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The effect of bamboo shoot (*Gigantochloa albociliata*) addition on the physical properties and sensorial acceptability of beef patty

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Abstract

Presently, processed meat products are among the essential food item popularly consumed by the population of the developed and developing countries due to its convenience and quickly prepared. In recent years, various studies suggested that the increased intake of processed meat results in an increased risk of CVD, type 2 diabetes and colorectal cancer. The use of different levels of the bamboo shoot to improve dietary fibre in the beef burger and its effects on the nutrient composition, cooking characteristics and sensory acceptability of the beef patties were studied. The beef patties were formulated with either 0, 25 or 50% of ground bamboo shoot to partially replace ground beef. Fat content decreased in line with the bamboo shoot levels in both raw and cooked beef patties. Both raw and cooked patties incorporated with 50% bamboo shoot however showed the lowest fat concentration ($P<0.05$) at 21.32 and 19.36%, respectively. Both raw and cooked patties containing 50% bamboo shoot recorded the highest concentration ($P<0.05$) of crude fibre at 1.71 and 1.92%, respectively. All cooked patty samples recorded the moisture content ranging from 46.63-54.87%. Beef patty formulated with 50% bamboo shoot recorded the highest cooking yield at 87.57% ($P<0.05$) compared to other treatments. The addition of bamboo shoot did not influence the sensory acceptability of the bamboo shoot-based beef patties. In summary, the addition of bamboo shoot at 25% to partially replace the ground beef can be recommended to lower the production cost and fat content and not affecting sensory descriptors of the beef patty to which the consumer is familiarized.

1. Introduction

The meat and meat products are a major source of protein with high biological value and the main source of some essential fats, minerals and soluble vitamins and these components have a specific function to our body. Functional meat products possess nutritional ingredients that improve health or contain a lesser quantity of harmful compounds like fat and cholesterol. These products are generally produced by the reformulation of meat by incorporating health producing ingredients like a variety of fibres, protein, polyunsaturated fatty acids (PUFA) and antioxidants. Meat and meat products are essential in the diet of developed countries and the use of dietary fibre for meat replacement in beef burger formulation was investigated to reduce production cost (Biswall *et al*., 2010). However, a negative campaign about muscle foods and their possible adverse health effects have triggered consumers to put interest in health-oriented functional meat products.

In recent years, published prospective cohort studies from Europe and United States suggest that the increased intake of red meat and processed meat results in an increased the risk of CVD, type 2 diabetes and colorectal cancer (Battaglia *et al*., 2015). In contrast, low meat diet and high white meat intake were associated with a small decrease in cancer mortality. These findings complement the recommendations by the World Cancer Research Fund and American Institute for Cancer Research to reduce red and processed meat intake to decrease cancer incidence (Sinha *et al*., 2009). Indeed, parallel to this, sufficient intake of fruits and vegetables in human's daily diet was also important in sustaining their overall health status. The dietary fibre intake through meat substituted with fruits, vegetables and certain grains is associated with reductions in plasma and LDL-cholesterol, reduce the risk of major dietary problems such as obesity and coronary diseases (Biswas *et al*., 2010). The health benefits effects dietary fibre supplementations increase bulk and prevent cooking loss in meat products by enhancing water-binding

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capabilities. Daily recommended amount of dietary fibres which need to be consumed by an individual is around 20-30 g a day depending on their ages and gender. It means approximately 400-500 g of vegetables and fruits need to be consumed daily which is equivalent to at least 5 serving size a day.

The bamboo shoot is high in dietary fibre, low in fat and rich in minerals content. The value of bamboo shoot as food is based not only on its total fresh weight but also on the edible portion, which the amounts are about 27%. Most of the species growing in Thailand produce edible shoots, the best one is *Dendrocalamus asper, Dendrocalamus giganteus, Dendrocalamus merrillianus, Bambusa tulda, Pseudoxytenanthera albociliata* and *Thyrsostachys siamensis*. In Japan, more than 8000 tonnes of shoots are consumed every year and the main source is *Phyllostachys pubescens* (Satya *et al*., 2010). Bamboo shoot (*Gigantochloa albociliata*) is a group of genera of evergreen plants belonging to the family Poaceae and sub-family Bambuseae. They are harvested after attaining 20–30 cm height. Dietary fibres provide many health benefits as they control, hypertension, blood pressure, obesity and protect the body from coronary heart diseases. The consumption of fibre-rich diets helps in reducing bad cholesterols (low-density lipoprotein-LDL) in the blood and lowering insulin demand. The intake of the bamboo shoots regularly also improves lipid profile and bowel movement. Besides, the fibre content in bamboo shoot was not decreased after boiled (Nongdam and Tikendra, 2014). The presence of high fibre in bamboo shoots and its benefit on health making them popular as health foods among health-conscious individual.

