International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 11, No. 1, p. 332-342, 2017

RESEARCH PAPER OPEN ACCESS

Effect of incorporating varying amount of soy protein on nutritional composition and sensory quality of beef patties

Gourpada Biswas*[1,2], Most. Nurtaj Khatun[2]

[1]*Department of Applied Nutrition and Food Technology, Islamic University, Kushtia, Bangladesh.*

[2]*Department of Food Science and Technology, Henry Institute of Bioscience and Technology, Sirajganj, Bangladesh*

Key words: Evaluation, Effect, Soy protein, Nutritional, Sensory

http://dx.doi.org/10.12692/ijb/11.1.332-342 Article published on July 28, 2017

Abstract

Meat is an important source of protein and essential nutrients including iron, zinc, vitamin B12 and folic acid .The cost of animal source protein is increasing day by day. So it is necessary to investigate the use of cheaper and nutritive alternatives in various meat industries. In this study, complete randomized design (CRD) having five treatments with three replications was used. Soy meat was incorporated to replace beef at 0% (T_0), 25% (T_1), 50% (T_2), 75% (T_3) and 100% (T_4) levels in beef patties. The physico-chemical properties including moisture (%), crude protein (%), ether extract (%), ash (%), carbohydrate (%), pH, cooking yield (%) and cooking loss (%); sensorial characteristics (appearance, aroma, texture and taste) and color parameter (L*, a*, b*, c* and h*) were determined. The results indicated that the incorporation of soy meat decreased crude protein, ether extract but increased cooking yield, ash in beef patties samples. Highly significant (<0.0001) difference was observed in moisture, crude protein, ether extract, ash, carbohydrate and cooking yield. pH of all the samples decreased with the advancement of storage time but increased with the incorporation of soy meat. There was highly significant (<0.0001) difference found in pH. L* values increased and a* values decreased with high level of soy meat incorporation. No significant difference was observed in color parameter except in L* values. Production cost was reduced for incorporating soy meat in beef patties. Beef patties treated with 50% and 75% soy meat found to be more acceptable in terms of sensory evaluation.

* **Corresponding Author:** Gourpada Biswas ✉ gourbiswas2010@gmail.com

Introduction

Humans have consumed red meat for thousands of years and in fact, meat played an important role in human evolution (Milton, 2003). Meat is an important source of protein and essential nutrients including iron, zinc, vitamin B12 and folic acid (Scollan *et al.,* 2006). Meat consumption varies worldwide, depending on cultural or religious preferences, as well as economic conditions.

Beef is the culinary name for meat from bovines especially cattle. Minced meat is used for the preparation of a variety of products such as patties, sausages and meat balls.

The minced meat is mixed with various condiments and spices, shaped and then fried or roasted (Hsu *et al.,* 1999). Among these different meat products beef patty is one of the tasty and popular foods.

Bangladesh is densely populated country. As the human population increases, the protein requirement also increases. Beef patty can meet up the protein requirement. Some studies have shown the benefits of meat consumption (Givens *et al.,* 2006; McAfee *et al.,* 2010). However, a sector of the population perceives meat as a food that is detrimental to their health (Oliveira *et al.,* 2011) because some epidemiological studies have associated meat consumption with cardiovascular diseases (CVD) and colon cancer (Paik *et al.,* 2005; Chan & Giovannucci, 2010).

For these reasons, these meat consumers look for healthier food alternatives as a means to maintain good health. To achieve healthy meat products, it is recommended to reduce high fat content to appropriate limits and increase the levels of other substances with beneficial properties (Arihara *et al.,* 2006). This new tendency represents a good opportunity for the meat industry to develop new products such as functional meat ones (Arihara & Ohata, 2010; Bhat & Bhat, 2011). Functional meat products are generally produced by reformulating meat through incorporation of health promoting ingredients (Fernandez *et al.,* 2005).

Natural foods may be used as nontraditional ingredients to develop new meat products to reach health-oriented consumers with the objective of increasing antioxidant activity (Yildiz-Turp & Serdaroglu, 2010), improving the fatty acid profile (Rodriguez-Carpena *et al.*, 2012), fiber addition (Fernandez-Gines *et al.*, 2003) or incorporate other bioactive compounds (Bhat & Bhat, 2011).

