2ND EDITION

E-EXTENDED
ABSTRACT

INTERNATIONAL AGROTECHNOLOGY INNOVATION SYMPOSIUM (i-AIS)

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ABOUT FACULTY OF PLANTATION AND AGROTECHNOLOGY

The Faculty of Plantation and Agrotechnology was established in 2010 at Universiti Teknologi MARA (UiTM). The mission of the faculty is to play the vital role of producing well-trained professionals in all areas of plantation and agriculture-related industries at national and international levels.

Bachelor of Science (Hons) Plantation Technology and Management is a three-year program that strongly emphasizes the various aspects of Production Technology, Management, and Information Technology highly sought after by the agricultural and plantation sectors. Students in this program will be fully trained to serve as professionals in the plantation sector and related industries. They will have ample opportunities to fulfill important positions in the plantation industry such as plantation executives. This program provides a strong balance of technology and management courses essential for the plantation industry such as management of plantation crops, soil fertility, plantation management operation, plantation crop mechanization, and agricultural precision. As an integral part of the program, students will be required to undergo industrial attachment to gain managerial skills in the plantation industry.

The faculty is highly committed to disseminating, imparting, and fostering intellectual development and research to meet the changing needs of the plantation and agriculture sectors. With this regard, numerous undergraduate and postgraduate programs have been offered by the government's intention to produce professionals and entrepreneurs who are knowledgeable and highly skilled in the plantation, agriculture, and agrotechnology sectors.

PREFACE

International Agrotechnology Innovation Symposium (i-AIS) is a platform to be formed for students/lecturers/ staff to share creativity in applying the knowledge that is related to the world of Agrotechnology in the form of posters. This virtual poster competition takes place on the 1st of December 2022 and ends on the 8th of January 2023. This competition is an assessment of students in determining the level of understanding, creativity, and group work for the subject related to agrotechnology and being able to apply it to the field of Agrotechnology. The i-AIS 2022 program takes place from December 1, 2022, to January 8, 2023. The program was officiated by the Dean of the Faculty of Plantation and Agrotechnology, namely Prof. Madya Ts. Dr. Azma Yusuf. The program involves students from faculties of the Faculty of Plantation and Agrotechnology (FPA)and HEP participating in i-AIS 2022, namely, the Faculty of Education and Pre-Higher Education. This program involves the UiTM student and some of the non-UiTM students which come from the international university and the local university. Two categories are contested, namely UiTM and non-UiTM. To date, students from these programs have shown remarkable achievements in academic performance and participation in national as well as international competitions.

This competition is an open door for the students and lecturers to exhibit creative minds stemming from curiosity. Several e-content projects have been evaluated by esteemed judges and that has led to the birth of this E-Poster Book. Ideas and novelties are celebrated, and participants are applauded for displaying ingenious minds in their ideas.

It is hoped that such an effort continues to breed so that there is always an outlet for these creative minds to grow.

Thank you.

Dean
On behalf of the Organizing Committee
Conference Chair
Universiti Teknologi MARA
Faculty of Plantation and Agrotechnology
http://fpa.uitm.edu.my

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DEVELOPMENT OF PLANT-BASED MEAT FROM JACKFRUIT (*Artocarpus heterophyllus, Lam*)

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ABSTRACT

Unripe jackfruit has great potential as a meat analogue due to its great nutritional profile and naturally meat-like texture. This research paper aims to highlight the potential of unripe jackfruit in the development of plant-based meat and determine the best formulation of the jackfruit meat analogue. Three different formulations of meat analogues had been developed with different percentages of unripe jackfruit and vital wheat gluten (F1= 55% jackfruit + 25% vital wheat gluten; F2 = 45% jackfruit + 35% vital wheat gluten; F3 = 35% jackfruit + 45% vital wheat gluten). Nutritional composition, physicochemical characteristics and sensory evaluation were investigated for all three formulations. Results demonstrated that the texture of the jackfruit meat analogue was improved with increasing vital wheat gluten percentage, where the meat analogue of F3 was observed to have significantly ($p<0.05$) higher value texture attributes as compared to others. Sample of F1 and F3 showed a significant difference ($p<0.05$) in cooking loss with 11.88% and 9.13% respectively. While in terms of diameter and thickness shrinkage, there was a significant difference ($p<0.05$) found between all three formulations in which F3 has the lowest shrinkage after cooking. No significant difference ($p>0.05$) was found in the colour index of L*, a* and b* between all three samples before and after cooking. But there is a decrease in brightness and yellowness of the sample after cooking. F3 was observed to have a significantly higher ($p<0.05$) percentage of protein as compared to the F1 due to the high content of vital wheat gluten which has been a good source of protein. Data also showed that F3 was the most preferred meat analogue among the other samples. Thus, the meat analogue of F3 was chosen to have the best formulation of the jackfruit meat analogue.
Keywords: meat analogue, unripe jackfruit, texture analysis, nutritional composition, protein source

