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Quality and acceptability of value-added beef burger

Gehan M. A. Kassem, M. M. T. Emara

Department of Food Hygiene and Control, Faculty of Veterinary Medicine, Cairo University, Giza, Egypt.

The sensory quality attributes of coated and uncoated beef burger patties formulated with texture soy granules or vegetables (peas and carrots) were studied in comparison to that of the control ones. Incorporation of textured soy granules significantly reduced the color, marbling, appearance, flavor, tenderness, juiciness, taste and overall acceptability in comparison with either control or vegetable extended burger. Addition of peas and carrots to uncoated burger significantly reduced the binding scores in raw samples, as well as flavor and juiciness in cooked samples, however, no significant differences could be observed in the other sensory attributes in both raw and cooked products. Vegetable extended burger had the highest cooking loss percent (20.14), followed by control samples (17.83), while soy extended product had the lowest value (15.82%). Application of batter and breading to vegetable extended burger significantly improved the investigated sensory parameters in comparison with the uncoated samples. On the other hand, application of batter and breading to soy extended burger revealed no improvement in the sensory quality attributes in both raw and cooked samples. Addition of soy granules and vegetables significantly increased the moisture, ash and carbohydrate and reduced the fat content of raw burger patties. Moreover the incorporation of textured soy significantly increased the protein content.

The retail sale of beef-burger is a big business. High meat prices prompted the meat producers in Egypt to produce various meat brands extended with non-meat ingredients. However, maintaining the nutritional contribution, organoleptic and textural properties of such products is a matter of challenge, which necessitates more effort to protect the product integrity, taste, flavor and textural sensory attributes (Chambers and Bowers, 1993; Risvik, 1994). Most of the meat products are rich in fats, but deficient in complex carbohydrates (Papadina and Bloukas, 1999). High animal fat content, saturated fatty acids and cholesterol of various meat products are associated with cardiovascular diseases (Oh *et al.,* 2005), some types of cancer (Smith-Warner and Stampfer, 2007) and obesity (Howarth *et al.,* 2005; Fernandez-Gines *et al.,* 2005). To achieve healthier meat products, it is recommended to reduce high fat content to appropriate limits, and increase the levels of other substances with beneficial properties (Jo *et al.,* 2003; Arihara, 2006).

Vegetable products (Serdaroglu and Degirmencioglu, 2004; Turhan *et al.,* 2007) and soy bean (Ray *et al.,* 1981; Miles *et al.,* 1984; Pietrasik and Duda, 2000; Porcella *et al.,* 2001; Gujral *et al.,* 2002; Das *et al.,* 2008) are added to raw or cooked meat products to improve its functional properties, minimize the product cost while improving or at least maintaining nutritional and sensory qualities of end products that consumers expect (McWatters, 1990). Soy protein is one of the most widely used vegetable proteins in meat industry due to its various technological benefits, where it plays a significant role in the modification of the functional characteristics of meat products. It can also be used to replace part of the animal fat. With its hydrating capacity, soy protein can considerably decrease the final cost of the meat products. Despite the many advantages of soybean, its use has been limited because of the characteristic beany flavor (Mizutani and Hashimoto, 2004). Beside the important role in human nutrition as vegetables provide essential minerals and vitamins. (Yue Xu, 2001), they could also serve as fillers, binders, fat replacers, and sources of dietary fiber and natural antioxidants in a meat system (Hedrick *et al.,* 1994). Moreover, extension of meat products with green vegetables could reduce production costs and improve the nutritional qualities of the products.

Meat industry is in continuous updating to improve eating quality characteristics, desirability, value, and palatability attributes which are the major determinants of consumer acceptance and preference. In this respect, many efforts have been made to improve the quality and stability of burgers to meet the consumer demands. However, to date, there are no vegetable-extended burgers on the commercial Egyptian markets. Therefore, the objective of this research was to develop vegetable-based beef burger and to maintain the sensory and chemical characteristics of this burger.