Soy protein is a great health promoting ingredient andone of the most widely used vegetable proteins in the meat industry. Since soy bean is a rich and cheaper source of plant protein, increasing research into its production and utilization would ensure a steady avenue for providing the much needed cheap but balanced protein. This would meet the teething challenges of declining protein availability in the form of soy-based food; such as soy meat combination in the form of soy meat burger (Igene *et al.,* 2006).

In view of the increased interest in soy-based foods such as soy-meat, there is need to strategies in defining the relationship between specific diet component such as soy protein and human health. This specifically relates to the mechanisms of beneficial cholesterol lowering and anti-carcinogenic effects of soy proteins and other soy components (Raji *et al.,* 2008).

High meat prices have prompted the food industry to produce non-meat proteins such as Textured Soy Protein (TSP) which is widely used in meat products as extenders to provide an economical high quality protein source. Textured Soy protein (TSP), soy meat, or soya chunkrefers to defatted soy flours or concentrates that are mechanically processed by extruders to obtain meat-like chewy textures when hydrated and cooked (Singh *et al.,* 2008). It is regarded as a healthy choice because it is cholesterol-free, and low in fat and calories (Asgar *et al.,* 2010).

So, incorporating soy meat as a nontraditional ingredient in beef patties formulation not only would reduce the cost but also would decrease saturated fats and replace simple carbohydrates whose consumption has been linked to health problems.

The increased level of urbanization in Bangladesh has informed the need to develop more convenience products using meat and to date there are no soy meat-extended beef patties on the commercial markets in Bangladesh.

However, soya meat is a popular, available and low cost product in Bangladesh and the utilization of soya meat in any beef product or beef patty is never been studied. The present study has been undertaken to investigate the effect of incorporating varying amount of soy protein on nutritional composition and sensory quality of beef patties and its economical feasibilities.

Materials and methods

Collection of raw materials

Minced beef (approximately 1 kg) , soy meat (approximately 400 g) , Egg, bread (Fu-Wang Foods Ltd), milk (Pran Food Co.), tomato sauce (Pran Food Co.), soya sauce (Sajeeb Co.), green chili, fresh parsley, onion, garlic, ginger, black pepper, salt, radhuni garammasala powder (Square Food and Beverage Ltd) were purchased from a local market of Kushtia city .

Experimental design

The characteristics of quality were conducted using a completely randomized design (CRD) having five (5) treatments (T_0 =100% beef; T_1 =75% beef+25% soy meat; T_2 =50% beef+50% soy meat; T_3 =25% beef+75% soy meat; T_4 =100% soy meat) with three (3) replications of beef patties formulated with soya meat in comparison with the control one. Five different meat mixes were prepared; the 1st meat mix (control) was prepared with 100% beef, 0.43% sodium chloride, 4.81% egg, 6% bread, 8.58% milk and 15.78% spices. The second mix was prepared with replacement of 25% of the meat mass with soy meat, the third mix was prepared with replacement of 50% of the meat with soy meat, the fourth mix was prepared with replacement of 75% of the meat with soy meat, the fifth mix was prepared with replacement of 100% of the meat with soy meat. All measurements were made in duplicate.

Preparation of soy meat

At first dry soy meat was cooked for five minutes in boiling water and then drained out all excess water. After that these boiled soya meat were grinded by using a blender machine. Blended soy meat were packed in zipper bags and stored at -18°C till the product processing.

Beef patties formulation

The stored minced beef and blended soy meat was thawed at room temperature (26 ± 2°C). 644g of minced beef meat and soy meat were weighed out and divided into 5 portions of 0, 25, 50, 75 and 100 %. Mixing of beef patty was done in 400g lots such that 257.60g, 193.2g, 128.8g, 64.4g and 0g of beef was incorporated into 0g, 64.4g, 128.8g, 193.2g and 257.60g of soy meat. Some spices (i.e. garlic paste about 9.6g, Onion chopped 20.6g, chopped green chili 4g, chopped coriander leaves about 10.32g, ginger paste about 8.6g, garammasala powder about 0.52g, black pepper powder about 0.88g, tomato sauce about 3.44g and soy sauce about 5.16g), bread about 24g, milk about 34.32g, egg about 19.24g and salt about 1.72g were added in each sample . After that each sample were thoroughly mixed by hand using hand glove and the finished meat batters were then weighed into 100g portions, and then manually stamped to produce a uniform beef patty. After completing all these process each patties sample was tagged, wrapped in zipper bags and immediately transported to storage at -18°C till used for analysis.