INTRODUCTION

The existing global population is expected to escalate up to 9.8 billion by 2050 along with an increasing demand for 50% of vegetarian food and 70% of animal-based foods (Choudhury *et al*., 2020). This alarming issue can pose a threat to the affordability of feeding the global population without negatively impacting the environment (Kyriakopoulou *et al*., 2019). Following these challenges, the food industry, especially food scientists and researchers is actively exploring the potential of plant proteins as a replacer for conventional meat (Boukid, 2021). According to Ismail *et al*. (2020), a meat analogue which is also called a meat substitute refers to a meat-free food product that can imitate the structure, flavour, appearance, haptic experience, and nutrition of conventional meat products. The development of a plant-based meat analogue has caught the special attention of many consumers and become a current food trend in the market due to the increasing popularity of vegetarianism, rising awareness of natural resource depletion, and health awareness among society (Poshadri & Pawar, 2021). Sun *et al*. (2020) reported that plant protein contains good-balanced amino acid composition which indicates the high potential as a meat substitute via the production of a healthy meat analogue. This research aims to investigate the nutritional composition, texture properties and sensory evaluation of jackfruit plant-based meat. It is well known that jackfruit provides a good nutritional profile, including its therapeutic benefits that have been described in numerous studies (Ranasinghe *et al*., 2019). Swani *et al*. (2020) studied that jackfruit contains abundant vitamins and nutritional contents, including isoflavones and saponins with anti-ageing, anti-inflammatory and anti-cancer, and anti-ulcer properties, preventing cardiovascular disease and others. The potential of unripe jackfruit is currently being explored in the development of novel plant-based meat as an alternative option for protein-based meat that could be a depleted natural resource in the future. This research aims to investigate the nutritional composition, texture properties and sensory evaluation of jackfruit plant-based meat.

MATERIAL AND METHOD

Preparation of raw materials

Fresh unripe jackfruit was purchased from a farm located in Kampong Parit Babok, Pagoh, Muar and other ingredients, including seasoning and spices, were purchased from local supermarkets around Shah Alam, Selangor. The jackfruit was stored at room temperature before use.

Preparation of jackfruit rags

The rinds (soft thorny green skin) of the outer layer of the jackfruit were removed using the oil-coated knife. The rags were cut into smaller pieces followed by proper washing. Then, the rags were boiled until it softens for about 30 minutes. After that, the boiled rags were filtered and put aside to let them cool down. The seeds were removed from the rags and stored in a container at 4℃ until further usage.

Production of meat analogue patties

Three different formulations of jackfruit meat analogue with the variation of jackfruit and vital wheat gluten (VWG) content were prepared according to the formulation shown in Table 2.1. The blended jackfruit rags and other spices were weighed according to the formulation. The prepared rags and other ingredients including spices were added into a mixer until obtaining a homogenous and desirable coarse texture. Then, the dough was divided into similar weights and shaped into a suitable size of patty using a shaper. Then, the prepared meat analogues were stored in a freezer at -18℃ before analysis.

Nutritional composition

Moisture content

The moisture content of the meat analogues was determined using AOAC methods by drying methods using an air oven. An aluminium dish with a cover was dried in an oven at 105℃ for 3 hours followed by cooling down in a desiccator. Approximately 5 g of samples were weighed into the aluminium dish and heated at 60℃ overnight without the covers. The weight will be recorded and the drying was repeated until a constant weight was achieved. The analysis was done in triplicate for each formulation and the results were averaged. The percentage (%) of moisture will be calculated as shown in the formula below.

Moisture content (%) = [(weight of wet sample + pan) - (weight of dried sample + pan)/ (weight of wet sample +pan) – weight of pan] x 100

Crude fat content

To measure crude fat content, Soxhlet extraction methods were used by the solvent extraction system (FAM 9209-06, MTOPS Limited, UK). Approximately 2 g of the dried sample was placed into an organic thimble. Then, the sample was heated gently on the electrothermal extraction unit for 10 hours and petroleum ether was used as a solvent. The fat from the solvent was extracted using a steam bath to evaporate the solvent. The analysis was done in triplicate for each formulation and the results were averaged. The crude fat content as a percentage (%) will be determined as shown in the equation given below.

$$\text{Crude fat (\%)} = [(W1 - W2) / W1] \times 100$$

Where W1 and W2 are the sample weights before and after the extraction process respectively.