Materials and methods

Experimental design. A three trial-based experiment was designed to evaluate the quality of coated and uncoated beef burger formulated with textured soy protein and vegetables (peas and carrots) in comparison with the control one. Three different meat mixes (30 kg each) were produced; the first (control) was prepared with 65% lean beef, 20% beef fat, 1.8% sodium chloride, 0.003 polyphosphate, 3% bread crumb, iced water and spices. The second one was prepared with replacement of 20% of the meat mass with hydrated soy, and the third one was prepared with replacement of 20% of the meat with the vegetables. After forming of the burger patties, half of each trial was coated with batter and breading, and the other half left uncoated.

Preparation of the materials. Imported frozen beef chuck was purchased from a local store during the 1st third of its shelf life (9 months). Local beef fat was purchased from the Cairo abattoir shortly after preparation of beef carcasses, washed and kept frozen. The lean meat materials were ground through a 6 mm plate, while the fat radicals were ground through a 4 mm plate.

The soy granules were purchased from a local supplier, then soaked with twice its weight water and kept in the refrigerator for the second day, where it was minced using 3 mm plate before use. Small pieces of peeled carrots and peas were boiled for 15 minutes, cooled and kept frozen.

The dry batter mix used for application of batter and breading was formulated with 73% wheat flour, 24% maze starch, 2% salt and 0.5% spices. All dry ingredients were mixed at low speed for 1 minute in a stainless steel bowl mixer. Dry ingredients were then re-hydrated with water at a rate of 1:1 for two minutes, cooled to 10ºC in a refrigerator, and then stored in an ice bath till use to maintain the temperature during batter application.

Burger production. For the production of control samples, the ground beef was first mixed in a paddle-type mixer with sodium chloride, polyphosphates, and spices for short time before iced water was added, and then fat is mixed for short time before bread crumbs is added, with the temperature of the final meat mix must not exceed -5ºC. The meat mix was then formed into discs of 100g, kept frozen at -18ºC, and used as control. For the production of beef burger extended with soy or vegetables, the ground beef was mixed with the recommended amount of rehydrated textured soy or vegetables before mixing with other ingredients.

The produced burger patties from each group were divided into two parts, the 1st part was kept uncoated at -18ºC. The second part was coated with batter and breading. Where, the burger discs were pre-dusted with wheat flour, dipped into liquid batter (10ºC) for 15 seconds, drained for 15 seconds and coated with bread crumps. The burger discs were weighed again to determine the coated mass (batter uptake). Coated burger was flash fried using sunflower oil at 170ºC for 30 seconds. The flash fried burger discs were cooled and kept frozen at -18ºC till examination.

Investigations.

Sensory evaluation and cooking loss. Three samples from each of the uncoated beef burger patties were coded with random numbers and evaluated by 15 members with past experience of meat product examination, from the Department of Food Hygiene and Control, Faculty of Veterinary Medicine, Cairo University. The samples were evaluated for forming, binding, color, marbling, appearance, odor and overall acceptability using 10-point descriptive scales, where 1 for extremely poor and 10 for excellent. The beef burger patties were then cooked in a preheated electrical grill for a total of 5 minutes, 2.5 minutes for each side (70ºC core temperature) before being coded and evaluated by the same panelists for bite, tenderness, flavor, juiciness, taste, binding, shape and overall acceptability.

The batter and breaded beef burger was evaluated by the same panelists before cooking for the color and adhesion of the coat, texture, hardness and overall acceptability, and immediately after deep-fat frying to 70ºC core temperature for evaluation of coating characteristics after frying as well as for bite, tenderness, flavor, juiciness, taste, shape, binding, crispiness and overall acceptability. Moreover, breading crumbs that collected after frying were weighted and the percentage of breading loss was determined as a percentage of the original weight of the coated product (Suderman *et al.,* (1981). The weight of the three beef patties per each trial was measured at room temperature before and after cooking to detect cooking loss.

Proximate composition and energy value. Three samples from each experiment were homogenized thoroughly two times before being sampled for chemical analysis. Moisture, ether-extractable fat, protein and ash contents were determined by the standard procedure of AOAC, (1995). Carbohydrate contents were calculated by difference. Total energy estimates (kcal) for raw and cooked beef patties were calculated on the basis of a 100 g sample using Atwater values for fat (9 kcal/g), protein (4.02 kcal/g) and carbohydrate (3.87 kcal/g) (Mansour and Khalil, 1997).