Determination of proximate composition

The proximate composition of beef patties was analyzed for the content of moisture, crude protein, ether extract and ash, according to the methods of AOAC (2000), which is described here below.

Determination of moisture

The percentage of the moisture content was calculated by the following formula:

% Moisture at 104°C = x 100

Where,

W_1=weight of dish in grams

W_2=initial weight of sample and dish in grams

W_3=dry weight of sample and dish in grams

Determination of crude protein

The percentage of the crude protein content was calculated by the following formula:

% Crude Protein using the 6.25 factor for the conversion of Total N to protein.

% N= Volume HCL x normality of HCL x 0.014 x 100/weight of sample (gm).

To report results as % Total N, divide the % Crude Protein value by 6.25.

Determination of total lipids

The percentage of the lipid content was calculated by the following formula:

%Lipid = x 100

Determination of ash

The percentage of the ash content was calculated by the following formula:

% Ash= x 100

Where,

W_1= Weight of crucible in grams

W_2= Weight of sample in grams

W_3= Weight of crucible and ash in grams

Determination of carbohydrate

Carbohydrate content was calculated by using following formula

%CHO= 100-(%CP+ %EE+ %Ash).

Determination of pH

A 5g sample of homogenized sample was weighed into a beaker and 50 mL of distilled, deionized water was added to the sample. A stir bar was placed in the homogenized solution, and pH was measured after stirring. A bulb tip combination electrode (Orion model 9256BN, Orion Research Inc., Boston, MA) with an Orion SA 720 pH meter (Orion Research Inc.) was used in this procedure. Five treatments with three replications were analyzed for five days with the interval of 24 hours.

Determination of cooking yield and cooking loss

The percentage of cooking yield and cooking loss was calculated by the following formula:

Cooking loss (%) = x100

Cooking yield (%) = x100

Where,

A = Weight of cooked sample in gram

B = Weight of cooked sample in gram.

Color measurement

A sample section 12 cm thick was removed. Samples were individually, vacuum packaged and frozen at −20 °C. Each frozen sample was standardized into two 2.54 cm thick steak samples (AMSA, 1995) for objective color evaluation (L, a*, b*, c* and h*). Color readings were obtained from 63 cores covering the full spectrum of discoloration in beef: from fresh samples having a bright-red color to stale samples with a green brownish tint. Readings were taken near the center of each core using a CM (Minolta Chromameter CR-300, Osaka, Japan;) with a 1 cm aperture, illuminant C and a 2_ viewing angle. Before data collection, the instrument was calibrated with a white calibration plate (L* = 97.06, a* = _0.14, b* = 1.93) covered in the same film wrapping the beef samples. Data were collected in CIE L*a*b* color space through the meat film. Lightness (L*), redness (a*), yellowness (b*), chroma [or color saturation, ða_2 þ b_2 Þ0:5], and hue angle [arctangent (b*/a*) _ 360_/ (2 _ 3.14)] were evaluated. Sample color coordinates (L*, a* and b*) were recorded with a digital Minolta CR300 chromometer (Minolta Co., Osaka, Japan) on the surface exposed by cutting between 12th and 13th ribs. Coordinate a* ranged from red (+a*) to green (−a*) and coordinate b* from yellow (+b*) to blue (−b*). Three readings of L*, a*, b*, c* and h* values were obtained at different sites.

