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Effect of Some Nutritional Additives on the Quality and Formulation Cost of Beef Burger

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Abstract: This experimental work included production of beef burger using beef meat only (control), textured soy granules replace 20 and 30% of meat mass, sweet potatoes also replace 20 and 30% of meat mass and mixture of textured soy granules and sweet potatoes (1:1) replace 30% of meat mass. The incorporation of textured soy granules or sweet potatoes significantly improves the nutritional value, physicochemical and hygienic qualities of the product. The antioxidant effect of sweet potatoes significantly decreases the deterioration criteria in its extended formulations. Moreover, there was a significant improvement in the color, juiciness and tenderness of burger which formulated with sweet potatoes. Recognizable reduction in the formulation cost of burgers was achieved in all extended formulations whereas the replacement of meat mass by 30% mixture of textured soy granules and sweet potatoes (1:1) scored the lowest price and still with accepted quality parameters.

Key words: Beef burger · Nutritional additives · Quality · Formulation cost · Textured soy granules and sweet potatoes

INTRODUCTION

Increasing interest have being shown in partial replacement of meat items with extenders/binders/fillers in order to minimize the product cost while improving or at least maintaining nutritional and sensory qualities of end products that consumers expect [1]. Among the non-meat additives tried soya beans in beef patties represent a good model [2]. Soy protein is one of the most soy bean derivatives used as non meat proteins in meat industry due to its various technological benefits, whereas it plays a significant role in the modification of the functional characteristics of meat products. Adding soy protein to meat products, particularly ground beef patties (hamburger), has been practiced since the early 1900s [3]. It can also be used to replace part of the animal fat. With its hydrating capacity, soy flakes considerably decrease the final cost of the meat products. Hydrated soy flakes are well suited in high volume applications. Its meat-like appearance and mouthfeel remain intact throughout the different processing procedures. Despite the many advantages of soybean, its use has been limited because of the characteristic beany flavor [4].

Vegetable products [5] are added to raw or cooked meat products to improve its functional properties. The vegetables could serve as fillers, binders, fat replacers, sources of dietary fiber and natural antioxidants in a meat system [6]. Sweet potatoes are a nutritious food, low in fat and protein, but rich in carbohydrate. Because of their nutritional qualities, sweet potatoes were selected as one of the foods tested for long-term space travel [7]. Moreover, the high carotenoid content and good yields of orange fleshed sweet potatoes allow its incorporation in several small-scale studies to increase vitamin A deficiency. Therefore, the objective of this work was to evaluate the effect of adding textured soy granules and sweet potatoes on the quality attributes and cost of beef burger.

MATERIALS AND METHODS

Experimental Design: The experimental work was designed to investigate the effect of using of non meat ingredients on the different quality attributes of beef burger. Textured soy granules and sweet potatoes were used in formulation of the product which were kept frozen at -18°C for 3 months and examined periodically every two weeks in comparison with Egyptian standard specifications *(ESS)* of frozen beef burger [8].

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Ingredients Preparation: Imported deep frozen beef chuck was trimmed off all visible fat and connective tissue and kept frozen at-18°C for the next day in 1 kg portions. Moreover, beef fat was obtained from the same source from a local store.

Yellow type sweet potatoes, obtained from a local market, were boiled, drained and finely mashed before being added into patties.

Textured soy granules, obtained from a local market, were hydrated with cold water (1:2) over night.

Product Formulations: For performing the study, six models from each of beef burger were formulated. The 1st model was formulated according to the *ESS* [8]. For beef burger and used as a control. The burger was formulated with 75% beef meat, 10% beef fat, 5% bread crumbs, 1.5% common salt, 0.3% sodium tripolyphosphate, 0.5% seasonings and the rest was cold water.

Frozen beef meat was ground with a commercial food processor at 8 mm diameter and then transferred to a paddle mixer, whereas the dry ingredients (common salt, polyphosphates and seasonings) were slowly added to the ground beef meat as powders while mixing. Afterwards cold water was incorporated, then beef fat was added during mixing and finally bread crumbs were added. The final temperature of batters varied between -5 to-7°C. The batter was manually formed into discs of 75 grams using manual former (*Fac Affecttatrici*). Formed burger discs were then kept frozen at-18°C.