Statistical analysis. The values given in each treatment category are the mean value of three replicates. All data were analyzed using Statistical Analysis System (SAS, 1995). 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 $P \leq 0.05$.

Results and discussion

Sensory quality of uncoated burger patties. There was no significant difference ($p \leq 0.05$) in the sensory scores of forming, color, marbling, appearance, odor and overall acceptability between control and vegetable extended raw burger patties, whereas, binding scores for vegetable-extended burger were lower than the other treatments. Incorporation of texture soy granules significantly decreased sensory scores of color, marbling, appearance, odor and overall acceptability than either that of control or vegetable extended burger (Table 1). However, burger containing texture soy granules were similar in forming and binding characteristics with the other products.

Cooked burger patties extended with soya showed significantly lower scores for the majority of examined sensory parameters except binding than control and vegetable extended burger. Meanwhile, no significant difference was established among the control and vegetable extended burger patties. The obtained results were in agreement with those reported by (Brewer *et al.,* 1992; Bilek and Turhan, 2009).

Soybean is a highly nutritious food material. It plays an important role in human nutrition and health (FDA, 1999). It is used extensively in meat products as a binder for improving yields, as a gelling agent to enhance emulsion stability and as a meat replacement to reduce costs (Lecomte *et al.,* 1993; Rentfrow *et al.,* 2004).

The lower sensory scores of flavor in both soy- and vegetable extended burger may be due to decrease in fat content and/or the beany flavor detected by the panelists in the soy-extended burger (Mizutani and Hashimoto, 2004; Das *et al.,* 2006). In this regard, Singh *et al.,* (2002) reported that addition of texture soy protein significantly reduced acceptability of goat meat patties in a dose dependent manner. Moreover, Brewer *et al.,* (1992); King *et al.,* (2001) pointed out that the addition of soy extenders decreased beefy flavor and increased off flavor scores in ground beef patties.

The control samples had significantly higher cooking loss percent probably due to the higher loss of fat during cooking (Bilek and Turhan, 2009). 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 (Muller and Redden, 1995), whereas, soy-formulated burger had the lowest cooking loss percent due to its ability to hold up water and fat during cooking. A possible connection between increased cooking yield and higher fat retention has been reported by (Serdaroglu and Degirencloglu, 2004). Keeping fat within the meat batter during processing is necessary to ensure sensory quality and acceptability. These results supported the findings of (Turhan *et al.,* 2005) in meat burgers containing hazelnut pellicle and Turhan *et al.,* (2007) in beef patties formulated with wet okara.

Generally, the sensory quality of beef burger was adversely affected with the use of non-meat ingredients. However, the effect of vegetable is lower than that of soy granules. A limited number of studies had been conducted on the suitability of vegetables for use in comminuted meat products. Muller and Redden, (1995) reported a decrease in fat and cooking loss due to addition of culinary beans in ground beef patties. Addition of 2% carrot and 10% spinach improved the oxidative stability of poultry hamburgers (Pizzocaro *et al.,* 1998). Improvement in color and of beef patties due to the addition of boiled carrot and sweet potato have also been reported by (Saleh and Ahmed, 1998). However, Bilek and Turhan, (2009) reported that the addition of flaxseed flour significantly affected the appearance, flavor, tenderness, juiciness and overall acceptability of beef patties. On the other hand, the sensory scores of beef patties decreased as the flaxseed content increased. Turhan *et al.,* (2005) found that the overall acceptability scores of beef burgers decreased after more than 1–2% hazelnut pellicle addition.

Meat consumers can readily distinguish characteristics of raw and cooked meat and meat products that they prefer. Color measurement is a critical objective quality parameter that can be used for quality index measurements of quality of the meat products as well as quality changes as a result of processing, storage, and other factors (Hutchings, 1999). Aroma and flavor are probably the most important attributes that influence the sensory properties of comminuted meat products extended with nonmeat protein additives. Brewer *et al.,* (1992) reported that soy extenders decreased beefy flavor and increased off-flavor scores.