Crude protein content

Kjeldahl Method was used in the determination of crude protein content. The Kjeldahl method is based on three steps which are digestion, distillation, and titration. Firstly, the sample was digested using a digestion system (TURBOSOG, Gerhardt, Malaysia). Approximately 0.8 g of the sample was weighed into a digestion tube and 2 pills of catalyst mixture (5g of potassium sulphate and 5 g of selenium) were added followed by the addition of 20 ml of concentrated sulfuric acid. After the digestion is complete, the liquid was distilled using a distillation apparatus (Vapodest 45 S, Gerhardt, Malaysia) and 70 ml of 2% boric acid was added with screened methyl red as an indicator. Then, 50 ml of distilled water and 80 ml of 32% NaOH were used to start the distillation. After completion, the sample was titrated with 0.1M HCl. The volume of titrant was recorded and the percentage of protein will be calculated. The analysis was done in triplicate for each formulation and the results were averaged.

Total nitrogen (g) per 100g food sample = (titre – blank) x 1.4 x 100 /1000 x

sample weigh (g) Crude protein (g) per 100g food sample = total nitrogen x

conversion factor for foodstuff analysed.

Ash content

The ash content of meat analogues, also known as total mineral content, is an important parameter that influences their nutritional and quality attributes. A muffle furnace will be used in the dry-ashing method (Daihan Scientific, South Korea). Approximately 5g of homogenized food sample will be weighed into the pre-heated and labelled crucible and dried in the oven for 1 day at 105°C. The dried sample was gently burned on a Bunsen burner until no smoke evolved followed by being heated in a muffle furnace at 330°C for 3 hours until a whitish or greyish sample is obtained. The dish will be cooled down in a desiccator followed by weighing the sample. The analysis was done in triplicate for each formulation and the results were averaged. The ash content was calculated in percentage (%) as shown in the equation given below.

$$\text{Ash content (\%)} = (\text{Weight of ash} / \text{Sample weight}) \times 100$$

Carbohydrate content

For the determination of carbohydrates, total carbohydrate content (%) was determined using the equation shown below.

$$\text{Total carbohydrate (\%)} = 100\% - \text{moisture content (\%)} - \text{Fat (\%)} + \text{Protein (\%)} - \text{Ash (\%)}$$

Physicochemical analysis

Water holding capacity

Water holding capacity (WHC) is a standard parameters test that was performed in the meat science industry which describes the ability of meat to hold the water contents and bind fluids within its semi-solid matrix (McClements *et al*., 2021). The WHC is often determined by a centrifugal method. Approximately 10 g of sample (W1) was weighed into a centrifuge tube before centrifugation at a moderate gravitational force (<10,000g). Then, the water was drained and weighed W2. The measurement was taken in triplicate for each formulation and the results were averaged. The WHC was determined using the equation given below.

$$WHC = 100 \times (W1 - W2)/ W1$$

Where W1 and W2 are the sample weights before and after centrifugation respectively.

Cooking loss

Cooking loss refers to the percentage of weight loss in meat after cooking (Baioumy & Abedelmaksoud, 2021). The weight of the meat analogue before (W1) and after (W2) cooking process was measured. The cooking loss (CL) was determined by calculating the difference in weight of the meat analogue before and after the cooking process as shown in the equation given below. The measurement was taken in triplicate for each formulation and the results were averaged.

$$CL = [(W1 - W2) / W1]\ 100 \times$$

Where W1 and W2 are the sample weights before and after the heating process respectively.

Water activity

Water activity, often known as 'free water', reflects the active part of the moisture content that is responsible for microorganism growth which can lead to food spoilage (Baioumy & Abedelmaksoud, 2021). The water activity of each sample of different formulations was determined using the Water Activity Metre (AQUA LAB 4TE, TMS, Germany). The measurement was taken in triplicate for each formulation and the results were averaged.

pH value

In pH value determination, a pH meter equipped with a penetration probe was used. The measurement was taken in triplicate for each formulation and the results were averaged.