The 2nd model of beef burger was formulated with 60% beef meat, 15% hydrated soy granules. While, the 3rd model of beef burger was formulated with 52.5% beef meat, 22.5% hydrated soy granules. The 4th model of beef burger was formulated with 60% beef meat, 15% finely meshed boiled sweet potatoes. While, the 5th model of beef burger was formulated with 52.5% beef meat, 22.5% finely meshed boiled sweet potatoes. Finally, The 6th model of beef burger was formulated with 52.5% beef meat, 22.5% hydrated soy granules and finely meshed boiled sweet potatoes (1:1).

Investigations: All the experimentally produced beef burger were kept at-18°C and sampled every two weeks throughout three months for examinations. The investigations included:

Sensory Evaluation: Beef burger samples were evaluated according to the scheme postulated by *Poste et al.* (1991) [9] for appearance, color, odor, consistency, comminution, binding, forming, fringe formation and overall acceptability.

Chemical Examinations: The techniques recommended by *AOAC* [10] were applied. Samples from each package were rendered into uniform mass by passing through a meat mincer three times and mixed thoroughly then used for the following chemical analysis:

A Proximate chemical analysis[10]
- Determination of moisture content [10]
- Determination of protein content[10]
- Determination of ether extractable fat[10]

B Deterioration criteria
- Measurement of pH value [11]
- Determination of thiobarbituric acid value [12]
- Determination of Total volatile Basic Nitrogen [13]

Physicochemical Characteristics: Beef burger samples were cooked and all measurements were done on 3 replicates per treatment.

- Moisture retention [14]
- Fat retention [15]
- Diameter reduction [16]
- Shrinkage percentage [16]
- Water Holding Capacity [17]

Bacteriological Examinations: The bacteriological analysis of the examined beef burger was based on the recommendation of *ICMSF* [18] including *mesophiles*, *psychrotrophs*, *coliforms*, *E.coli* and *S. aureus* to assess microbiological safety, sanitation conditions during processing and keeping quality of beef burger.

Statistical Analysis: All data were analyzed using Statistical Analysis System [19]. Comparisons between treatments within each analysis were tested. Significance was determined by the F-test and least square means procedure. Main effects were considered significance at P<0.05.

RESULTS AND DISCUSSION

Meat eaters have become more selective and conscious of quality, particularly freshness, wholesomeness and palatability but the price of the product also plays a role in their selection and attracts their concern.

Sensory Quality: Mean values of sensory panel scores for experimentally produced raw beef burger (Fig. 1) showed that all investigated sensory attributes of control formulation were relatively high (near 9).