The bamboo shoot has a long history of being used as a source of medicine and food in China and Southeast Asia (Chongtham *et al*., 2011). While in Japan, they called it 'King of Forest Vegetables.' The new culms in bamboos usually develop with the beginning of monsoon season during which the young edible shoots are harvested and the typical 'shooting season' rarely exceeds two months. Bamboo shoots are available in 3 forms which is fresh, fermented, and canned. Young shoots have a crisp, sweet flavour and crunchy taste. They are mostly used in making delicious snacks, appetizing soups, spicy stir-fries, hot curries, pickles, attractive salads, spring rolls, aromatic fried rice and other fried and stewed dishes. More than 2 million tons of bamboo shoots are consumed annually worldwide and about 1.3 million tons of bamboo shoots are produced in China. The consumption of bamboo shoots is mainly in Southeast Asia and its popularity is at Chinese restaurants (Chongtham *et al*., 2011).

The high content of proteins, amino acids, carbohydrates, minerals and vitamins makes bamboo shoot to have a great potential of being used as important health food. Fresh bamboo shoots have a good amount of thiamine, niacin, vitamin A, vitamin E and vitamin B6. Bamboo shoot-based diets are a rich source of dietary fibres and phytosterols and fewer cholesterol contents also make them popular as natural health foods (Nongdam and Tikendra, 2014). Fresh bamboo shoots are good a source of protein with content ranging from 1.49 g/100 g to 4.04 g/100 g for fresh weight. Protein content in shoots of Bambusa bamboos is decreased gradually when shoots were subjected to heat treatment in an increase of salt concentration (Xu et al. 2005). The level of carbohydrates presents in bamboo shoots are reported to be high and it's content in edible shoots of *Bambusa nutans, Bambusa vulgaris, Dendrocalamus strictus*, and *Dendrocalamus asper* was found at 3.3%, 3.4%, 0.6%, and 2.9%, respectively (Satya *et al*., 2012).

Bamboo shoot have very less amount of fat and its low content in fat makes them healthy food (Das, 2019). The fat content is very low (0.1 g/100 g fresh weight) in the young shoot of *Dendrocalamus strictus*. The maximum fat level was found at 1.00 g/100 g fresh weight in shoots of *Bambusa nutans*. After processing, the fat level in boiled and steamed shoots of Phyllostachys praecox was reduced as compared to stirred fried bamboo shoot which had gain fat content from 0.21 g/100 g fresh weight in the raw shoot to 1.32 g/100 g fresh weight in stirred food. There was also the presence of linoleic, palmitic, and linolenic acid in bamboo shoots (Singhal *et al*., 2013). The present study aimed to investigate the effect on the addition of different levels of the bamboo shoot (*Gigantochloa albociliata*) on the physical properties and sensorial acceptability of the beef patty.

2. Materials and methods

2.1. Sample preparation of bamboo shoot

Fresh bamboo shoot (*Gigantochloa albociliata*) was used in this study. A total of 3 kg of the bamboo shoot was purchased from Siti Khadijah wet market located in Kota Bharu, Kelantan state of Malaysia. Before the cooking process, the bamboo shoot was washed and stored at 4±0.5°C to slow down the respiration, chemical and physiological changes (Kleinhenz *et al*., 2000). The outer sheaths were removed and washed thoroughly to remove any adhering extraneous matter. The bamboo shoot was boiled three times by changing the water after 20 minutes and immediately cooled. The bamboo shoot was tossed and ground through a 8 mm diameter grinder plate (Model HR2710/10, Philips brand). The prepared bamboo shoot was then manually press using a muslin

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cloth for 1 min to remove excess water before incorporated partially to replace beef in patty formulations. The bamboo shoot was prepared in the Nutrition Laboratory of the School of Health Sciences, Universiti Sains Malaysia Health Campus, Kota Bharu, Kelantan, Malaysia.