Thickness and diameter reduction

To prepare the meat analogues, the samples were thawed for a few minutes before cooking at 180℃ for 5 minutes using a gas cooker (PGC 26N, Pensonic, Malaysia). The meat analogue thickness and diameter before and after the cooking process were measured using vernier callipers. The measurement was taken in triplicate for each formulation and the results were averaged. The change in thickness and diameter of the meat analogue was determined using the given formulas below.

Thickness reduction (%) = (Initial thickness − final thickness)/ Initial thickness × 100 Diameter reduction (%) = (Initial diameter−final diameter)/ initial diameter × 100

Texture analysis

Hardness (N) is considered the maximum force required for the first compression, while chewiness applies to the required work to masticate the sample as N.mm (Paredes *et al*., 2022). The hardness and chewiness of a cooked meat analogue product were determined using a texture analyser with a P/51 probe (TA. XT2i, Stable Micro Systems, UK). The samples were cut into a square shape with a dimension of 2.5 cm × 2 cm × 2 cm and compressed the sample to 50% of their original thickness at 5 .00mm/s of crosshead speed for 5.00 seconds.

Sensory evaluation

Sensory evaluation was performed by panellists comprising 33 untrained panels of students from the Faculty of Applied Science, UiTM Shah Alam to evaluate three formulations of meat analogue samples using a 9- point hedonic scale (1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5=neither like nor a dislike, 6=like slightly, 7=like moderately, 8=like very much, 9=like extremely) based on the attributes of appearance, colour, aroma, taste, hardness, juiciness, and overall acceptability.

Statistical analysis

The readings of each measurement will be recorded in triplicate for each sample of each analysis. The data obtained for the quality parameters of the patties including proximate analysis, physicochemical analysis, and sensory evaluation were analysed using One-way Analysis of Variance (ANOVA) to evaluate the complete set of the data and determine significant differences between the different formulations of the patties in each study. SPSS Statistics will be used in the statistical analysis, where significant differences among the means of different formulations at $p < 0.05$ will be used.

RESULTS AND DISCUSSION

Nutritional composition

The nutritional composition of jackfruit meat analogue of the different formulations is shown in table 3.1. The results showed a significant difference ($p<0.05$) in nutritional composition in the different formulations of the jackfruit meat analogue. The meat analogue of F1 had significantly higher ($p<0.05$) carbohydrate content as compared to the other formulations. This is expected due to the addition of the high content of unripe jackfruit which is attributed to the high carbohydrate content. This can be supported by Akter and Haque (2020), that there is about 88% of carbohydrate content in jackfruit.

Protein content exhibited a significant difference ($p<0.05$) between the meat analogue of F1 and F3. Meat analogue of F3 had a significantly higher ($p<0.05$) content of protein which is 10.66 % as compared to F1 which had the lowest percentage of protein which is 9.16 %. This can be explained by the variation of vital wheat gluten content in the meat analogue that give an impact on the protein content. Vital wheat gluten, also called Seitan can range in protein content from above 70 % according to the United States of America Patent No. US20190191725A1 (2019).

The fat content of the F3 meat analogue (5.63 %) is significantly higher ($p<0.05$) as compared to F2 (4.40 %) and F1 (4.23 %). This might be due to the higher oil holding capacity of the patty. According to Ozyurt and Ötles (2018), oil holding capacity is the amount of oil retained by the fibres after mixing, incubation with oil, and centrifugation. A finding reported by Felli *et al*. (2021) revealed that oil absorption capacity can be promoted by starch or gluten and controlled by protein and insoluble fibre. The addition of a higher percentage of vital wheat gluten in F3 (45 %) might be contributed to the high oil holding capacity as compared to the F1 (25 %) and F2 (35 %) resulting in higher fat content.

The moisture content of the F2 meat analogue (11.21 %) exhibits a higher value ($p<0.05$) as compared to F1 (10.02 %) and F3 (9.95 %). F3 (4.12 %) shows the lowest ash content ($p<0.05$) among other formulations. Ash content refers to the inorganic residue including minerals left after ignition or complete oxidation of organic matter (Ismail, 2022). Ranasinghe *et al*., (2019) reported that unripe jackfruit contains a substantial amount of minerals such as potassium, calcium, and phosphorus. Hence, the lower ash content in the F3 meat analogue might be due to the lower content of jackfruit rags (35 %) as compared to F1 and F2 meat analogues with 55 % and 45 % of unripe jackfruit rags respectively.