Sensory evaluation

This was conducted following the procedures of Peryam and Piligrim (1957). Five samples were coded and presented to sensory panel to evaluate samples according to degree of likeness in respect to appearance, aroma, taste, texture and overall acceptance. Water and cracker biscuits were served in between samples assessment to enable panelists rinse properly and neutralize carryover flavors in their mouth. Panelists were served in their separate locations far away from the sample cooking and preparation room and samples were coded to reduce bias.

A 9-point hedonic scale having 1 (like extremely) as the highest score and 9 (dislike extremely) as the lowest score was used.

Statistical analysis

The experiment was conducted under a completely randomized design (CRD) having five (5) treatments with three (3) replications of beef patties and the data were analyzed using the GLM procedure of SAS version 9.1, (SAS Institute, Inc.).

Effects of soya in beef patties were tested by analysis of variance and when differences were detected, DMRT was used to compare the treatment means, with significance considered at $P<0.0001$.

Result and discussion

Proximate composition of beef patties

Moisture content

Moisture contents of beef patties are presented in Table 2. Moisture contents were noted down 70.20%, 69.30%, 68.97%, 68.10% and 67.85% in T_0, T_1, T_2, T_3 and T_4, respectively. Moisture content was highest in T_0 than those of other treatments. Moisture content gradually decreased from T_0 to T_4.

The loss of moisture probably associated with incorporation of soy meat as soy meat contains less amount of moisture.

Table 1. Ingredients Composition of Beef Patties.

Variable	Treatment				
	T_0 (100beef:0soy meat)	T_1 (75beef:25soy meat)	T_2 (50beef:50soy meat)	T_3 (25beef:75soy meat)	T_4 (0beef:100soy meat)
Beef (g)	257.60	193.2	128.8	64.4	0
Onion (g)	20.6	20.6	20.6	20.6	20.6
Garlic (g)	9.6	9.6	9.6	9.6	9.6
Ginger (g)	8.6	8.6	8.6	8.6	8.6
Chillies (g)	4	4	4	4	4
Fresh parsley (g)	10.32	10.32	10.32	10.32	10.32
Soya sauce (g)	5.16	5.16	5.16	5.16	5.16
Tomato sauce (g)	3.44	3.44	3.44	3.44	3.44
Salt (g)	1.72	1.72	1.72	1.72	1.72
Pepper (g)	0.88	0.88	0.88	0.88	0.88
Garammasala (g)	0.60	0.60	0.60	0.60	0.60
Egg (g)	19.24	19.24	19.24	19.24	19.24
Milk (g)	34.32	34.32	34.32	34.32	34.32
Bread (g)	24	24	24	24	24
Soy meat (g)	0	64.4	128.8	193.2	257.60

The lowest moisture content was found in T_4. There was a highly significant differences ($p<0.001$) in moisture content of the beef patties among the treatments. Similar results were obtained by Kotula *et al.* (1974) who reported that patties with 20% Textured Soy Protein rated slightly lower in moisture than the control (all beef). This study agreed to the present study. Gehan *et al.* (2010) reported that when TSP was used to substitute beef in beef burgers the moisture content of the control burger patties was lower than the soy extended burgers and the addition of hydrated soy significantly increased the moisture content of raw beef patties due to its higher water content. This study disagreed to the present study in case of moisture because quality and amount of ingredients, temperature, instrumental defects & other factors might responsible for that dissimilarity.

Crude protein

Crude protein (CP) content of five treatments was analyzed and the results are presented in Table 2. In T_0 the CP was 49.78%. The CP was found 45.28%, 40.18%, 36.80% and 35.87% in the treatments of T_1, T_2, T_3 and T_4, respectively. The highest value was found in T_0. The CP value was decreased with the increasing incorporation of soy meat as it contains less amount of protein than the beef.

Table 2. Proximate composition beef patties with varying amounts of soy meat.

