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Utilization of elephant foot yam (*Amorphophallus paeoniifolius*) and Lasia stem (*Lasia spinosa*) replacers in burger patties

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Abstract Many meat-based processed foods have been developed with plant-based fat replacers due to the adverse effects of cholesterol and unsaturated fatty acids in meat. Many underutilized plants have the potential to be used as fat replacers in processed meat-based products. In this study, different amounts of elephant foot yam (*Amorphophallus paeoniifolius)* flour and lasia (*Lasia spinosa*) stem flour were used as replacements for the chicken burger patty. The treatments were developed with the composition of elephant foot yam flour, lasia stem flour and chicken meat as T1 (30 %, 30 %, 40%), T2 (25 %, 25 %, 50 %), T3 (25 %, 15 %, 60 %), T4 (15 %, 25 %, 60 %) respectively, and T5 (100 % chicken) as a control treatment. The physico-chemical, cooking, and sensorial properties of the triplicated samples were then compared to those of a control group made with 100% chicken. Cooking properties such as cooking loss, cooking yield, water holding capacity, fat retention, moisture retention, and shrinkage have shown significant differences (p<0.05) among the treatments. Overall, 25% elephant foot yam flour and 15% lasia stem flour incorporated patties have shown optimum values for water holding capacity, cooking yield, fat retention, moisture retention, and cooking loss compared to control except shrinkage. The proximate analysis, such as moisture content, protein, fat, fiber content, and ash content had significant differences (p<0.05) among the treatments and 25 % elephant foot yam flour and 15 % lasia stem flour incorporated patties showed favorable values. Compared to the control, patties incorporated with elephant foot yam and lasia stem flour replacements have shown lower fat content and higher fiber content. However, the sensory attributes of the replaced burger patties were not different compared to 100% chicken meat burger patty except for colour and taste.

Keywords: Burger patties, meat-replacers, proximate analysis, sensory attributes.

1 Introduction

The major ingredient in processed meat-based products is animal meat. Meat is generally considered to be an expensive source of protein, which has led to the exploration and use of various non-meat alternatives as substitutes for animal protein. Meat is rich in saturated fatty acids and cholesterol, both of which have been associated with health issues (Fernandez-Gines *et al.* 2005). In recent years, food scientists have focused on low-fat meat products that incorporate plant-derived flour components. Such efforts aim to reduce the intake of cholesterol that may be associated with the consumption of processed meat products (Takder 2013).

A variety of underutilized tuber crops have optimum nutritional composition and the potential to be used as functional replacers in meat-based processed foods. Elephant foot yam belongs to the family Araceae (Aroidae) (Singh and Wadhwa 2014), and it is primarily grown in Asian countries. This crop is considered as a valuable tuber producer; however, it is underutilized. Research has shown that elephant foot yam offers significant health benefits, including lowering cholesterol levels, regulating triglyceride content, reducing blood sugar levels, and promoting intestinal activity and immunological function in humans (Yao-ling *et al.* 2013). Omega-3 fatty acids present in elephant foot yam aid in increasing the levels of the good cholesterol range in the body, while decreasing the levels of low-density and very low-density lipoproteins (Singh *et al.* 2016). The perennial plant *Lasia spinose* (also locally known as 'Kohila') has a spiny rhizome, which is a rich source of dietary fiber content ranging from 40% to 75% of the total dry weight (Shefana and Ekanayake 2008). Moreover, *Lasia spinose* has demonstrated antimicrobial, antioxidant, and anticancer properties (Nanasombat and Teckchuen 2009).

The trend of primary food consumption and food choice of consumers has considerably shifted towards fast-food consumption due to changes in lifestyle with urbanization (Neelam 2022). Currently, there is an increasing interest among consumers in purchasing reduced-calorie and reduced-fat foods due to health concerns (McClements *et al.* 2015). Therefore, there is a high potential to use elephant foot yam and lasia stem as a replacer to produce food items with low or reduced fat. However, there has not been enough attention given to the utilization of elephant foot yam and lasia stem as fat replacers in meat products. The objective of this study is to produce a low-fat meat product using plant-based fat replacers, specifically elephant foot yam flour and lasia stem starch. Additionally, this study aims to assess the cooking and nutritional properties as well as the sensory acceptability of composite burger patties.

2 Material and Methods

The experiment was conducted in the Food Science and Technology Laboratory, Faculty of Technology, South Eastern University of Sri Lanka. The good quality elephant foot yam and lasia stem were purchased from the local market in Kaluaggala and Ampara, Sri Lanka and other ingredients such as chicken breast meat, butter, egg, bread crumbs, oil, ginger, chilli pepper, salt, onion, garlic, and corn flour were purchased from a supermarket in Ampara, Sri Lanka.

The elephant foot yam flour and the lasia stem flour were processed as described below. Good quality elephant foot yam and lasia stems were selected and peeled off. After that, they were washed and cut into small slices at a thickness of 2.5cm. Then, they were allowed for sun drying at temperature of 28 ± 5 °C and relative humidity of 75 ± 5%. After getting a good sound of brittleness, they were ground and sieved with 0.3mm mesh. Then, they were stored in airtight condition separately.