2.2 Beef patty formulation

The patties were prepared according to the formulations described by Wan Rosli and Solihah (2015) with slight modification. The patties were prepared with either a combination of 100% beef + 0% bamboo shoot (control), 50% beef + 50% bamboo shoot or 75% beef + 25% bamboo shoot. Meanwhile, the percentages of other ingredients in all treatments are unchanged. The ground bamboo shoot was incorporated into the beef patties by using the formulations as described in Table 1. The finished patties were directly stored in a freezer at -18°C while waiting for further analysis. The beef cut of hindquarter beef was purchased from the wet market around Kota Bharu, Kelantan Malaysia. Other dry ingredients (Table 1) such as vegetable fat, potato starch, bread crumb, isolated soy protein, salts, spices and seasoning were purchased from local suppliers.

Table 1. Beef patty formulated with different levels of bamboo shoot

Ingredient (g)	Bamboo shoot Level (%)		
	0 (control)	25	50
Beef	65	48.75	32.5
Bamboo shoot	0	16.25	32.5
Vegetable fat	9	9	9
Isolate soy protein	3	3	3
Potato starch	6	6	6
Spices and seasoning	2	2	2
Salt	1	1	1
Bread Crumb	7	7	7
Freshly chopped vegetable (red, green and yellow capsicum)	7	7	7
Total	100	100	100

2.3 Beef patty processing

The beef (hindquarter) was manually diced (approximately 4cm each side) using a utility knife and minced by using electrical meat mincer through an 8 mm -diameter grinder plate (Model HR2710/10, Philips brand). The minced beef flesh was stored in a freezer at –18°C while waiting for processing. Isolated soy protein was blended with vegetable fat by using a mixer (Model HM200, Khind brand) for 2 mins until homogenous. The emulsion prepared (called pre-emulsion) was kept in a chiller at 5°C while waiting for mixing with the minced beef-based mixture. Salt was added to the minced beef and mixing process was carried out by using a Khind mixer for 3 mins. Chopped vegetables were mixed with spices, potato starch, bread crumb and bamboo shoot and mixed for another 2 mins. The pre-emulsion was then added, and the mixing process continued for another 2 mins. The finished beef batters were then weighed into 70g portions. Then it is manually stamped to produce a uniform beef patty with the diameter and thickness of 100 and 10 mm, respectively. The raw beef patties were then frozen in a freezer at –18°C until further analyses. All the procedures above were repeated for all formulation of beef patties (0%, 25% and 50%).

2.4 Cooking procedure

The raw patties were thawed at 4°C in the chiller for 12 hrs. The patties were then cooked on a pan-fried electric skillet (Model KX-11K1, Sharp Corporation, Japan) for 7-8 mins until an internal temperature of 72±1°C was achieved.

2.5 Analysis of nutritional composition

Both raw and cooked samples were analysed for mineral analysis and also proximate analysis for determination of moisture, ash, crude fat, crude protein, crude fibre and caloric value (AOAC 2020). All measurements were carried out in triplicate (n=3).

Total carbohydrate (CHO) content was calculated by the difference. The calculation was as follow:

Total carbohydrate (%) = 100 - (moisture + ash + crude protein + crude fat) %

2.6 Cooking characteristics analyses

2.6.1 Cooking yield analysis

Cooking yield analysis of beef patties were determined by measuring the weight of three patties for each treatment/batch including control patty and calculating weight differences for patties before and after cooking, according to El-Magoli *et al*. (1996):

$$\text{Cooking yield (\%)} = \frac{\text{Cooked weight} \times 100}{\text{raw weight}}$$

2.6.2 Moisture and fat retention

The moisture and fat retention values represent the amount of moisture and fat retained in the cooked product per 100 g of raw sample. These values were calculated using the following equations (El-Magoli *et al*., 1996):

$$\text{Moisture retention (\%)} = \frac{\text{Percent yield} \times \text{\% moisture in cooked patties}}{100}$$

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

2.6.3 Diameter reduction

Diameter reduction of beef patty is measured to know the shrinkage of the cooked patties. The measurements for diameter reduction were determined according to the equation below (Wan Rosli *et al*., 2011):

$$\text{Diameter reduction (\%)} = \frac{(\text{raw patties diameter} - \text{cooked patties diameter}) \times 100}{\text{raw patties diameter}}$$

2.7 Sensory evaluation

All beef patties samples were evaluated by untrained consumers according to the hedonic scaling method outlined by Piggott (1989). Sensory evaluations were carried out by 60 untrained consumers consisting of staff and students of the School of Health Sciences, Universiti Sains Malaysia Health Campus. The cooked beef patty samples were equally divided into 6 portions. Each portion of samples was placed in a paper plate with stickers coded with four-digit random numbers and warm to the panelist. The permutation sample presentation applied to the patties before presented to the consumer. The evaluations of samples were on colour, aroma, flavour, juiciness, texture and overall acceptance on a 7 point scale (1=dislike extremely and 7=like extremely). Water and unsalted cream crackers were served to clean the mouth between the samples.