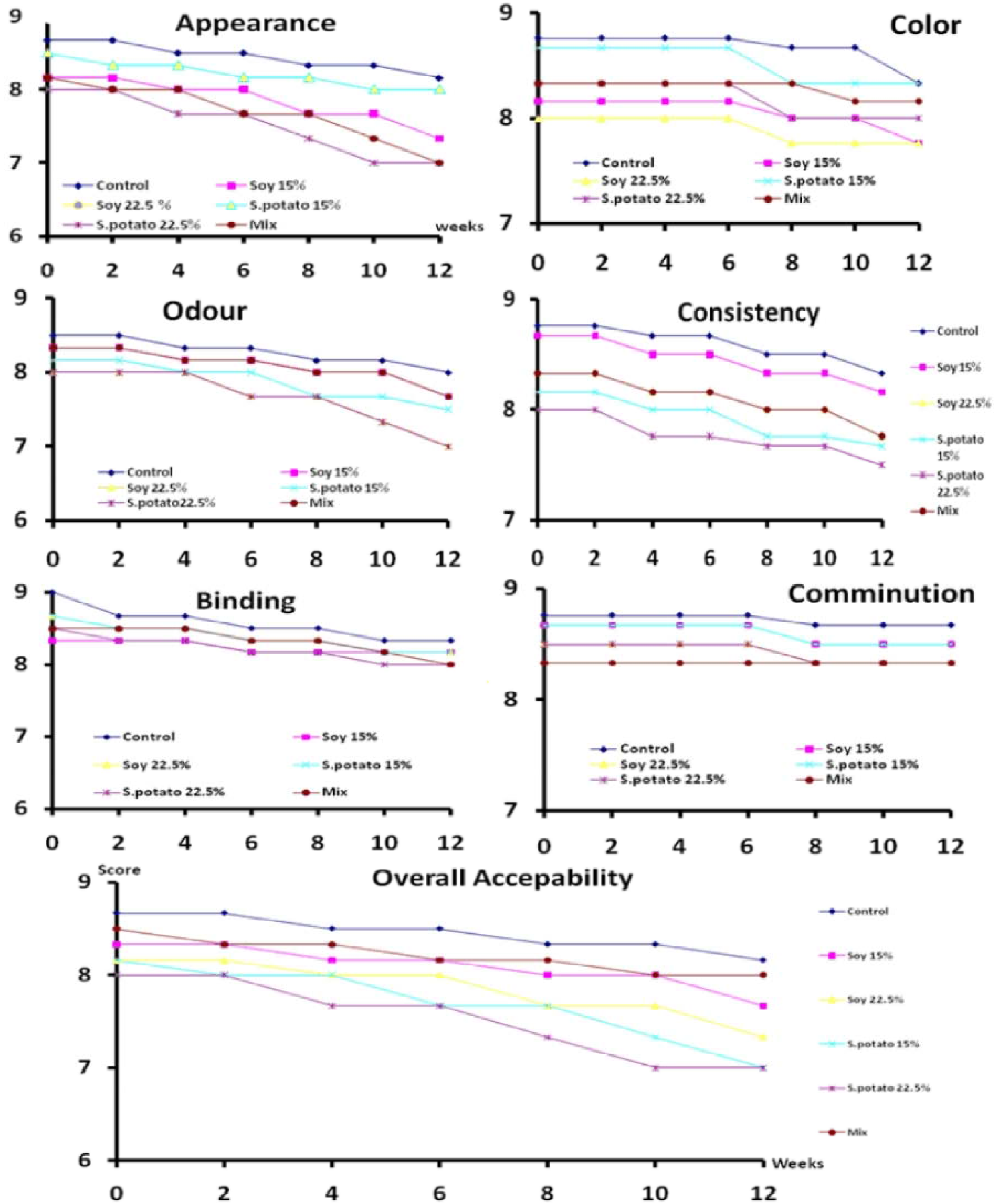

Fig. 1: Sensory panel scores for experimentally produced raw beef burger

Concerning the storage experiment, it was cleared that freezing storage at -18°C for 12 weeks induced significant ($p<0.05$) but slight decrease in all the sensory parameters.

Concerning the storage, it was evident that freezing storage at -18 °C for 12 weeks induced weak to slight decrease in all the sensory parameters.

Sensory analysis of cooked beef burger (Fig. 2) indicated that control formulation scored the highest score, especially in appearance and color. Moreover, it scored the highest sensory panel scores for flavor immediately after processing and through the frozen storage time. However, using of different non meat