Parameters %	Treatment					Significant Level
	T_0	T_1	T_2	T_3	T_4	
Moisture	$70.20^a±0.11$	$69.30^b±0.14$	$68.97^b±0.07$	$68.10^c±0.5$	$67.85^c±0.24$	***
CP	$49.78^a±0.18$	$45.28^b±0.21$	$40.18^c±0.14$	$36.80^d±0.34$	$35.87^e±0.15$	***
EE	$24.75^a±0.11$	$18.70^b±0.17$	$13.70^c±0.20$	$6.52^d±0.19$	$2.87^e±0.12$	***
Ash	$5.70^e±0.13$	$6.52^d±0.14$	$7.73^c±0.017$	$8.32^b±0.17$	$9.30^a±16$	***
CHO	$19.77^e±0.30$	$29.50^d±0.39$	$38.38^c±0.33$	$48.33^b±0.36$	$51.97^a±0.38$	***

T_0 (100% beef); T_1 (75% beef+25% soy meat); T_2 (50% beef+50% soy meat); T_3 (25% beef+75% soy meat); T_4 (100% soy meat); DM= Dry matter; CP= Crude Protein; EE= Ether extract; CHO= Carbohydrate; NS = Non significant;*= p<.05; **= p<0.01;***= p<0.0001; Mean with different superscripts within same row differ significantly (p<.0001).

The lowest value was found in T_4. There was a highly significant differences (p<0.001) in CP content of the beef patties among the treatments. The decrease in protein content is consistent with the work of Ray *et al.* (1981) that as the soy level increased in ground meat, the protein decreased.

Ether extract

Ether extract (EE) content of five treatments was determined and results are presented in Table 2.

The EE content were found 24.75%, 18.70%, 13.70%, 6.52 % and 2.87% in T_0, T_1, T_2, T_3 and T_4, respectively.

Table 3. pH, cooking yield and cooking loss of beef patties with varying amounts of soy meat.

Parameters	Treatment					Significant Level
	T_0	T_1	T_2	T_3	T_4	
pH after one hour	$6.45^e±0.02$	$6.53^d±0.01$	$6.71^c±0.02$	$6.84^b±0.01$	$6.99^a±0.01$	***
pH after 24 hours	$6.35^e±0.00$	$6.42^d±0.01$	$6.58^c±0.01$	$6.71^b±0.02$	$6.82^a±0.02$	***
pH after 48 hours	$6.23^e±0.01$	$6.33^d±0.01$	$6.45^c±0.00$	$6.57^b±0.01$	$6.77^a±0.01$	***
pH after 72 hours	$6.02^e±0.01$	$6.13^d±0.01$	$6.23^c±0.01$	$6.34^b±0.01$	$6.78^a±0.01$	***
pH after 96 hours	$5.95^d±0.01$	$6.04^c±0.00$	$6.08^c±0.02$	$6.31^b±0.01$	$6.74^a±0.01$	***
Cooking yield	$60.96^e±0.01$	$67.77^d±0.01$	$77.46^c±0.01$	$88.07^b±0.01$	$89.18^a±0.01$	***
Cooking loss	$38.85^a±0.01$	$32.03^b±0.01$	$22.30^c±0.01$	$11.73^d±0.01$	$10.62^e±0.01$	***

T_0 (100% beef); T_1 (75% beef+25% soy meat); T_2 (50% beef+50% soy meat); T_3 (25% beef+75% soy meat); T_4 (100% soy meat); NS = Non significant;*= p<.05; **= p<0.01;***= p<0.0001; Mean with different superscripts within same row differ significantly (p<.0001).

The EE content in T_0 was 24.85% while that for T4 was 2.97% representing approximately 90% reduction in fat. This reduction was due to the low fat content of rehydrated soy meat used to replace minced beef. The EE content of the beef patties was highly significant (p<0.0001) in the treatments. Rhee *et al.* (1983) reported a decrease in fat content in raw ground beef patties with addition of up to 30% rehydrated Textured Soy Protein. Similar trends were reported by Anwar *et al.* (2011) and Gehan *et al.* (2010) when Textured Soy Protein was used to substitute beef in beef burger.

Ash content

Ash content of five treatments was analyzed and the results are presented in Table 2. In T_0, T_1, T_2, T_3 and T_4 the ash contents were found 5.70%, 6.52%, 7.73%, 8.32% and 9.30%, respectively. The lowest value was found in T_0. The ash content was increased with the increasing incorporation of soy meat as it had a higher concentration of ash than the beef.