A preliminary trial was conducted to determine the ideal ratio of ingredients and formulation. Then burger patties were prepared using the selected formulations with triplicate samples per treatment (Table 1). The defatted and deboned chicken breast meat was ground into small pieces using a meat mincer (Brice TC12, Australia). Then, minced chicken meat was mixed with egg, butter, ginger, garlic, onion, pepper, chili, salt, vegetable oil, bread crumb, and corn starch. Then, elephant foot yam flour and lasia stem flour were added to the mixture according to the proportions. The mixture was spread out in an aluminium tray and flattened. The mixture was cut into shapes by using a round-shaped mould. Cut patties were coated with wheat flour, egg yolk, and breadcrumbs. After the preparation, the burger patties were stored in the freezer (Innova C585, Canada) at -18 ± 1 °C until further analysis. The frozen burger patty was thawed at the ambient condition (27 ± 5 °C, 70 ± 5 % R.H) before cooking.

Table 1: Treatment and formulation of burger patties with different levels of ingredients used.

Ingredients (g)	T_1	T_2	T_3	T_4	T5 (Control)
Elephant foot yam flour	30	25	25	15	-
Lasia stem flour	30	25	15	25	-
Chicken breast	40	50	60	60	100
Corn flour	20	20	20	20	20
Bread crumbs	15	15	15	15	15
Butter	22	22	22	22	22
Egg	8	8	8	8	8
Ginger	2	2	2	2	2
Oil	10	10	10	10	10
Chili	2	2	2	2	2
Pepper	2	2	2	2	2
Onion and Garlic	12	12	12	12	12
Salt	2.5	2.5	2.5	2.5	2.5
Total	195.5	195.5	195.5	195.5	195.5

2.1 Cooking measurements

The patties were cooked in a preheated oven at 180 ± 1 °C for 20 minutes until they reached an internal temperature of 75 °C at the center, as measured by a digital thermometer (TP-02S, China) before the cooking measurements. To ensure that the patties were evenly cooked, they were flipped at every 10 minutes.

Cooking loss

The cooking loss of the triplicated samples was measured by the ratio of difference between the initial weight and the weight after cooking, divided by the initial weight (Kim *et al.* 2013; Rifath and Jemziya 2021).

$$\text{Cooking loss (\%)} = \frac{\text{Raw sample wight} - \text{Cooked sample weight}}{\text{Raw sample weight}} \times 100$$

Cooking yield

Following the cooking process, cooking yield was measured by using the following equation (Naveena *et al.* 2006).

$$\text{Cooking yield (\%)} = \frac{\text{Weight of cooked patties}}{\text{Weight of raw patties}} \times 100$$

Fat retention

Fat retention after cooking process was calculated according to Murphy *et al.* (1975) using the following equation:

$$\text{Fat retention (\%)} = \frac{\text{Cooked weight} \times \text{Fat in cooked patties}}{\text{Raw weight} \times \text{Fat in raw patties}} \times 100$$

Moisture retention

After the cooking process, moisture retention was calculated according to El-Magoli *et al.* (1996) using the following equation:

$$\text{Moisture retention (\%)} = \text{Cooking yield} \times \left(\frac{\text{Moisture \% in cooked patties}}{\text{Moisture \% in raw patties}}\right) \times 100$$

Shrinkage

Shrinkage of burger patties during the cooking process was calculated using the following equation (Serdaroğlu and Değırmencioğlu 2004). The thickness and diameter measurements were taken by using the Vernier caliper.

$$\text{Shrinkage (\%)} = \frac{(\text{Raw thickness - Cooked thickness}) + (\text{Raw diameter - Cooked diameter})}{(\text{Raw thickness + Raw diameter})} \text{x}100$$

Water holding capacity (WHC)

The burger patty was cooked at 70 °C for 30 minutes in a water bath (Memmert w350, Germany), cooled and centrifuged for 1000 rpm for 10 minutes in a high-speed centrifuge (MSC-3000, Latvia). The exudate centrifugation loss of the burger patty was calculated as the difference in weight before and after process (Kristensen and Purslow 2001; Rifath and Jemziya 2021).

$$\text{WHC }(\%) = \left[\frac{[\text{Total water content -Separated water content}] \times 0.951}{\text{Total water content}}\right] \times 100$$

where, pure water content of meat that is separated under 70 °C is 0.951.

2.2 Proximate analysis

Moisture (MC)

The burger patty samples were placed in a hot air oven (TLPPL 131, India) at 105 °C overnight. The samples were kept in the oven until they reached a consistent weight. Before calculating the weight difference, the samples were placed in a desiccator to cool down (AOAC 2000).

$$MC\ (\%) = \frac{\text{Initial weight - Weight after oven drying}}{\text{Initial weight}} \times 100$$

Crude fiber

Approximately, 5 g of burger patty sample was taken and boiled with 200 ml of 0.2 H_2SO_4 for 30 minutes. The boiled sample was filtered to drain the acid solution, and it was washed with hot water to remove the acid residue completely. Further, the residue was boiled with 200 ml of 0.2 M NaOH. Then, the sample was filtered to drain NaOH and washed with hot water to remove NaOH residue completely. The filtrate was collected into a crucible and placed it in an oven (TLPPL 131, India) for two hours. After that the crucible was placed in a desiccator for 20 minutes and weighed. Then after, it was placed inside the muffle furnace (MF 1400 –30, India) at 550 °C for two hours. Finally, the sample was placed in a desiccator for 20 minutes and ash was weighed (AOAC 2000).