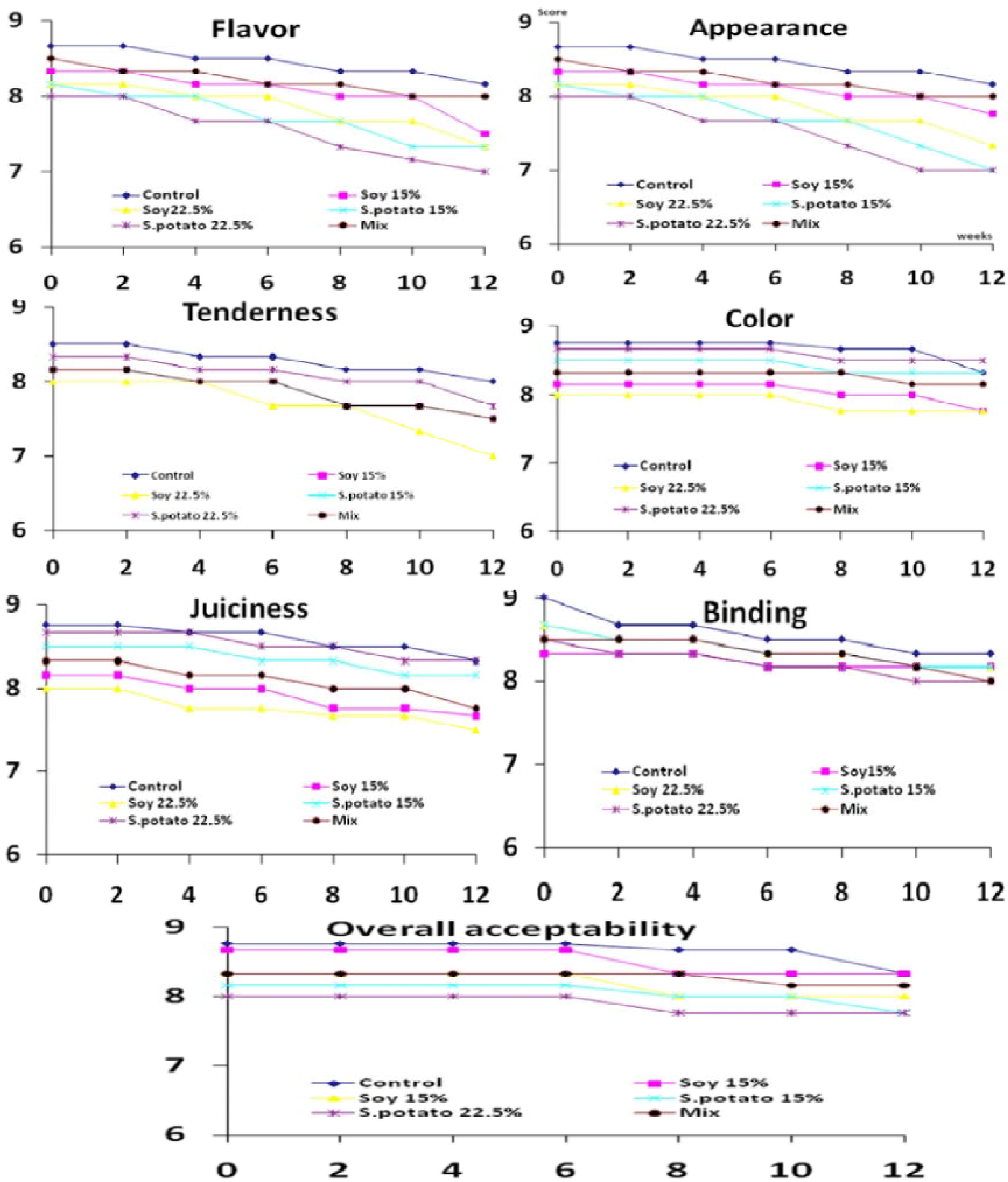

Fig. 2: Sensory panel scores for experimentally produced cooked beef burger

ingredient in formulation of beef burger significantly reduced ($p < 0.05$) the sensory panel scores for all the investigated parameters. The most pronounced effect was the effect of the various non-meat additives on the flavor and overall acceptability. The most affected formulation by addition of non meat ingredients was the sweet potatoes (22.5%) extended one at which the flavor score reach 7 at the end of the storage period.

Regarding tenderness and juiciness of cooked burger (Fig.2), it was evident that the control product had the highest score followed by sweet potatoes (22.5%) which is not significantly different from the control one. It was cleared that significant improvement in the color of burger which formulated with sweet potatoes were achieved. In this regard, *Saleh and Ahmed* [20] reported that there was an improvement in color of beef patties due to the addition of boiled carrot and sweet potatoes.

Table 1: Mean values of proximate chemical analysis for experimentally produced raw beef burger

Formulation	Moisture %	Fat %	Protein %
Control	63.5^{a}	17.25^{a}	$15.62^{a,b}$
Soy (15%)	67.5^{b}	13.50^{b}	16.65^{a}
Soy (22.5%)	$68.5^{b,c}$	13^{b}	17.36^{a}
Sweet potatoes (15%)	$70.5^{d,e}$	$10^{c,d}$	12.03^{c}
Sweet potatoes (22.5%)	71.5^{d}	8.70^{c}	11.15^{c}
Mix	$69.5^{c,e}$	10.85^{d}	14.81^{b}

(a-e. Means with different superscript within the same column differ significantly (P<0.05)

Table 2: Mean values of proximate chemical analysis for experimentally produced cooked beef burger

Formulation	Moisture %	Fat %	Protein%
Control	57.40^{a}	20^{a}	20.27^{a}
Soy (15%)	59.95^{b}	15.60^{b}	25.32^{b}
Soy (22.5%)	61.82^{c}	15^{b}	26.36^{c}
Sweet potatoes (15%)	53.11^{d}	$12.4^{c,d}$	28.03^{d}
Sweet potatoes (22.5%)	54.32^{e}	11.04^{c}	27.79^{d}
Mix	56.07^{f}	13.11^{d}	26.57^{e}

(a-f. Means with different superscript within the same column differ significantly (P<0.05)

The lower sensory scores of flavor in both soy and sweet potatoes formulations may be due to decrease in fat content and/or the beany flavor detected by the panelists in the soy-extended burger [4,21].However, *Vasquez et al.* [22] found no juiciness difference when 30% Textured soy protein was added to ground beef. All the obtained sensory panel scores of both raw and grilled beef burger in all formulations were in agreement with *ESS* [8].