The highest value was found in T_4. There was a highly significant difference ($p<0.0001$) in the ash content of beef patties among the treatments. The increase in ash content is consistent with the work of Gehan *et al.* (2010) that as the soy level increased in ground meat, the ash content increased. Similar findings were reported by Kotula *et al.* (1974).

Table 4. Instrumental color measurement of beef patties with varyingamounts of soy meat.

Parameters	Treatment					Significant Level
	T_0	T_1	T_2	T_3	T_4	
L*	$48.69^c\pm0.14$	$48.71^c\pm0.19$	$53.35^a\pm0.61$	$51.17^b\pm0.46$	$50.92^b\pm0.61$	**
a*	$1.92^a\pm0.41$	$1.37^a\pm0.87$	$0.98^a\pm0.45$	$1.38^a\pm0.23$	$1.46^a\pm0.13$	NS
b*	$14.99^b\pm0.67$	$14.29^b\pm0.46$	$16.12^{ab}\pm0.49$	$15.99^{ab}\pm0.18$	$17.26^a\pm0.66$	NS
c*	$15.09^b\pm0.75$	$14.44^b\pm0.51$	$16.17^{ab}\pm0.47$	$16.06^{ab}\pm0.20$	$17.33^a\pm0.67$	NS
h*	$84.51^a\pm3.03$	$81.97^a\pm1.34$	$86.10^a\pm0.1.74$	$84.66^a\pm0.75$	$84.77^a\pm0.32$	NS

T_0 (100% beef); T_1 (75% beef+25% soy meat); T_2 (50% beef+50% soy meat); T_3 (25% beef+75% soy meat); T_4 (100% soy meat); NS = Non significant;*= p<.05; **= p<0.01;***= p<0.0001; Mean with different superscripts within same row differ significantly.

Carbohydrate content

Carbohydrate content of five treatments was analyzed and the results are presented in Table 2. In T_0, T_1, T_2, T_3 and T_4 the ash contents were found 19.77%, 29.50%, 38.38%, 48.33% and 51.97%, respectively. The lowest value was found in T_0.

The carbohydrate content in beef patties increased with the increasing incorporation of soy meat and it could be due to an increase of starch content (acts as extender) to substitute for raw meat in the manufacturing of beef patties.

Table 5. Sensory evaluation of beef patties with varying amount of soy meat.

Sensory Attributes	Treatment				
	T_0	T_1	T_2	T_3	T_4
Appearance	3.28	3.28	1.4	2.78	3.15
Aroma	2.65	2.4	2.90	3.53	3.53
Taste	3.15	2.90	1.78	3.28	3.03
Texture	3.4	3.15	2.28	2.78	3.78

T_0 (100% beef); T_1 (75% beef+25% soya); T_2 (50% beef+50% soya); T_3 (25% beef+75% soya); T_4 (100% soya).

The highest value was found in T_4. There was a highly significant difference ($p<0.0001$) in the ash content of beef patties among the treatments. Gehan *et al.* (2010) reported an increase in carbohydrate content in raw ground beef patties with addition of up to 20% rehydrated Textured Soy Protein. Similar trends were reported by Bilek *et al.* (2009) when flaxseed flour was used in beef burger.

pH, cooking yield and cooking loss of beef patties pH of samples was analyzed within one hour to 96 hours after preparing samples and the results are presented in Table 3. The initial mean levels of pH of beef patties was found 6.45 in T_0 and 6.99 in T_4.

It was found that pH increased with addition of soy meat into beef patties. In T_o, T_1, T_2, T_3 and T_4 these pH were found 6.45, 6.53, 6.71, 6.84 and 6.99, respectively.

There was a highly significant difference (p<0.0001) in the pH of beef patties among the treatments. It was also clear that during frozen storage the pH were significantly decreased with storage time. The reduction in pH might be due to the production of acid from the fermentation of carbohydrates of meat, binders and spices. At the end of storage period (after 96 hours of time), the pH was 5.95, 6.04, 6.08, 6.31 and 6.74 for T_o, T_1, T_2, T_3 and T_4, respectively. An increase in pH due to TSP addition into beef patties formulation and frozen storage was reported previously by Kotula *et al.* (1974) and Anwar *et al.* (2011). These studies agreed to the condition of Textured Soy Protein addition but disagreed to frozen condition.