2.8 Data analyses

All the data obtained were tested for significance using ANOVA and Duncan Multiple Range Test using SPSS software version 24.0 (SPSS Inc. Illinois, USA). All the measurements were carried out in triplicates (n = 3), except for sensory evaluation. The significant level is p≤ 0.05.

3. Results and discussion

3.1 Nutritional composition of raw beef patties

The determination of moisture content is important in a food product, especially for a food manufacturer, because water is an inexpensive filler. The dry matter that remained after moisture removal is referred to as total solid and it is important to use in the proximate analysis. The proximate composition of raw beef patties formulated with and without bamboo shoot is shown in Table 2. The moisture content of all raw patties was ranged from 50.29% to 59.94%. Among all treatments analysed, beef patty formulated with 50% bamboo shoot showed significantly higher (P<0.05) in moisture content than patties formulated with 25% of bamboo shoot and control. They had 59.94% of moisture while control patty without bamboo shoot had the lowest moisture content (50.29%). The increase of moisture content in the finished products is proportional to the level of bamboo shoot incorporated in the patty formulations. This linear relationship may be due to the high percentage of water presented in the bamboo shoot. Roseli *et al*. (2013) also reported that fresh bamboo shoot (*G. albociliata*) contained 92.8 g/100 g of moisture content. The patty is difficult to be shaped during the forming process if the levels of moisture content are more than 62%. In this study, the content of raw ground bamboo shoot was approximately 55% (some of the water already removed after being pressed with muslin cloth before mixing with beef). In the present study, the patty formulated with 25% of the bamboo shoot was easily formed compared to the patty containing 50% of bamboo shoot. The formation of emulsified patty is highly depended on the presence of protein content in the patty formulation. Due to the slightly reduction of protein content in beef (because of the bamboo shoot which is low in protein content used to partially replace beef in patty formulation), emulsification agent is required. Thus, the addition of isolated soy protein (ISP) was done to emulsifies water (from ground bamboo and beef) and fat (from beef and vegetable fat) in patty formulation. Emulsion capacity or the ability of a protein from ISP to emulsify water and fat is the most vital functional parameter in many foods especially processed meat-based products. The ISP can emulsify from 10 to about 35mL of oil/fat per 100mg of protein (Singh *et al*., 2008).

Table 2. Proximate analysis of raw beef patty prepared with different levels of bamboo shoot

Proximate analysis (%)	Bamboo shoot Level (%)		
	0 (Control)	25	50
Moisture	50.29±0.73^{c}	55.99±0.41^{b}	59.94±0.47^{a}
Crude fat	13.06±0.04^{a}	12.45±0.09^{b}	11.32±0.32^{c}
Crude protein	20.60±0.25^{a}	16.98±0.39^{b}	14.63±0.26^{c}
Crude fibre	0.58±0.03^{c}	1.15±0.02^{b}	1.71±0.02^{a}
Ash	4.40±0.73^{a}	3.92±0.29^{b}	3.61±0.17^{c}
Total carbohydrate	11.07±0.38^{a}	9.51±0.62^{b}	8.79±0.24^{b}

Mean values within the same row bearing different superscripts differ significantly (P<0.05)

Fat is just as important nutrient in a patty as the beef used to make it. While the beef contains its distinctive flavour, it's the fat (and marbling) that surrounds it that gives it richer flavour and juiciness. However, an excessive amount of fat content in patty confers higher calorific value. The concentration of fat was also inversely proportional to the levels of bamboo shoot incorporated in the raw beef patty. All raw beef patty incorporated with bamboo shoot recorded fat content ranging from 11.32% to 13.06% which comply with the Malaysian Food Act 281 and Regulations 1983 (Ministry of Health, 2005). According to this Act, the fat content of processed meat products should not more than 30%. Beef patty incorporated with 50% of the bamboo shoot was significantly (P<0.05) recorded the lowest concentration in fat (11.32%). The fat content of raw beef patty incorporated with 25% beef patty with the bamboo shoot (12.45%) were also significantly lower (P<0.05) than control beef patty (13.06%). The lowest fat percentage that found in beef patty formulated with 25% and 50% of the bamboo shoot may because of fresh bamboo shoot containing very low-fat content. Roseli *et al*. (2013) reported that the fresh bamboo shoot (*G. albociliata*) contained 0.1 g/100 g of fat.