Proximate Chemical Composition: Proximate chemical analysis of experimentally prepared raw beef burger immediately after processing (Table 1) pointed out the presence of significant differences (P <0.05) between the different formulations whereas the moisture content of the control burger patties was 63.50% which was lower than that of soy- or vegetable extended ones. It was cleared that addition of hydrated soy (2:1) and sweet potatoes significantly increased the moisture content of raw beef patties due to its higher water content. However, addition of sweet potatoes (15 and 22.5%) (Table 1) significantly reduced the fat content of raw beef burger patties to 10 and 8.7% respectively, attributable to the low fat content of the added vegetables. While, the addition of textured soy (15 and 22.5%) also reduced the fat content of raw beef burger patties to 13.50 and 13% respectively. The protein content of the control was significantly lower than that of soy-extended one, probably due to the high protein content of textured soy (40-45%). The protein content in raw beef patties with added sweet potatoes was significantly lower than that of the control due to the decrease in red meat content.

Similar results were obtained by *Tömek et al.* [23] *and Kaya and Gökalp* [24] who reported the increased protein content of meat products extended with textured soy.

Results of chemical analysis of experimentally formulated beef burger immediately after processing (Table 2) indicated that cooking resulted in decrease in moisture content by about 6.1 % in control formulation. The decrease in moisture content was slightly higher in the other treatments. The protein and ether extractable fat contents were slightly increased in all formulation after cooking. It was also obvious that the products formulated with sweet potatoes (22.5%) had the lowest fat content. All results of chemical analysis of experimentally formulated beef burger were copy with *ESS* [8].

Deterioration Criteria: The initial mean levels of pH of experimentally formulated beef burger (Table 3) ranged from 5.98 in the control products to 6.08 in soy (22.5%) extended one. However, frozen storage resulted in steady and slight, but not significant increase in the pH values for all formulations of both products, whereas the values at the end of the three months storage period were 6.13, 6.12, 6.16, 6.01, 6.14 and 6.07 for beef burger formulated with all beef, soy (15%), soy (22.5%), sweet potatoes (15%), sweet potatoes (22.5%) and mixture, respectively.

The mean values of total volatile base nitrogen immediately after formulation of beef burger were obviously low in all formulations while that of control were significantly lower than other formulations.

Table 3: Mean values of deterioration criteria for experimentally produced beef burger

		Storage time/w						
		0	2	4	6	8	10	12
pH	Control	5.98^{a}	5.99^{a}	6.02^{a}	6.06^{a,b}	6.09^{a}	6.11^{a}	6.13^{a}
	Soy (15%)	6.05^{a}	6.05^{a}	6.07^{a}	6.08^{a,b}	6.10^{a}	6.11^{a}	6.12^{a}
	Soy (22.5%)	6.08^{a}	6.09^{a}	6.11^{a}	6.12^{a}	6.14^{a}	6.15^{a}	6.16^{a}
	Sweet potatoes (15%)	5.93^{a}	5.93^{a}	5.95^{a}	5.96^{b}	5.98^{a}	5.99^{a}	6.01^{a}
	Sweet potatoes (22.5%)	6.00^{a}	6.05^{a}	6.06^{a}	6.08^{a,b}	6.09^{a}	6.12^{a}	6.14^{a}
	Mix	6.02^{a}	6.02^{a}	6.04^{a}	6.04^{a,b}	6.05^{a}	6.06^{a}	6.07^{a}
TVBN mg%	Control	3.3^{a,b}	3.7^{a,b,c,d,e}	4^{a}	4.3^{a}	4.4^{a}	4.5^{a}	5^{a}
Soy (15%)	4.8^{a,b}	5.1^{b,d,f}	5.1^{a}	5.2^{a}	5.5^{a}	5.8^{a}	6^{a}	
	Soy (22.5%)	4.9^{a}	5.2^{d}	5.3^{a}	5.5^{a}	5.8^{a}	5.9^{a}	6.1^{a}
	Sweet potatoes (15%)	3.2^{a,b}	3.4^{e,f}	3.7^{a}	3.8^{a}	4.2^{a}	4.5^{a}	4.8^{a}
	Sweet potatoes (22.5%)	3.1^{b}	3.3^{c,e}	3.6^{a}	3.9^{a}	4.1^{a}	4.4^{a}	4.7^{a}
	Mix	3.6^{a,b}	4^{b,c,d,e}	4.3^{a}	4.7^{a}	5^{a}	5.3^{a}	5.6^{a}
TBA mg/kg	Control	0.154^{a}	0.219^{a}	0.273^{a}	0.343^{a}	0.412^{a}	0.442^{a}	0.462^{a}
	Soy (15%)	0.141^{a,b}	0.200^{b}	0.259^{a}	0.311^{b}	0.391^{b}	0.411^{b}	0.422^{b}
	Soy (22.5%)	0.144^{a,b}	0.207^{a,b}	0.265^{a}	0.333^{a}	0.400^{c}	0.421^{b}	0.431^{b}
	Sweet potatoes (15%)	0.132^{b}	0.162^{c,d}	0.194^{b}	0.220^{c}	0.257^{d}	0.282^{c}	0.310^{c}
	Sweet potatoes (22.5%)	0.128^{b}	0.155^{c}	0.187^{b}	0.216^{c}	0.246^{d}	0.270^{c}	0.303^{c}
	Mix	0.134^{b}	0.173^{d}	0.223^{c}	0.263^{d}	0.312^{e}	0.352^{d}	0.396^{d}