$$\text{Crude fiber }(\%) = \frac{\text{Weight of crucible with fiber - Weight of crucible with ash}}{\text{Weight of sample}} \times 100$$

Crude Protein

Triplicate samples of 2 g were placed into a Kjeldahl flask with the catalyst mixture. The 10 ml of distilled water and 20 ml of concentrated sulphuric acid were sequentially added. The mixture was digested at 400 °C for four hours until it became colourless. The digested solution was allowed to cool, decanted into a volumetric flask, and distilled water was added. An aliquot of 10 ml was pipetted into a Kjeldahl distillation flask and 90 ml distilled water was added to make up to 100 ml. Afterwards, 20 ml of 40% sodium hydroxide was also added to the mixture and distillated into a solution containing 10 ml of 4 % boric acid. Afterward, a distillate solution was added, along with three drops of mixed indicators. The distillate, which was light blue in colour was titrated against 0.1 N of hydrochloric acid until the colour changed to pale pink. A blank was also prepared by the same procedure.

$$\text{Crude Protein (\%)}=\frac{V \times N \times M}{Ws \times 10} \times 6.25$$

where, N= Concentration of acid, V = Volume of acid, M =Molecular Weight of nitrogen (14.007), Ws =Sample weight, and 6.25is the Conversion Factor.

Crude fat

The 5g of patty sample was wrapped by a filter paper, transferred to an extraction thimble and placed in a Soxhlet exactor (FAT 06A, China). The fat was extracted by allowing it to reflux at 80°C for 4 hours using 50 ml of petroleum ether. After the extraction, the flask was kept in the oven at 100 °C to evaporate excess moisture. Finally, the weight of the extracted fat was taken, and calculate the fat content (AOAC 2000).

$$\text{Crude fat (\%)}=\frac{\text{Weight of the extract}}{\text{Weight of the patty sample}} \times 100$$

Ash content

Initially, 5g of burger patty sample was placed inside a muffle furnace (MF 1400 –30, India) at 700 °C for two hours. Afterward, the crucibles were pulled out from the furnace and transferred into the desiccator to cool down (AOAC 2020).

$$\text{Ash (\%)} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

2.3 pH

The pH of the burger patty sample was evaluated by grinding 15 g of it with 150 ml of deionized water for five minutes using a meat mincer (Brice TC12, Australia) at high speed (Rifath and Jemziya, 2021). The solution's pH was determined using a benchtop pH meter (Bp3001, Singapore).

2.4 Sensory analysis

The 30 untrained panelists were asked to score their preference and general acceptability based on a 9 - point hedonic scale with 9 like extremely and 1 dislike extremely. The attributes assessed were colour, flavor, texture, taste, odor, and overall acceptability.

2.5 Statistical Analysis

The Analysis of Variance (ANOVA) was performed on the cooked burger patties and proximate analysis data to identify any significant differences assuming that they were normally distributed. Mean values were compared using Tukey's range test at a 95% significance level. Friedman test was used to analyze the sensory profile data as they were not normally distributed. Bonferroni method was used to test multiple comparisons. All the analyses were done by using the SPSS statistical package (SPSS 20.0, IBM, New York, NY, USA).

3 Results and Discussion

3.1 Cooking properties

Cooking loss

The cooking loss occurs mainly due to the evaporation of moisture and the dripping of melted fat (Mansour and Khalil 1997). There was a significant difference ($p<0.05$) in cooking loss among different treatments. The mean cooking loss of burger patties ranged from 3.62% to 6.74% in the study, as shown in Table 2. According to Ramadhan *et al.* (2011), the cooking loss of selected commercial burger patties varied from 5.32 % to 11.0%. The highest cooking loss was observed in Treatment 5, which is a control (100% chicken meat burger patty). Higher moisture content and lower emulsion stability of chicken meat can account for this phenomenon (Zargar *et al.* 2014). The burger patties that were developed using a combination of elephant foot yam and lasia stem showed lower cooking loss when compared to burger patties made with 100% chicken meat. According to Saklani and Kaushik (2020), elephant foot yam bound a larger amount of water, which could have been attributed to higher water retention and lower shrinkage in burger patty developed with a combination of elephant foot yam and lasia stem flour. Therefore, the combination of elephant foot yam and lasia stem flour reduces the cooking loss of the burger patties. Further, the lowest cooking loss (3.62%) was observed in Treatment 3. Therefore, a composite burger patty with 25% elephant foot yam and 15% lasia stem flour would be the appropriate level to reduce the cooking loss.

Cooking yield

Cooking yield is an important factor in the production of burger patties, as it directly impacts the final product and consumer satisfaction, as well as the overall profitability of the production. A high cooking yield means that more of the original weight of the meat is retained after cooking. The cooking yield of burger patties developed with varying amounts of fat replacers ranged from 93.26 % to 96.38 % (Table 2).

Table 2: Cooking properties of burger patties developed with different combinations of elephant foot yam flour and lasia stem flour (*) compared to control (T5).