Protein analysis is important in the determination of nutrition labelling, pricing, functional property investigation and biological activity determination. Protein in food has various type of functional properties such as casein in milk for coagulation of cheese or egg albumin for foaming property. Besides, there is certain protein enzyme such as a proteolytic enzyme that can be used as a meat tenderizer. The protein concentration in this study was decreased proportionally with the levels of bamboo shoot used in raw beef patty formulation. The percentage of protein in all raw beef patties were ranged from 14.63% to 20.60%. Beef patty formulated without bamboo shoot (control) significantly (P<0.05) recorded the highest protein concentration (20.60%) compared to 25% beef patty with the bamboo shoot (16.98%). Patty added with 50% bamboo shoot showed significantly lower in protein content as compared to 25% formulation. Low protein content in patties formulated with 25% and 50% bamboo shoots maybe because of the low protein content of bamboo shoots which ranging from 1.49 g/100 g to 4.04 g/100 g (Nongdam and Tikendra, 2014). The slight low protein content of finished beef patty containing bamboo shoot was stabilized by the addition of ISP which facilitate the emulsion of fat and water to form a homogenous emulsified beef patty.

On the other nutrient, the percentage of crude fibre was increased in line with the levels of fresh bamboo shoot. All raw beef patty formulated with bamboo shoot recorded fibre content ranging from 0.58% to 1.71%. Beef patty formulated with 50% bamboo shoot showed significantly (P<0.05) the highest concentration of fibre (1.71%) followed by 25% beef patty with the bamboo shoot (1.15%) and control beef patty without bamboo shoot (0.58%). The total mineral content in patty samples is represented by ash content. Ash content was slightly decreased with the level of bamboo shoot in beef patties. The percentage of ash in all raw beef patties were ranged from 3.61% to 4.40% and not significant among treatments. The ash content in control beef patty (without bamboo shoot) was slightly higher (4.40%) and there was no significant difference between 25% and 50% beef patty with bamboo shoot. The percentage of carbohydrate in all raw beef patties were ranged from 8.79% to 11.07%. Control beef patty without bamboo shoot contained higher in carbohydrate content (11.07%) and showed significant different (P<0.05) to 50% and 25% beef patty with the bamboo shoot (8.79% and 9.51% respectively). However, there is no significant different (P>0.05) in carbohydrate content between 50% and 25% beef patty added with bamboo shoot.

3.2 Nutritional composition of cooked beef patties

Table 3 shows the chemical composition of the cooked beef patty formulated with different levels of bamboo shoot. The concentration of moisture in cooked beef patty was proportional to the level bamboo shoot used. All cooked beef patty incorporated with bamboo shoot recorded moisture content ranging from 50.93% to 54.87%. Cooked beef patty formulated without bamboo shoot (control) significantly (P<0.05) recorded the lowest concentration of moisture at 46.63%. The highest moisture content was recorded in 50% bamboo shoot formulation (54.87%) and was significant to 25% bamboo shoot formulation (50.93%). The concentration of fat in cooked beef patty was decreased proportionally with the level of bamboo shoot used. The percentage of fat in all cooked beef patties were ranged from 9.37% to 11.67%. Beef patty formulated with 25% and 50% bamboo shoot significantly (P<0.05) recorded lower content of fat at 10.30% and 9.37%, respectively as compared to control (11.67%). The percentage of fat is slightly reduced compared to raw beef patty due to the frying process causes the loss of fat and water content in the cooked beef patty.

Table 3. Proximate analysis of cooked beef patty prepared with different levels of bamboo shoot

Proximate analysis (%)	Bamboo shoot Level (%)		
	0 (Control)	25	50
Moisture	46.63±0.47^{c}	50.93±0.87^{b}	54.87±0.48^{a}
Crude fat	11.67±0.25^{a}	10.30±0.31^{b}	9.37±0.25^{c}
Crude protein	19.37±0.07^{a}	16.41±0.16^{b}	14.00±0.22^{c}
Crude fibre	0.51±0.03^{c}	1.20±0.01^{b}	1.92±0.04^{a}
Ash	3.94±0.60^{a}	3.79±0.25^{a}	3.50±0.49^{a}
Total carbohydrate	17.88±1.19^{a}	17.37±0.94^{a}	16.34±1.11^{a}