(a-f. Means with different superscript within the same column differ significantly ($P<0.05$))

The mean values were 3.3, 4.8,4.9, 3.2, 3.1and 3.6 mg/100g for all beef, soy (15%), soy (22.5%), sweet potatoes 15 %, sweet potatoes (22.5 %) and mixture, respectively. It was also clear that during frozen storage the values were significantly increased with storage time of the soy (22.5 %) formulation showed the most significant changes probably due to the high microbial load of soy. At the end of storage period, the mean values were 5.0, 6.0, 6.1, 4.8, 4.7 and 5.6 mg/100g for all beef, soy (15%), soy (22.5%), sweet potatoes (15%), sweet potatoes (22.5 %) and mixture, respectively.

The initial mean levels of thiobarbituric acid calculated as mg malonoldehyde/kg were 0.154, 0.141, 0.144, 0.132, 0.128 and 0.134 mg/kg in beef burger for the products formulated all beef, soy (15%), soy (22.5%), sweet potatoes (15%), sweet potatoes (22.5 %) and mixture, respectively. Moreover, there was slight and steady increase in the values with frozen storage along the three months, whereas the values reached 0.462, 0.422, 0.431, 0.310, 0.303 and 0.396 mg/kg beef burger for the products formulated all beef, soy (15%), soy (22.5%), sweet potatoes (15%), sweet potatoes (22.5%) and mixture, respectively.

In this consideration, lipid oxidation has economic importance for the meat industry as it leads to the development of rancidity and chemical spoilage in food [25.26].

The results indicated that the thiobarbituric acid values were significantly higher in soy extended formulations than that of sweet potatoes extended formulations may be due to antioxidant effect of sweet potatoes. Similar findings were reported by *Ang and Young* [27] who found that thiobarbituric acid values were not affected by fat content or storage time except in products stored for 9 months.

Physicochemical Characteristics: Cooking characteristics for experimentally produced beef burger (Table 4) indicated that incorporation of soy (15 or 22.5%) significantly ($P< 0.05$) decrease the cooking loss percentage i.e. increase the cooking yield, due to its ability to hold up water and fat during cooking. *Muller and Redden,* [28] reported a decrease in fat and cooking loss due to addition of culinary beans in ground beef patties. *Sheard et al.* [29] reported that the cooking loss percentage of burger after frying was 28%. Cooking loss was relatively independent upon cooking method and being more dependent on product formulation and manufacturing. However, the use of sweet potatoes resulted in significant increase in cooking loss. *Muller and Redden* [28] reported that the cooking loss significantly increased with the use of vegetables extended burger probably due to its lower ability to hold the moisture in the meat matrix.

Table 4: Mean values of physicochemical criteria for experimentally produced beef burger

Formulation	WHC%	Shrinkage%	Diameter reduction%	Moisture retention%	Fat retention%	Cooking loss %
Control	94.45^{a}	10.00^{a,b}	10.20^{a,b,d}	48.79^{a,b}	98.55^{a,b}	15.00^{a}
Soy (15%)	95.95^{b,c}	9.43^{a,b}	9^{a,b,c}	51.56^{c,d}	99.37^{a,b}	14.00^{a,b}
Soy (22.5%)	96.40^{b}	9.00^{a}	8.43^{b}	53.47^{e}	99.80^{b}	13.50^{b}
Sweet potatoes (15%)	91.85^{b,c}	12.90^{c}	11.10^{d}	42.49^{a,c}	99.20^{a,b}	20.00^{c}
Sweet potatoes (22.5%)	90.65^{b,c}	13.10^{c}	11.16^{d}	42.37^{b,d}	98.90^{a,b}	22.00^{d}
Mix	94.05^{c}	11.05^{b}	10.65^{c,d}	46.12^{c,d,e}	99.35^{a}	17.75^{e}