T*	Cooking loss (%)	Cooking yield (%)	Water Holding capacity (%)	Fat retention (%)	Moisture retention (%)	Shrinkage (%)
1	3.77±0.33[a]	96.23±0.33[c]	85.09±0.33[a]	97.23±0.25[ab]	32.22±0.28[a]	3.52±0.19[b]
2	5.62±0.12[b]	94.38±0.12[b]	76.88±0.39[b]	96.58±0.71[a]	34.76±0.21[b]	3.84±0.03[b]
3	3.62±0.07[a]	96.38±0.07[c]	78.79±0.23[c]	98.81±0.14[b]	36.47±0.28[c]	3.26±0.12[ab]
4	5.53±0.20[b]	94.47±0.20[b]	80.19±0.31[c]	96.35±0.14[a]	35.66±0.71[bc]	2.81±0.09[a]
5	6.74±0.02[c]	93.26±0.02[a]	76.07±0.34[b]	96.02±1.08[a]	45.42±0.03[d]	3.52±0.14[b]

The values are means of triplicates ± Standard error of the mean, different superscript letters in the same column indicate significant differences by the Tukey's HSD at $p<0.05$. (* Treatments as in Table 1)

There was a significant difference ($p<0.05$) observed among the treatments for the cooking yield, and it implies that the addition of different proportions of elephant foot yam and lasia stem flour affects the cooking yield of the final product. Compared to the 100 % chicken meat burger (control), it was found that the cooking yield of the other formulations was significantly increased. Further, the highest cooking yield obtained from Treatment 3 was 96.38%. Based on the cooking yield, it is inferred that the composite burger patty developed using 25% elephant foot yam and 15% lasia stem flour would be economical. The research conducted by Pearson and Gillett (1999) revealed that plant protein has a high water absorption capacity and can become adhesive, which results in the composite burger patty obtained in this study. Cooking yield can be expressed as water absorption or fat loss during burger cooking because the yield value is related to fat and water retention. According to Colmenero *et al.*

(2003), the ability of the protein matrix to hold water and bind fat determines the yield of meat products, whereas, carbohydrates and fiber have also been good at enhancing cooking yield, lowering formula costs, and improving texture.

Water-holding capacity

The water-holding capacity of a burger patty plays a crucial role in determining the juiciness and texture of the cooked patty. A patty with a high water-holding capacity yields a juicier and more tender texture and retains flavour and taste. The results showed that the water-holding capacity of burger patties varied significantly ($p<0.05$) among the different treatments, with a range of 76.07% to 85.09%. The highest water-holding capacity was obtained in Treatment 1 and the lowest was obtained in Treatment 5 (Table 2). Except for Treatment 2, the formulations containing lasia stem and elephant foot yam flour had higher water-holding capacities compared to the control. Mahmoud *et al.* (2017) study demonstrated that an increase in the percentage of replacers led to a corresponding increase in the water-holding capacity of burger patties. The presence of lasia stem and elephant foot yam flour, which are high in crude fiber may have contributed to the higher water-holding capacity observed in Treatment 1. Saklani and Kaushik (2020) reported that elephant foot yam flour contains approximately 5.3% crude fiber, further supporting the potential role of crude fiber in the observed increase in water-holding capacity.

Fat retention

Fat retention in meat is an outcome of several chemical and physical mechanisms (Anderson and Berry 2001). The interaction between starch, fiber, fat, and protein in meat affects the fat retention in the product. When starch and fiber swell and absorb some of the fat, they can interact with the protein in the ground meat matrix to prevent migration of fat from the product (Anderson and Berry 2001). The fat retention of developed burger patties ranged from 96.02 to 98.1%. There was a significant difference ($p<0.05$) among the treatments (Table 2). However, there is no significant difference in the lasia stem and elephant foot yam flour composite burger patty compared to the 100% chicken meat burger except for Treatment 3. Anderson and Berry (2001) observed higher cooking yields and higher fat retention values in high-fat patties with pea fiber.

Moisture retention

Moisture retention in meat products is a significant cooking parameter, since retained moisture in the product affects eating quality (Serdaroğlu *et al.* 2017). It is represented by the amount of moisture retained in the 100g cooked product. Significant variation

($p<0.05$) was observed in the moisture retention levels among the composite burger patties (Table 2). Compared to the 100% chicken meat burger patty, composite burger patties developed with lasia stem and elephant foot yam were shown to have lower moisture retention. Based on the observed results, it could be argued that an increase in the amount of lasia stem and elephant foot yam in the treatments led to a decrease in the level of moisture retention. Tsai *et al.* (1999) found that the capacity to absorb water was shown by restructured beef products was greatly improved when hydrolyzed oligofructose was added.

Shrinkage

Shrinkage refers to the reduction in size of a burger patty as it cooks. According to the current study, shrinkage ranged from 2.81% to 3.84% and there was a significant difference ($p<0.05$) among the treatments (Table 2). Treatment 4 exhibited the lowest level of shrinkage. Swelling of starch and fiber, as well as some fat absorption by fiber may interact with the protein of the meat matrix, preventing fat migration and increasing the textural characteristics of burger patties. The improvement in fat retention because of the presence of elephant foot yam and lasia stem was dramatic, increasing from flour level. Anderson and Berry (2001) reported that meat fat retention is a complicated phenomenon that is caused by a number of chemical and physical processes.