Mean values within the same row bearing different superscripts differ significantly (P<0.05)

The concentration of protein in cooked beef patty was decreased proportionally with the levels of bamboo shoot used. The percentage of protein in all cooked beef patties were ranged from 14.00% to 19.37%. Cooked beef patties formulated without bamboo shoot (control) significantly (P<0.05) recorded the highest protein concentration (19.37%) followed by beef patty with 25% and 50% bamboo shoot (16.41% and 14.00%). When the protein was subjected to heating (for cooked beef patty), they will undergo denaturation and cause a slight reduction in protein content as compared to raw beef patty. Since bamboo shoot has a low amount of protein content, the addition of it in beef patty formulation is recommended not to be beyond 25%. In this study, the addition of bamboo shoot at 25% to replace beef resulted in 16.41% protein content which still complies with the Food Act 281 (1983). The addition of bamboo shoot at 50% to replace beef in patty formulation confer significant reduction of protein content (less than 16.00%) and does not comply with the Food Act 281 (1983) guidelines.

On the other nutrient, the concentration of crude fibre was increased in line with the level of fresh bamboo shoot. All cooked beef patty incorporated with bamboo shoot recorded fibre content ranging from 0.51% to 1.92%. Beef patty added with 50% bamboo shoot significantly (P<0.05) recorded the highest concentration of crude fibre at 1.92% as compared to beef patty containing 25% bamboo shoot formulation (1.20%) and control patty without bamboo shoot (0.51%). Bamboo shoot (*G. albociliata*) also contained significant amount of crude fibre at 5.0 g/100 g (Roseli *et al*., 2013) after half of its moisture being removed during processing. That is why beef patty contained a slightly higher percentage of crude fibre as compared to control patty without a bamboo shoot.

The percentage of ash in all cooked beef patties were ranged from 3.50% to 3.94% and not significant among treatments. Patty added with 50% bamboo shoot were slightly lower in ash content at 3.50% and there was no significance to 25% bamboo shoot formulation (3.79%) and control patty (3.94%). The percentage of carbohydrate in all cooked beef patties were ranged from 16.34% to 17.88% and not significant amongst treatments. The 50% formulation contains slightly lower in carbohydrate content (16.34%) compared to control patty without bamboo shoot contain 17.88% of carbohydrate content. These results were in agreement with Wan Rosli *et al*. (2012) who observed that ash content was not significant in cooked beef patties developed with either 25 or 50% oyster mushroom.

3.3 Physical properties of cooked beef patties

Physical characteristics of cooked beef patties added with bamboo shoot are presented in Table 4. According to Serdaroglu *et al*. (2018), the differences in cooking yield in processed meat products probably related to water absorption degrees of the non-meat ingredient used in the formulations. Compared to the control sample formulation, beef patties formulated with bamboo shoot showed an increase (P<0.05) in cooking yield. The high cooking loss was from the control's beef patty (without bamboo shoot). This could be attributed to the high loss of fat and moisture content during the cooking process. The cooking yield was significantly (P>0.05) higher in beef patty incorporated with bamboo shoot. Patty formulated with 50% bamboo shoot recorded the highest cooking yield (87.57%) and was not significant (P<0.05) with 25% patty formulation (87.11%). This was probably due to the ability of bamboo shoot fibre to create a tridimensional matrix, that able to hold water and fat added to the formulation, avoiding losses of water and fat during cooking (Warner and Inglett, 1997). Similarly, Serdaroglu *et al*. (2018) reported that the addition of dried pumpkin pulp and seed powder at the level of 2% and 3% increased the cooking yield value of beef patty compared to control samples.

Table 4. Physical properties of cooked beef patty prepared with different levels of bamboo shoot

Proximate analysis (%)	Bamboo shoot Level (%)		
	0 (Control)	25	50
Cooking yield	81.87±1.34[b]	87.11±2.37[a]	87.57±2.59[a]
Moisture retention	38.17±0.23[c]	44.39±0.53[b]	48.05±1.02[a]
Fat retention	77.01±1.76[a]	78.81±1.37[a]	79.54±2.56[a]
Diameter reduction	17.26±2.55[a]	13.12±0.49[b]	9.56±2.43[b]

Mean values within the same row bearing different superscripts differ significantly (P<0.05)