Texture analysis

The instrumental textural parameters including hardness, springiness, and chewiness of different formulations with different jackfruit percentages are shown in table 3.2. Hardness is considered as the maximum force of the first compression, while chewiness applies only to solid products and is calculated as hardness × cohesiveness × springiness. Springiness is typically expressed as the ratio or percentage of a product's original height. The results showed that the addition of different percentages (%) of jackfruit and vital wheat gluten had a significant effect ($p<0.05$) on the hardness and chewiness of the meat analogues.

The hardness and chewiness of the jackfruit meat analogue was improved with increasing vital wheat gluten percentage, where the meat analogue of F3 with the highest content of vital wheat gluten (55 %) was observed to have a significantly ($p<0.05$) higher value of the hardness and chewiness as compared to the other formulations with lower content of vital wheat gluten. This is expected due to the higher content of vital wheat gluten that can increase the firmness and hardness of the patty. These findings were supported by Gao *et al.*, (2021), where the incorporation of vital wheat gluten which acts as a protein boost enhances a stronger gluten network formation that can improve the overall texture. A tougher network formation internally enhances the resistance to compression which can contribute to the overall texture quality of the patty. The meat analogue with the lowest percentage of vital wheat gluten (35 %) recorded the lowest value of the textural properties. It is noticeable that the texture was more fragile as compared to the F2 and F3 due to the formation of a weaker protein network resulting from the lower content of gluten.

Sensory evaluation

Sensory characteristics of three different formulations of jackfruit meat analogue were evaluated, and the mean scores for 33 panellists of 9 samples are presented in Table 3.3. Based on the data, there was no significant difference ($p>0.05$) between the three formulations in terms of appearance, aroma, and colour of the meat analogues. These findings indicate that different percentages of jackfruit and vital wheat gluten had no significant effect on these attributes. However, results demonstrated that the addition of different percentages of jackfruit and vital wheat gluten had a significant effect ($p<0.05$) on hardness, juiciness, taste, aftertaste, and overall acceptability of the prepared meat analogue.

The three formulations showed a significant difference ($p<0.05$) in terms of hardness. Meat analogue samples of F3, with the incorporation of 35% of jackfruit and 45% of vital wheat gluten recorded the highest acceptance score of hardness and juiciness attributes. The addition of high content of vital wheat gluten enhances the texture quality and juiciness of the patty which can contribute to the overall texture quality of the patty. In terms of taste, results indicated that there was a significant difference ($p<0.05$) between the three formulations. Taste attributes are the most significant element in food for consumer acceptance. The meat analogue of F3 recorded the highest acceptance score in terms of taste. In terms of aftertaste, the meat analogue of F1, with the addition of 45% jackfruit showed a significant difference ($p<0.05$) as compared to the sample of F2 and F3. The lowest acceptance score of the F1 in terms of aftertaste indicates that the higher content of jackfruit might affect the aftertaste of the meat analogue. In terms of overall acceptability, there was also a significant difference ($p<0.05$) between all three formulations. Based on the data, the meat analogue of F3 (35% jackfruit + 45% vital wheat gluten) showed the highest score of overall acceptance and thus, it is chosen as the best formulation.

Table 1: Formulation (F) of Meat Analogue (%) based on 1000 g

Ingredients	F 1	F 2	F 3
Jackfruit	55 %	45 %	35 %
Vital Wheat Gluten	25 %	35 %	45 %
Soy protein isolate	7 %	7 %	7 %
Vegetable oil	5 %	5 %	5 %
Mix spices	4.2 %	4.2 %	4.2 %
Ice flakes	2.3 %	2.3 %	2.3 %
Salt	1.5 %	1.5 %	1.5 %

Mix spices: Nutritional yeast (0.70%), mushroom seasoning (0.75%), garlic powder (0.6%), onion powder (0.6%), paprika powder (1.3%), ground black paper (0.25%)

Table 2: Nutritional Composition of Different Formulations of Jackfruit Meat Analogues per 100 g

Composition (%)	Formulation		
	F1	F2	F3
Carbohydrate	71.63 ± 0.32^{a}	69.74 ± 1.57^{b}	69.64 ± 0.91^{b}
Protein	9.16 ± 0.89^{a}	9.81 ± 1.12^{ab}	10.66 ± 0.85^{b}
Fat	4.23 ± 1.29^{a}	4.40 ± 0.27^{a}	5.63 ± 0.13^{b}
Moisture content	10.02 ± 0.67^{a}	11.21 ± 0.41^{b}	9.95 ± 0.81^{a}
Ash	5.33 ± 0.38^{a}	4.84 ± 0.67^{a}	4.12 ± 0.21^{b}

Values are expressed as mean values of triplicate ± SD. Samples F1= 55% jackfruit + 25% vital wheat gluten; F2 = 45% jackfruit + 35% vital wheat gluten; F3 = 35% jackfruit + 45% vital wheat gluten. A number followed by the different superscript alphabets in the same row indicates a significant difference ($p<0.05$) obtained at the Duncan test level of 5%.