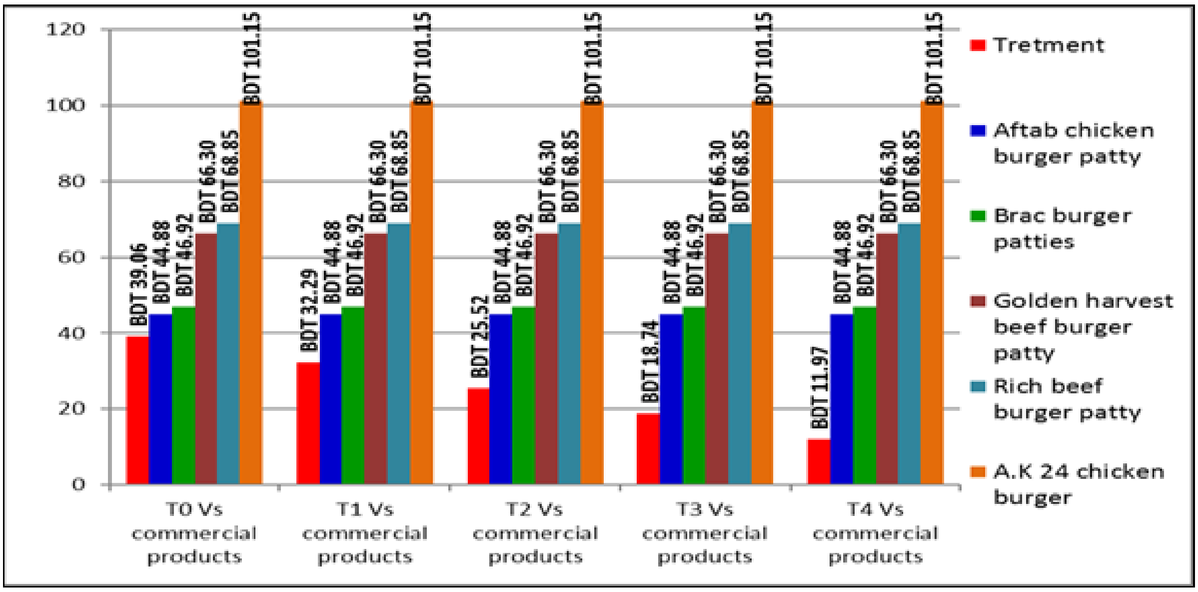

Fig. 1. Comparison of prices among commercial and present prepared beef patties.

Cooking yield and cooking loss

The percent cooking loss and cooking yield of soy-beef patties is shown in Table 3. It was observed that cooking loss decreased when more textured soy protein is blended with the beef patties i.e. increase the cooking yield, due to its ability to hold up water and fat during cooking. The cooking yield in T_o, T_1, T_2, T_3 and T_4 were 60.96%, 67.77%, 77.46%, 88.07% and 89.18%, respectively. There was a highly significant difference (p<0.0001) in the percent cooking yield of beef patties among the treatments. Anderson *et al.* (1975)reported that the level of soy in a meat product determines the amount of moisture retention. A functional property of soy is to retain moisture; consequently the cooking yield of soy-extended products is greater than that of all beef products. The cooking losses in T_o, T_1, T_2, T_3 and T_4 were 38.85, 32.03, 22.30, 11.73 and 10.62%, respectively. There was a highly significant difference (p<0.0001) in the percent cooking loss of beef patties among the treatments.

Reports by Gehan *et al.* (2010); and Anwar *et al.* (2011) also indicated soy protein ability to reduce cooking loss when compared to products with 100% meat in it.