Percentage of cooking yield in beef or beef products is associated with water and fat retention (Serdaroglu *et al*., 2018). The grinding process of beef during patty formation results in a tender product due to the breakdown of the connective tissue and myofibrils, which promotes weight loss during cooking. The percentage of moisture retention of beef patties formulated with the bamboo shoot was proportionally increased with the increment of fibre content in patty formulations. The higher the amount of bamboo shoot, the lower the loss of moisture during the cooking process. Control beef patty shows more loss in moisture and fat (P<0.05) after cooking as compared to a bamboo shoot-added beef patty. Control beef patty recorded 38.17% moisture retention and 77.01% fat retention while bamboo shoot-added beef patty recorded moisture and fat retention ranging from 44.39-48.07% and 78.81-79.54%, respectively. All cooked patty samples recorded fat retention ranging from 77.01-79.54% and there was no significant difference (P>0.05). This result indicated that incorporation of bamboo shoot leads to a slight increase in fat retention of the samples. This result was in concordance with the findings of Wan Rosli *et al*. (2011) who found that fat retention and moisture retention of beef patty formulated with corn silks powder was higher than in control beef patties. In control beef patty, fat was more easily removed during the cooking process, this may be due to a low density of meat protein matrix, along with a high-fat instability. This is in agreement with the previous study by Suman and Sharma (2003) who investigated the effect of grind size and levels on the physicochemical and sensory characteristics of low-fat ground buffalo meat patties.

Based on the result of this study, cooking loss increased proportionally with fat content in patty formulation. According to Tornberg *et al*. (1989), the increase in fat content will cause the decrease in mean free distance between fat cells, thus increasing the possibility of fat coalescing and then leaking from the product during cooking. Therefore, high-fat products tend to lose a large amount of fat during the cooking process while low-fat meat products lose relatively little fat. Cooking yield increase proportionally with a fibre content of bamboo shoot in patty because of their high ability to keep fat and moisture in the matrix. This finding was supported by the previous research by Aleson-Carbonella (2005) on the incorporation of lemon albedo fibres in beef patty formulation. Besides, Turhan *et al*. (2005) and Mansour and Khalil (1997) also found the similar findings in their research on the utilization of hazelnut pellicles; wheat fibres, respectively in beef patties formulations.

The reduction of diameter in patty is the result of the denaturation of meat proteins with the loss of fat and water content (Serdaroglu *et al*., 2018). Diameter retention of patty decreased with the level of bamboo shoot in the formulations. This cooking trait values were higher in control beef patty without bamboo shoot (9.56%) and there was significantly different (P < 0.05) with 25% and 50% beef patty formulation with bamboo shoot. Patty formulated with 50% of bamboo shoot recorded the lowest diameter reduction (9.56%) and was not significant (P>0.05) with 25% patty formulation (13.12%). The low reduction of the size and shape of bamboo shoot-added beef patty during cooking could be due to the binding and stabilizing property of bamboo shoot fibre, which held the meat particle together and resisted changes in the shape of the product. The previous study on the partial replacement of meat by pea fibre and wheat fibre found the reduction in diameter of control beef patty is due to denaturation of meat proteins with the loss of fat and water during cooking (Besbes *et al*., 2008). The same results were also supported by Wan Rosli *et al*. (2011) who found that the diameter retention was slightly increased in beef patty incorporated with cornsilk powder at the level of 2%, 4% and 6%. The differences in the diameter retention of the patty could be related to water absorption degrees of the non-meat ingredient used.

3.4 Sensory acceptability of cooked beef patties

Table 5 shows the sensory acceptability scores for beef patties incorporated with bamboo shoot. Generally, the scores of all attributes were increased with the levels of bamboo shoot added in the beef patty. The scores of all sensory attributes were in the range between 5.02-5.50 with the patty containing 25% bamboo shoot received the highest score as perceived by untrained panelists. Even though control beef patty without bamboo shoot had slightly lower scores (5.20) for flavour attributes but there was no significant different (P>0.05) compared to 25 and 50 % beef patty formulated with bamboo shoot. However, beef patty formulated with 25% bamboo shoot had a slightly higher score value at 5.57 compared to 50% formulation and control beef patty. Based on the result, the addition of bamboo shoot in patty formulation could increase or improve the flavour of beef patty which is favoured by consumers. The present sensory data for aroma attribute shows that beef patties formulated with 25 and 50% bamboo shoot were not significantly different (P>0.05) compared to control beef patty. The scores of aroma attributes were in the range between 5.13-5.50. Among all bamboo shoot-based patty treatments, a patty with 50% bamboo shoot had the lowest scores value for the colour attribute (5.13). Most of the panellist give the highest score for patty formulated with 25% bamboo shoot (5.50) as compared to control beef patty without a bamboo shoot. This indicates that the addition of a minimum amount of bamboo shoot in beef patty formulation could increase the aroma as compared to control.