Table 3.2 Instrumental Textural Properties of Different Formulations of Meat Analogues

Instrumental Textural Properties	Formulation		
	F1	F2	F3
Hardness	24174.64 ± 4.08^{a}	27028.15 ± 5.35^{b}	29079.0 ± 7.62^{c}
Springiness	0.60 ± 0.55^{a}	0.65 ± 0.33^{a}	0.77 ± 0.76^{b}
Chewiness	6478.65 ± 3.91^{a}	10868.00 ± 4.85^{b}	13580.65 ± 4.17^{c}

Values are expressed as mean values of triplicate ± SD. Samples F1= 55% jackfruit + 25% vital wheat gluten; F2 = 45% jackfruit + 35% vital wheat gluten; F3 = 35% jackfruit + 45% vital wheat gluten. A number followed by the different superscript alphabets in the same row indicates a significant difference ($p<0.05$) obtained at the Duncan test level of 5%.

Table 3.3 Sensory Characteristics of Different Formulations of Meat Analogues

Attributes	Formulations		
	F1	F2	F3
Appearance	7.97 ± 0.85^{a}	7.75 ± 0.95^{a}	7.84 ± 0.99^{a}
Colour	7.23 ± 1.01^{a}	7.15 ± 1.08^{a}	7.38 ± 0.91^{a}
Aroma	7.64 ± 1.17^{a}	7.41 ± 1.34^{a}	7.28 ± 1.14^{a}

Hardness	4.18 ± 0.64^{a}	6.47 ± 0.84^{b}	7.81 ± 0.97^{c}
Juiciness	4.43 ± 0.87^{a}	6.88 ± 1.45^{b}	7.63 ± 1.79^{c}
Taste	5.85 ± 1.06^{a}	6.59 ± 1.14^{b}	7.69 ± 0.97^{c}
Aftertaste	6.13 ± 1.22^{a}	7.893 ± 1.03^{b}	7.75 ± 0.98^{b}
Overall Acceptability	6.05 ± 1.09^{a}	7.42 ± 1.04^{b}	8.33 ± 0.87^{c}

Values are expressed as mean values of triplicate ± SD. Samples F1= 55% jackfruit + 25% vital wheat gluten; F2 = 45% jackfruit + 35% vital wheat gluten; F3 = 35% jackfruit + 45% vital wheat gluten. A number followed by the different superscript alphabets in the same row indicates a significant difference ($p<0.05$) obtained at the Duncan test level of 5%.

CONCLUSION

The potential of unripe jackfruit in the development of plant-based meat analogues was studied. Three different formulations of meat analogues had been developed with different percentages of unripe jackfruit and vital wheat gluten. Meat analogue of F3 had a significantly higher ($p<0.05$) content of protein which is 10.66 % as compared to F1 which had the lowest percentage of protein which is 9.16 % due to the high content of vital wheat gluten which has a good source of protein. The fat content of the F3 meat analogue (5.63 %) is significantly higher ($p<0.05$) as compared to F2 (4.40 %) and F1 (4.23 %). This might be due to the higher oil holding capacity promoted by the high gluten content in the patty. Moreover, the result exhibits a significant difference ($p<0.05$) in the water holding capacity (WHC) among the formulations where the F3 meat analogue showed the highest WHC that contributed to the low cooking loss and shrinkage which have been favourable characteristics for meat products. The hardness of the jackfruit meat analogue was improved with increasing vital wheat gluten percentage, where the meat analogue of F3 with the highest content of vital wheat gluten (55%) was observed to have a significantly ($p<0.05$) higher value of the hardness, springiness and chewiness as compared to the other formulations with lower content of vital wheat gluten. Results from the sensory evaluation showed that F3 (35 % of unripe jackfruit and 45% of vital wheat gluten) was the most preferred sample among the others based on the overall acceptability attributes. Thus, it can be concluded that the meat analogue of F3 is chosen as the best formulation of the jackfruit meat analogue.

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