3.2 Proximate composition of burger patties

Moisture content

According to the results, the moisture content of developed burger patties ranged from 33.15 % to 48.82 % (Table 3), and there was a significant difference ($p<0.05$) among the treatments. Treatment 1 had the lowest moisture content (33.15%), while the highest moisture content (48.82%) was that of Treatment 5. Compared to the 100 % chicken meat burger patty, there was a significant difference observed for other burger patties developed with elephant foot yam and lasia stem replacers. Therefore, it implies that the addition of elephant foot yam and lasia stem replacers significantly reduced the moisture content of the burger patties. According to the study of Gök *et al.* (2011), a similar finding was observed in a meat burger patty prepared with poppy seed fat replacer. However, moisture content affects the juiciness and texture of the cooked patty.

Fiber content

The fiber content of the developed burger patty ranged from 1.65% to 38.75% (Table 3). A significant difference ($p<0.05$) was observed for fiber content among the treatments. The highest fiber content was obtained from Treatment 2 (38.75%), which was formulated with 25% of elephant foot yam and 25% lasia stem flour. The addition of flour as meat replacer resulted in a higher fiber content in the burger patties. Saklani and Kaushik (2020) reported that the crude fiber level of elephant foot yam flour was 5.3% and lasia stem was a more significant source of dietary fiber, containing 40% to 75% of the total dietary fiber on a dry weight basis. The results of this study revealed that the control sample of 100% chicken meat scored the lowest fiber content of burger patties compared to other samples. Wan-Rosli *et al.* (2014) also found 1.90% total dietary fiber in 100% chicken meat burger patty. Fiber offers several advantages in addition to enhancing the physicochemical qualities of most meat products, such as improving textural properties (Eastwood 1992). Therefore, with the addition of elephant foot yam and lasia stem flour, the total dietary fiber in the burger patty increases significantly.

Table 3: Proximate composition analysis results of burger patties.

Treatment	Moisture (%)	Fiber (%)	Ash (%)	Protein (%)	Fat (%)
1	33.15 ± 0.57[a]	35.08± 0.33[c]	3.66± 0.03[c]	22.71± 0.35[a]	11.60±0.07[a]
2	36.65± 0.31[b]	38.75± 0.363[e]	2.67± 0.08[b]	22.37± 0.25[a]	14.34±0.11[b]
3	38.07± 0.42[b]	36.96± 0.33[d]	2.66± 0.11[b]	24.11± 0.29[b]	16.36±0.10[c]
4	37.08 ± 0.69[b]	32.55± 0.36[b]	2.56± 0.11[b]	24.08 ± 0.20[b]	20.34±0.06[d]
5	48.82± 0.31[c]	1.65± 0.16[a]	1.73± 0.18[a]	29.08± 0.33[c]	21.08±0.01[e]

The values are means of triplicates ± Standard error of mean, different superscript letters in the same column indicate significant differences by the Tukey's HSD at p=0.05.

Ash content

According to the findings of this study, burger patties' ash content varied between 1.73% and 3.66% (Table 3). The study showed that the burger patty with a combination of 15% elephant foot yam flour and 25% lasia stem flour had the lowest ash content. The low ash content in the burger patties can be attributed to the lower proportion of elephant foot yam flour in the burger composite. Ash content increased with the increasing amount of lasia stem and elephant foot yam flours. Treatment 1, which consisted of 30% lasia stem and 30% Elephant foot yam, had a higher ash content in the resulting burger patties, with a value of 3.66%. According to Saklani and Kaushik (2020), elephant foot yam flour has a total ash content of approximately 7.6%. Similarly, Kumar *et al.* (2013) reported that lasia stem has an ash content of 16.34%. The study showed that the burger patty made with 100% chicken meat had the lowest amount of ash content compared to the other burger patties tested. Ramadhan *et al.* (2011) also reported a similarly low value of ash content (1.92 %) in chicken meat burger patties. The higher the ash content of the sample, the higher the mineral content. Therefore, the replacement of lasia stem and elephant foot yam flours improves the mineral content of the burger patty significantly compared with a 100 % chicken meat burger patty.

Protein content

The protein content of the burger patties varied significantly ($p<0.05$) among the treatments, ranging from 22.37% to 29.08% (Table 3). Treatment 5 had the highest protein content, while Treatment 2 had the lowest. Treatment 3, which consisted of 25% elephant foot yam flour, 15% lasia stem flour, and 60% chicken meat, had a higher protein content than the other treatments except for the control (Treatment 5). Therefore, the study suggests that replacing a portion of the chicken meat with elephant foot yam and lasia stem flour can enhance the protein content of the burger patty. However, the replacement of chicken meat with elephant foot yam and lasia stem flour resulted in a lower protein content, as these flours have lower protein levels compared to chicken meat. According to Saklani and Kaushik (2020), elephant foot yam flour contains 4.5% crude protein, while lasia stem flour has 0.41% crude protein (Shefana and Ekanayaka 2009). In contrast, Heikal *et al.* (2019) reported that burger patties made from chicken breast meat had a superior crude protein content.