(a-e. Means with different superscript within the same column differ significantly (P<0.05)

WHC*:* water holding capacity

Table 5: Mean values of bacterial load (log10 CFU/g) for experimentally produced beef burger

		Storage time/w						
		0	2	4	6	8	10	12
APC	Control	3.00^{a}	3.10^{a}	3.20^{a}	3.40^{a}	3.50^{a}	3.60^{a}	3.70^{a}
	Soy 15%	4.00^{b}	4.10^{a,b}	4.20^{b,c}	4.30^{b}	4.40^{b}	4.60^{b}	4.70^{b}
	Soy 22.5%	4.00^{b}	4.40^{b}	4.50^{b}	4.70^{b}	4.90^{b}	5.10^{b}	5.40^{c}
	Sweet potatoes15%	3.00^{a}	3.11^{a}	3.11^{a}	3.40^{a}	3.60^{a}	3.80^{a}	3.90^{a}
	Sweet potatoes 22.5%	3.00^{a}	3.10^{a}	3.10^{a}	3.40^{a}	3.70^{a}	3.70^{a}	3.80^{a}
	Mix	3.00^{a}	3.10^{a}	3.20^{b}	3.40^{a}	3.50^{a}	3.50^{a}	3.60^{a}
Psychrotrophes	Control	<2.00^{a}	2.00^{a}	2.50^{a}	2.70^{a}	3.00^{a}	3.10^{a}	3.20^{a}
	Soy 15%	2.00^{b}	2.40^{b}	2.50^{a}	2.70^{a}	2.90^{a}	3.00^{a,b}	3.10^{a,b}
	Soy 22.5%	2.10^{b}	2.40^{b}	2.50^{a}	2.60^{a,b}	2.90^{a}	2.90^{b,c}	3.00^{b,c,d}
	Sweet potatoes15%	<2.00^{b}	2.00^{a}	2.40^{a}	2.60^{a,c}	2.90^{a}	3.00^{a,c,d}	3.10^{a,c}
	Sweet potatoes 22.5%	2.00^{a}	2.00^{a}	2.00^{b}	2.50^{b,c,d}	2.70^{b}	2.90^{b,d}	3.00^{b,c,d}
	Mix	< 2.00^{a}	< 2.00^{c}	2.20^{c}	2.40^{d}	2.50^{c}	2.70^{e}	2.90^{d}
Staphylococci	Control	<2.00^{a}	2.00^{a}	2.20^{a}	2.30^{a}	2.40^{a}	2.40^{a}	2.20^{a}
Soy 15%	<2.00^{a}	2.00^{a}	2.20^{a}	2.30^{a}	2.40^{a}	2.40^{a}	2.20^{a}	
	Soy 22.5%	2.10^{b}	2.30^{c}	2.30^{b}	2.40^{b}	2.60^{c}	2.60^{c}	2.30^{b}
	Sweet potatoes15%	<2.00^{a}	2.10^{b}	2.30^{b}	2.30^{a}	2.40^{a}	2.40^{a}	2.30^{b}
	Sweet potatoes 22.5%	<2.00^{a}	2.30^{c}	2.40^{c}	2.40^{b}	2.50^{b}	2.50^{b}	2.40^{c}
	Mix	2.30^{c}	2.40^{d}	2.40^{c}	2.50^{c}	2.60^{c}	2.60^{c}	2.40^{c}
Coliforms	Control	0.60^{a}	0.60^{a}	0.60^{a}	0.60^{a}	0.84^{a}	0.95^{a}	0.95^{a}
	Soy 15%	0.95^{b}	1.14^{b}	1.14^{b}	1.14^{b}	1.17^{b}	1.30^{b}	1.30^{b}
	Soy 22.5%	1.17^{c}	1.30^{b}	1.36^{c}	1.36^{c}	1.60^{c}	1.60^{c}	1.95^{c}
	Sweet potatoes15%	0.60^{a}	0.60^{a}	0.60^{a}	0.60^{a}	0.84^{a}	0.95^{a}	0.95^{a}
	Sweet potatoes 22.5%	0.95^{b}	1.14^{b}	1.14^{b}	1.14^{b}	1.17^{b}	1.30^{b}	1.30^{b}
	Mix	1.30^{c,d}	1.30^{b}	1.32^{c}	1.32^{c}	1.36^{e}	1.84^{d}	1.84^{c}
EPEC	control	0.60^{a}	0.95^{a}	0.95^{a}	0.95^{a}	0.95^{a}	0.95^{a}	0.95^{a}
	Soy 15%	0.60^{a}	0.60^{b}	0.60^{b}	0.95^{a}	0.95^{a}	0.95^{a}	0.95^{a}
	Soy 22.5%	1.32^{b}	1.32^{c}	1.32^{c}	1.36^{b}	1.36^{b}	1.36^{b}	1.60^{b}
	Sweet potatoes15%	<0.48^{c}	<0.48^{d}	<0.48^{d}	0.60^{c}	0.60^{c}	0.60^{c}	0.84^{a}
	Sweet potatoes 22.5%	0.84^{a}	0.84^{b}	0.84^{b}	0.95^{a}	0.95^{a}	0.95^{a}	1.17^{c}
	Mix	<0.48^{c}	<0.48^{d}	0.60^{b}	0.60^{c}	0.60^{c}	0.60^{c}	0.95^{a}