The instrumental color measurement results of raw beef patties are shown in Table 4. The lightness values (L*) of beef patties in T_o, T_1, T_2, T_3 and T_4 were 48.69, 48.71, 53.35, 51.17 and 50.92, respectively. The redness values (a*) of beef patties found in T_o, T_1, T_2, T_3 and T_4 were 1.92, 1.37, 0.98,1.38 and 1.46, respectively. The yellowness values (b*) of beef patties found in T_o, T_1, T_2, T_3 and T_4 were 14.99, 14.29, 16.12, 15.99 and17.26 respectively. The chroma values (c*) of beef patties found in T_o, T_1, T_2, T_3 and T_4 were 15.09, 14.44, 16.17, 16.06 and 17.33, respectively. The hue angle values (h*) of beef patties found in T_o, T_1, T_2, T_3 and T_4 were 84.51, 81.97, 86.10, 84.66 and 84.77, respectively.

There was no significant difference in color of the beef patties among the treatments except lightness values (L*). There was a significant difference ($p<0.0031$) in the lightness values (L*) of beef patties among the treatments. The lightness (L*) of beef patties with varying amount of soy meat was comparable to the control, while those with soy meat displayed greater lightness than the control. Seideman *et al.* (1977) had shown in their study that raw patties containing 20% or 30% Textured Soy Protein were lighter in color than control (all-beef) patties and this study agree with the present study.

Sensory evaluation

The results of the taste panel evaluation on the various quality attributes such as appearance, aroma, taste and texture of soy-beef patties are summarized in Table 5. The scores for appearance in T_0, T_1, T_2, T_3 and T_4 were found 3.28, 3.28, 1.4, 2.78 and 3.15, respectively. Beef patties samples produced with 50% soy meat were chosen as beef patties with the most desirable appearance.

The scores for flavor in T_0, T_1, T_2, T_3 and T_4 were found 2.65, 2.4, 2.90, 3.53 and 3.53, respectively. As the addition of soy meat increased, the perception of meat flavor intensity decreased. The lower sensory scores of flavor in soy meat extended patties might be due to decrease in fat content and/or the beany flavor detected by the panelists in the soy meat extended patties.

The scores for taste in T_0, T_1, T_2, T_3 and T_4 were found 3.15, 2.90, 1.78, 3.28 and 3.03, respectively. Generally, the taste decreased in the likeness for texture and the scores for texture in T_0, T_1, T_2, T_3 and T_4 were found 3.4, 3.15, 2.28, 2.78 and 3.78, respectively. As the addition of soy meat increased, the beef patties were rated higher than the control except T_4. It is probably due to the increasing juiciness and tenderness with the increasing incorporation of soy meat. Non-meat protein sources such as egg, whey protein and Textured Soy Protein are able to improve the flavor and texture of burgers by increasing the fat and moisture binding ability (Gujral *et al.,* 2002; Rentfrow *et al.,* 2004; Gehan *et al.,* 2010). These studies agree with the present study.

Prices of beef patties

The difference of prices among present prepared beef patties and commercial beef patties is shown in Figure 1.

The price values per 100gm of present prepared beef patties were noted 39.06 BDT in T_0 and 11.97 BDT in T_4. In T_0, T_1, T_2, T_3 and T_4 the values were found 39.06, 32.29, 25.52, 18.74 and 11.97 BDT, respectively. Brac burger patties, Golden harvest beef burger patty, Rich beef burger patty, Aftab chicken burger patty and A.K 24 chicken burger are available in the commercial market. Price per 100gm of Brac burger patties, Golden harvest beef burger patty, Rich beef burger patty, Aftab chicken burger patty and A.K 24 chicken burger are 46.92, 66.3, 68.85, 44.88 and 101.15 BDT, respectively.

The difference of the prices among soy meat incorporating beef patties and commercial beef patties cause due to soy meat on the market is less expensive than the real meat counterparts.

Conclusion

From this study it can be concluded that, addition of soy meat resulted in an increase in the nutritional composition, cooking yield while maintaining the sensory quality of beef patties. A level of up to 50% soy meat can be used in beef patties production to obtain acceptable products that have better textural properties in which the flavor and taste are not significantly different from 100% beef patties. This incorporation could permit a reduction of the formulation cost without affecting sensory descriptors of the product to which the consumer is familiarized.

Acknowdgement

This study was supported by Food Chemistry Laboratory, Department of Applied Nutrition and Food Technology, Islamic University, Kushtia.

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