Fat content

The fat content of each treatment was significantly different ($p<0.05$) compared to 100 % chicken meat burger patty. The fat content of the developed burger patty varied from 11.60 % to 21.08 % (Table 3). Among the replaced burger patties, Treatment 1 had the lowest fat content (11.60 %) while, Treatment 4 had the highest fat content of 20.34 %. Replacement of elephant foot yam and lasia stem flour in the burger patties yielded lower fat content compared to the control. According to the above results, the lower fat content of the burger patties could be attributed to the lasia stem and elephant foot yam flour replacers. Low-fat burger patties typically have a fat level of 10 % or less (Dreeling *et al.* 2000). However, the sensory quality of burger patties is mostly influenced by fat, notably its taste (Suman and Sharma 2003).

3.3 pH content

The pH values of the burger patties ranged from 5.53% to 5.75%, and a significant difference ($p<0.05$) was observed among the treatments. Treatment 4, which incorporated elephant foot yam and lasia stem flour, had a significantly lower pH value compared to the 100% chicken meat burger patty. Treatment 5 had the highest pH value of 5.75, while Treatment 4 had the lowest pH value of 5.53 (Figure 2). It is worth noting that some authors reported an increment in the pH value of meat burgers formulated with different fiber types (Gok *et al.* 2011). However, similar pH results were obtained by Serdaroğlu *et al.* (2018) when formulating chicken burger patties with dried pumpkin pulp and seeds, with pH values ranging from 5.67% to 5.89%.

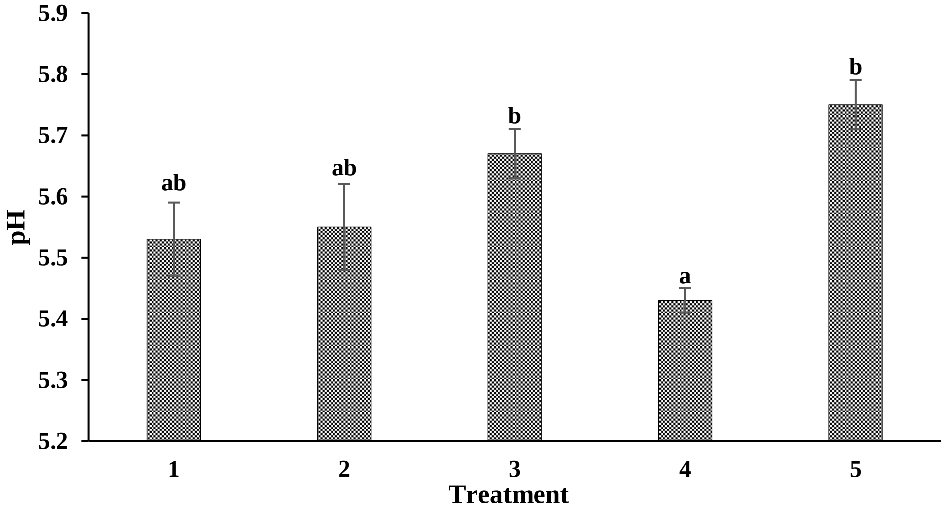

Fig 2. pH values of different burger patty formulations. The means of triplicates ± standard error of mean attached with the same a-b alphabet in a similar pattern is not significantly different by the Tukey's at p= 0.05.

3.4 Sensory properties of burger patties

The results of the sensory evaluation (Table 4) show significant differences ($p<0.05$) among the treatments for both colour and taste attributes of the burger patty. The colour of Treatment 3 was less preferred compared to the 100% chicken meat burger patty, and the taste of Treatments 2 and 3 also received lower preference scores than the 100% chicken meat burger patty.

Table 4: Sensory profile analysis of burger patties

T	Colour	Flavor	Texture	Taste	Odor	Overall acceptability
1	8.25 ± 0.29^a	7.95 ± 0.29^a	8.15 ± 0.22^a	8.45 ± 0.20^a	7.90 ± 0.27^a	8.30 ± 0.14^a
2	8.00 ± 0.30^a	7.85 ± 0.32^a	7.75 ± 0.29^a	7.60 ± 0.27^b	7.75 ± 0.21^a	7.75 ± 0.26^a
3	6.95 ± 0.24^b	7.15 ± 0.22^a	7.30 ± 0.32^a	7.30 ± 0.32^b	7.45 ± 0.27^a	7.55 ± 0.19^a
4	8.25 ± 0.17^a	8.05 ± 0.21^a	7.75 ± 0.28^a	8.30 ± 0.28^a	7.50 ± 0.22^a	8.15 ± 0.18^a
5	8.05 ± 0.18^a	8.00 ± 0.15^a	7.90 ± 0.22^a	8.20 ± 0.18^a	7.60 ± 0.23^a	8.00 ± 0.13^a

The values are means of 30 replicates ± standard error of mean, different superscript letters in the same column indicate significant differences by the Bonferroni method at p=0.05.