(a-e. Means with different superscript within the same column differ significantly (P<0.05)

APC: aerobic plate count

EPEC: Enteropathogenic E.coli

Water holding capacity percentage immediately after processing of beef burger showed significant differences (P<0.05) between different formulations where soy-extended formulations had the highest values followed by the control formulation, while those formulated with sweet potatoes had the lowest values.

The results for both cooking loss and water holding capacity percentages were reflected on the values of the other cooking parameters, where the formulations which had low cooking loss and higher water holding capacity generally had high moisture and fat retention as well as low diameter reduction and shrinkage percentages. In this respect, the soy extended formulations had significantly higher water and fat retention and lower shrinkage and diameter reduction percentages ($P<0.05$), whereas sweet potatoes formulations had lower water and fat retention values than that of soy extended formulations and higher diameter reduction and shrinkage percentages.

The results of fat retention in sweet potatoes extended formulations and soy extended formulation were higher than that of the control formulation and these results are in agreement with those obtained by *Kregal et al.* [30] and *Hoelscher et al.* [30] who observed that low fat patties retained more fat during cooking than higher fat patties.

Bacteriological Quality: Results of the bacterial loads of experimentally prepared raw beef burger immediately after processing (Table 5) indicated that the mean *counts of aerobic plate*, *psychrotrophic*, presumptive *Staphylococci*, *coliforms* and Enteropathogenic *E. coli* counts (log_{10} CFU/g) of control formulation were 3.0, <2.0, <2.0, 0.60 and 0.60 respectively. The mean counts of *aerobic plate*, *psychrotrophic*, presumptive *Staphylococci*, *coliforms* and Enteropathogenic *E. coli* counts (log_{10} CFU/g) of (15%) sweet potatoes extended formulation immediately after processing (Table 5) were 3.0, <2.0, <2.0, 0.60 and <0.48 compared with 3. 0, 2.0, <2.00, 0.95 and 0.84 for (22.5%) sweet potatoes extended formulation, respectively.

On the other hand, the mean counts of *aerobic plate*, *psychrotrophic*, presumptive *Staphylococci*, *coliforms* and Enteropathogenic *E. coli* counts (log_{10} CFU/g) of 15% soy extended formulation immediately after processing (Table 5) were 4.0, 2.0, <2.0, 0.95 and 0.60 compared with 4. 0, 2.10, 2.10, 1.17 and 1.32 for (22.5%) soy extended formulation respectively. Freezing storage induced slight effect on the investigated bacteria in all formulations. The results of APC are accepted according to *ESS* [8] in all formulations along the storage period except the 22.5% soy extended one. While, coliforms and Enteropathogenic *E.coli* count were within the accepted levels. Also, *S. aureus, Salmonellae* and *E. coli* were not found in all formulations along storage period of the beef burger.

CONCLUSION

Textured soy granules or sweet potato or mixture of them can partially substitute the meat in production of beef burger to decrease the cost of the product and provide a healthy food for the consumer. However, increasing the level of this substitution significantly reduced the sensory panel scores for nearly all the investigated parameters especially on the flavor and overall acceptability. Significant improvement in the color, tenderness, juiciness and low deterioration criteria of burger which were formulated with sweet potatowas achieved. Recognizable reduction in the formulation cost of burgers was achieved in all extended formulations where the replacement of meat mass by 30% mixture of textured soy granules and sweet potato (1:1) scored the lowest price and still with accepted quality parameters.

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