Table 5. Sensory scores of beef patty prepared with different levels of bamboo shoot

Proximate analysis (%)	Bamboo shoot Level (%)		
	0 (Control)	25	50
Colour	5.03 ± 1.09^{a}	5.40 ± 1.14^{a}	5.12 ± 1.12^{a}
Aroma	5.45 ± 1.03^{a}	5.50 ± 1.02^{a}	5.13 ± 1.20^{a}
Juiciness	5.13 ± 1.21^{a}	5.35 ± 1.15^{a}	5.18 ± 1.27^{a}
Texture	5.02 ± 1.13^{a}	5.35 ± 1.07^{a}	5.32 ± 1.23^{a}
Flavour	5.20 ± 1.21^{a}	5.57 ± 0.98^{a}	5.40 ± 1.24^{a}
Overall	5.32 ± 1.08^{b}	5.78 ± 0.90^{a}	$5.60\pm1.09^{\mathbf{ab}}$

Mean values within the same row bearing different superscripts differ significantly (P<0.05)

Even though the score values for both texture and juiciness attributes were not significant (P<0.05), however, it increased with the level of bamboo shoot used in the patty formulations. This higher score could be attributed to the higher moisture content of bamboo shoot in beef protein systems (Kotwaliwale *et al*., 2007). The result from this study shows that the texture and juiciness of beef patty are not affected by the addition of bamboo shoot in patty formulation. This increased in texture and juiciness attributed could be attributed to the higher in water holding capacity (WHC) of bamboo shoot in the beef patty. A similar trend was also recorded in a study reported by Wan Rosli, Solihah and Mohsin (2011) which found that WHC of oyster mushroom increased in beef patties. Other studies also reveal that the textural attributes (specifically adhesiveness and cohesiveness) were not significantly different among all levels of oyster mushroom addition to replace chicken partially in frankfurter formulations (Wan Rosli *et al*. 2015).

There were no significant differences (P>0.05) among all the samples for colour attributes. The scores of colour attributes were in the range between 5.03-5.40. The results of the colour attribute showed that cooked beef patty formulated with 25% bamboo shoot was found to be slightly higher than control beef patty. Cooked beef patty with 50% formulation had a slightly lower score value compared to 25% beef patty formulation. Beef patty containing 25% bamboo shoot had the highest score value (5.78) for overall acceptance and showed significantly different (P<0.05) compared to control beef patty without bamboo shoot (5.32). Cooked beef patty formulated with 50% bamboo shoot had score value at 5.60 for overall acceptance and there was no significant difference (P>0.05) between 25% patty formulation and control beef patty without a bamboo shoot. It shows that consumer prefers beef patty that partially incorporated with bamboo shoot compared to control patty (without bamboo shoot).

The results of the hedonic sensorial evaluation of beef patty indicated that the addition of the bamboo shoot did not negatively affect the taste and the texture of the beef patty. The scores given by consumers were almost similar for aroma, colour, texture, juiciness, flavour and overall acceptance of beef patties made from different levels of bamboo shoot. This data indicated that consumers accepting the patties prepared with all levels of bamboo shoot. These findings are in line to the result reported by Wan Rosli, Solihah and Mohsin (2011) who study on the addition of oyster mushroom (OM) (*Pleurotus sajor-caju*) on physical and sensorial properties of beef patty where the usage of OM did not change the sensory properties and consumer acceptability of OM-based beef patties.

4. Conclusion

Beef patty added with bamboo shoot recorded the highest content of crude fibre as compared to control beef patty. The addition of bamboo shoot in beef patty formulation resulted in increased cooking yield, moisture retention and diameter retention. Also, the addition of bamboo shoot reduces the diameter reduction of the beef patty. Beef patty added with 25% the bamboo shoot recorded the highest score for overall acceptance compared to a 50% beef patty formulation and control patty. Incorporation of bamboo shoot at 25% to can be suggested to reduce production cost and fat content, improve crude fibre, cooking yield and moisture retention while not affecting sensory acceptability of the beef patty. Bamboo shoot is economically sustainable and can be considered as a promising healthy food ingredient for incorporation in various types of processed food products.

Conflict of Interest

The authors declare no conflict of interest.

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