However, the replacement of elephant foot yam and lasia stem flour did not significantly affect other sensory attributes. It should be noted that product acceptability is not solely determined by sensory attributes but also by other factors such as consumer physiology, behavior, and cognition (Nasser and Olabi 2009). In conclusion, the replacement of chicken meat with elephant foot yam and lasia stem flour may affect the sensory attributes, particularly the colour and flavor, of the final product.

5 Conclusions

In summary, this study aimed to explore the potential of elephant foot yam flour and lasia stem starch as plant-based fat replacers in chicken burger patties. The results showed that these meat replacers significantly affected the physicochemical, sensory, and cooking properties of the burger patties compared to the 100% chicken meat burger patty. Treatment 3, which contained 25% elephant foot yam flour and 15% lasia stem starch, was found to have the most favourable overall properties among the replacer-containing patties. However, the sensory attributes of the replacer-containing patties did not differ significantly from the 100% chicken meat patty, except for colour and taste. These findings highlight the potential for using elephant foot yam flour and lasia stem starch as fat replacers in comminuted meat products. Further research is needed to optimize the formulation and processing of these replacers to enhance their sensory attributes and overall acceptability. Overall, this study provides valuable insights for practitioners and researchers in the field of meat product development.

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References

Anderson ET, Berry BW. 2001. Effects of inner pea fiber on fat retention and cooking yield in high fat ground beef. *Food Research International*: 34(8): 689-694. https://doi.org/10.1016/S0963-9969(01)00089-8

AOAC, 2000. Meat and Meat products. *In*: Official Methods of Analysis. Association of Official Analytical Chemists Inc. Gaithersburg, USA.

Behera SS, Ray RC. 2017. Nutritional and potential health benefits of konjac glucomannan, a promising polysaccharide of elephant foot yam, *Amorphophallus konjac* K. Koch: A review. *Food Reviews International* 33(1): 22-43. https://doi.org/10.1080/87559129.2015.1137310

Bradberry JC, Hilleman DE. 2013. Overview of omega-3 fatty acid therapies. *Pharmacy and Therapeutics* 38(11): 681-691

Colmenero FJ, Serrano A, Ayo J, Solas MT, Cofrades S, Carballo J. 2003. Physicochemical and sensory characteristics of restructured beef steak with added walnuts. *Meat Science* 65(4): 1391-1397. https://doi.org/10.1016/S0309-1740(03)00061-5

Dreeling N, Allen P, Butler F. 2000. Effect of cooking method on sensory and instrumental texture attributes of low-fat beef burgers. *LWT- Food Science and Technology* 33(3): 234-238. https://doi.org/10.1006/fstl.2000.0649

Eastwood MA. 1992. The physiological effect of dietary fiber: an update. *Annual Review of Nutrition* 12(1): 19-35. doi.org/10.1146/annurev.nu.12.070192.000315

Fernández-Ginés JM, Fernández-López J, Sayas-Barberá E, Pérez-Alvarez JA. 2005. Meat products as functional foods: A review. *Journal of Food Science* 70(2): R37-R43.

Gök V, Akkaya L, Obuz E, Bulut S. 2011. Effect of ground poppy seed as a fat replacer on meat burgers. *Meat Science* 89(4): 400-404. https://doi.org/10.1016/j.meatsci.2011.04.032

Heikal Z, Youssef MKE, Khalifa AH, Limam SA, Mostafa BMD. 2019. Improving the Quality Properties of Chicken Burger. *Journal of Food and Dairy Sciences* 10(6): 195-200. https://doi.org/10.21608/JFDS.2019.48285

Kilcast D, Angus F. 2007. Reducing salt in foods: practical strategies. Elsevier.

Kim HW, Kim JH, Seo JK, Setyabrata D, Kim YHB. 2018. Effects of aging/freezing sequence and freezing rate on meat quality and oxidative stability of pork loins. *Meat Science* 139: 162-170. https://doi.org/10.1016/j.meatsci.2018.01.024

Kristensen L, Purslow PP. 2001. The effect of ageing on the water-holding capacity of pork: role of cytoskeletal proteins. *Meat Science* 58(1): 17-23. doi.org/10.1016/S0309-1740(00)00125-X

Kumar M, Mondal P, Borah S, Mahato K. 2013. Physico-chemical evaluation, preliminary phytochemical investigation, fluorescence and TLC analysis of leaves of the plant Lasia spinosa (Lour) Thwaites. *International Journal of Pharmacy and Pharmaceutical Sciences* 5(2): 306-310.

Mahmoud MH, Abou-Arab AA, Abu-Salem FM. 2017. Quality Characteristics of Beef Burger as Influenced by Different Levels of Orange Peel Powder. *American Journal of Food Technology* 12 (4): 262-270.

