MH, Safari O, Mortazavi SA, Mehraban Sang, Atash M, Azghadi NM. Using an image processing based technique and predictive models for assessing lipid oxidation in rainbow trout fillet. Food Bioscience. 2017;19:42-48. https://doi.org/10.1016/J.FBIO.2017.05.005
15. Keerthana Priya R, Rawson A, Vidhyalakshmi R, Jagan Mohan R. Development of vegan sausage using banana floret (*Musa paradisiaca*) and jackfruit (*Artocarpus heterophyllus* Lam.) as a meat substitute: Evaluation of textural, physico-chemical and sensory characteristics. Journal of Food Processing and Preservation, 2021. https://doi.org/10.1111/jfpp.16118
16. Kumar S. Meat Analogs "Plant based alternatives to meat products: Their production technology and applications, 2016. Https://Doi.Org/10.1080/10408398.2016.1196162, 00–00. https://doi.org/10.1080/10408398.2016.1196162
17. McClements DJ, Weiss J, Kinchla AJ, Nolden AA, Grossmann L. Methods for testing the quality attributes of plant-based foods: Meat-and processed-meat analogs. Foods. 2021;10(2). https://doi.org/10.3390/foods10020260
18. Owiredu I, Laryea D, Barimah J. Evaluation of cashew nut flour in the production of biscuit. Nutrition and Food Science. 2014;44(3):204-211. https://doi.org/10.1108/NFS-06-2013-0067
19. Rajput E, Rawson A, Krishnamoorthy S, Rangarajan J. Jackfruit Byproducts: Functional Properties and Scope of Utilization as Unleavened Flat Bread, 2022. Https://Doi.Org/10.1080/15428052.2022.2027307, 1-23. https://doi.org/10.1080/15428052.2022.2027307
20. Ramos Diaz JM, Kantanen K, Edelmann JM, Suhonen H, Sontag-Strohm T, Jouppila K, *et al*. Fibrous meat analogues containing oat fiber concentrate and pea protein isolate: Mechanical and physicochemical characterization. Innovative Food Science & Emerging Technologies. 2022;77:102954. https://doi.org/10.1016/j.ifset.2022.102954
21. Ranasinghe RASN, Maduwanthi SDT, Marapana RAUJ. Nutritional and Health Benefits of Jackfruit (*Artocarpus heterophyllus* Lam.): A Review. 2019a.
22. Ranasinghe RASN, Maduwanthi SDT, Marapana RAUJ. Nutritional and Health Benefits of Jackfruit (*Artocarpus heterophyllus* Lam.): A Review. International Journal of Food Science, 2019b. https://doi.org/10.1155/2019/4327183
23. Samard S, Gu BY, Ryu GH. Effects of extrusion types, screw speed and addition of wheat gluten on physicochemical characteristics and cooking stability of meat analogues. Journal of the Science of Food and Agriculture. 2019;99(11):4922-4931. https://doi.org/10.1002/jsfa.9722
24. Sha L, Xiong YL. Plant protein-based alternatives of reconstructed meat: Science, technology, and challenges. Trends in Food Science & Technology. 2020;102:51-61. https://doi.org/10.1016/J.TIFS.2020.05.022
25. Sun C, Ge J, He J, Gan R, Fang Y. Processing, Quality, Safety, and Acceptance of Meat Analogue Products. Engineering. 2021;*7*(5):674-678. https://doi.org/10.1016/J.ENG.2020.10.011
26. Yadav S, Pathera AK, Islam RU, Malik AK, Sharma DP. Effect of wheat bran and dried carrot pomace addition on quality characteristics of chicken sausage. Asian-Australasian Journal of Animal Sciences. 2018;31(5):729. https://doi.org/10.5713/AJAS.17.0214