Mansour EH, Khalil AH. 1997. Characteristics of low-fat beefburger as influenced by various types of wheat fibers. *Food Research International* 30(3-4): 199-205. https://doi.org/10.1016/S0963-9969(97)00043-4

McClements DJ. 2015. Reduced-fat foods: the complex science of developing diet-based strategies for tackling overweight and obesity. *Advances in nutrition (Bethesda, Md.),* 6(3), 338S–52S. https://doi.org/10.3945/an.114.006999

Nanasombat S, Teckchuen N. 2009. Antimicrobial, antioxidant and anticancer activities of Thai local vegetables. *Journal of Medicinal Plants Research* 3(5): 443-449. doi.org/10.5897/JMPR.9000183

Nasser el dine A. Olabi A. 2009. Effect of Reference Foods in Repeated Acceptability Tests: Testing Familiar and Novel Foods Using 2 Acceptability Scales. *Journal of Food Science* 74(2): S97-S106. https://doi.org/10.1111/j.1750-3841.2008. 01034.x

Naveena BM, Muthukumar M, Sen AR, Babji Y, Murthy TRK. 2006. Quality characteristics and storage stability of chicken patties formulated with finger millet flour (Eleusine coracana). *Journal of Muscle Foods* 17(1): 92-104. https://doi.org/10.1111/j.1745-4573.2006. 00039.x

Neelam NT. 2022. Perception of Rural Community about Fast Food Patterns (A Qualitative Study of District, Muzaffargarh). *Meritorious Journal of Social Sciences and Management* 5(2): 60-69.

Pearson AM. Gillett TA. 1999. *Effects of fat on flavor in processed meats*. 3rd edn, pp: 356–358. Aspen Publisher, Inc. Gaithersburg, Maryland.

Ramadhan K, Huda N, Ahmad R. 2011. Physicochemical characteristics and sensory properties of selected Malaysian commercial chicken burgers. *International Food Research Journal* 18(4): 1340-1357.

Ranil RHG, Pushpakumara DKNG, Bandaranayake PCG, Ariyaratne WMTP, Wijesundara D SA, Eeswara RCJ. 2019. *Lasia spinosa* (L.) Thw., A High Potential Underutilized Aroid in Asia: A Step Towards Utilizing Neglected Crop Genetic Resources for Food and Nutritional Security. In: *Landscaping Agroecosystems: A Way Forward for Natural Resource Utilization*, Chapter 8, pp. 125-148, The Institute of Biology, Sri Lanka.

Rifath A, Jemziya F. 2021. The quality determination of broiler chicken thawed using different techniques. *Journal of Bangladesh Agricultural University* 19(1): 78-84. Https://doi.org/10.5455/JBAU.23371

Saklani A, Kaushik R. 2020. Development of elephant foot yam cake and its evaluation. The Annals of the University Dunarea de Jos of Galati. *Fascicle VI-Food Technology* 44(2): 159-172.

Serdaroğlu M, Değırmencioğlu Ö. 2004. Effects of fat level (5%, 10%, 20%) and corn flour (0%, 2%, 4%) on some properties of Turkish type meatballs (koefte). *Meat Science* 68(2): 291-296. https://doi.org/10.1016/j.meatsci.2004.03.010

Serdaroğlu M, Kavuşan HS, İpek GAMZE, Öztürk BURCU. 2018. Evaluation of the quality of beef patties formulated with dried pumpkin pulp and seed. *Korean Journal for Food Science of Animal Resources* 38(1): 1-11. https://doi.org/10.5851/kosfa.2018.38.1.001

Serdaroğlu M, Nacak B, Karabıyıkoğlu M. 2017. Effects of beef fat replacement with gelled emulsion prepared with olive oil on quality parameters of chicken patties. *Korean Journal for Food Science of Animal Resources* 37(3): 376.

Shefana AG, Ekanayake S. 2010. Some nutritional aspects of Lasia spinosa (kohila). Vidyodaya Journal of Science 14(1): 59-64.

Singh A, Wadhwa N. 2014. A review on multiple potential of aroid: Amorphophallus paeoniifolius. *International Journal of Pharmaceutical Sciences Review and Research* 24(1): 55-60.

Singh A, Chaurasiya A, Mitra S. 2016. Assessment of nutritional composition in elephant foot yam (*Amorphophallus paeoniifolius* Dennst-Nicolson) cultivars. *International Journal of Food Studies*: 5(2): 146-157.

Suman SP, Sharma BD. 2003. Effect of grind size and fat levels on the physico-chemical and sensory characteristics of low-fat ground buffalo meat patties. *Meat Science* 65(3): 973-976. https://doi.org/10.1016/S0309-1740(02)00313-3

Talukder S. 2015. Effect of dietary fiber on properties and acceptance of meat products: a review. *Critical Reviews in Food Science and Nutrition* 55(7): 1005-1011. https://doi.org/10.1080/10408398.2012.682230

Tsai CJ, Kumar S, Ma B, Nussinov R. 1999. Folding funnels, binding funnels, and protein function. *Protein Science* 8(6): 1181-1190.

Wan-Rosli WI, Solihah MA, Aishah M, Nik Fakurudin NA, Mohsin SSJ. 2011. Colour, textural properties, cooking characteristics and fiber content of chicken patty added with oyster mushroom (*Pleurotus sajor-caju*). *International Food Research Journal* 18(2): 612-618.

Yao-ling L, Rong-hua D, Ni C, Juan P, Jie P. 2013 Review of konjac glucomannan: isolation, structure, chain conformation and bioactivities. *Journal of Single Molecule Research* 1: 7–14.

Zargar FA, Kumar S, Bhat ZF, Kumar P. 2014. Effect of pumpkin on the quality characteristics and storage quality of aerobically packaged chicken sausages. *Springer Plus* 3(39): 1-10.