Sensory quality of battered and breaded beef burger patties. The results given in Table (2) indicated that the application of batter and breading significantly increased the weight of beef burger patties by 28.82, 29.74 and 25.93% for control, soy- and vegetable-extended burger. Moreover, the application of batter and breading slightly lower the color score in all the treatment with the vegetable extended burger had the highest score probably due to the color of peas and carrots. The differences in formulation of beef burger patties induced significant differences in all the investigated sensory characteristics, with the control and soy-extended had higher adhesion scores, while the vegetable-extended had the lowest value probably due to the bad adhesion between the vegetables and the coat. Moreover, the soy extended product showed the highest hardness score which generally decrease the overall acceptability. The coated soy-extended burger had the lowest sensory panel score, whereas the other two types were not significantly different in nearly all the investigated parameters. Cooking coated burger patties to an internal temperature of 70ºC in deep fat resulted in significant lower cooking loss than the uncoated burger due to the fact that the coat seals the product and prevents the moisture loss. Moreover, the significantly higher crump loss in vegetable extended burger was correlated with the low sensory score of adhesion in comparison to the high adhesion score for soy-extended burger.

Proximate chemical analysis and energy value. The data recorded in table (3) pointed out that the moisture content of the control burger patties was 60.75% which was lower than that of soy- or vegetable extended ones. It was clear that addition of hydrated soy (2:1) and vegetables significantly increased the moisture content of raw beef patties due to it higher water content. Moreover, the fat content of raw control was within the acceptable technological levels (20%). However, addition of peas and carrots significantly reduced the fat content of raw beef burger patties to 12.6%, attributable to the low fat content of the added vegetables and the elimination of the added beef fat. The addition of textured soy also reduced the fat significantly to 14.9%. 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 vegetables was slightly lower than the control due to the decrease in red meat content. Tömek *et al.,* (1988); Kaya and Gökalp, (1990) reported similar results regarding the increased protein content of meat products extended with textured soy**.** Meanwhile, ash and carbohydrate contents of raw beef patties were significantly increased by the addition of both textured soy and vegetables. Similar findings were reported by (Bilek and Turhan, 2009). Cooking of the studied burger patties precluded that there was about 5-7% less moisture, 2.34-4.4% higher fat, 3.5-4% higher protein, 1% higher ash, and 1-3% lower carbohydras depending on the formulation used in production of burger patties. Modi *et al.,* (2003) reported that frying resulted in about 10% less moisture, 1–2% higher protein and 0.4–1.2% higher ash content irrespective of binders.

The significantly higher energy value of the control burger formulated with beef fat than that of either soy- or vegetable extended beef burger could be attributed to the fact that fats provide 9 kcal/g, more than twice that supplied by proteins or carbohydrates (Giese, 1996). It is of interest to emphasize that cooking significantly increased the energy value of all types of burger patties. The highest energy value was observed in the control burger, while that of vegetable extended one was the lowest. However, Bilek and Turhan, (2009) attributed the high energy value of cooked beef patties to the reduction in moisture content during cooking.

The proximate chemical analysis and energy value of coated burger (Table 3) proved that the moisture content of control coated beef burger (60. 32%) was slightly and significantly lower than either soy-extended (61.5%) or vegetable extended burger (61.56%) burger.

Table (1): Sensory panel scores of raw and cooked burger patties.

	Control	Soy-extended	Vegetable-extended
Uncooked product			
Forming	9.33^{a}	9.33^{a}	9.00^{a}
Binding	9.67^{a}	9.67^{a}	9.00^{b}
Color	9.67^{a}	8.00^{b}	9.67^{a}
Marbling	9.67^{a}	7.00^{b}	9.00^{a}
Appearance	9.67^{a}	7.00^{b}	10.00^{a}
Overall acceptability	9.05^{a}	8.00^{b}	9.22^{a}
Cooked product			
Bite	8.67^{a}	7.33^{b}	8.67^{a}
Tenderness	8.67^{a}	6.17^{b}	8.33^{a}
Flavor	9.33^{a}	6.00^{b}	7.33^{c}
Juiciness	9.17^{a}	7.00^{b}	8.33^{c}
Taste	8.33^{a}	6.00^{b}	7.67^{c}
Binding	8.33^{a}	8.00^{a}	8.33^{a}
Shape	8.67^{a}	7.00^{b}	8.33^{a}
Overall acceptability	8.67^{a}	6.50^{b}	8.33^{a}
Cooking loss%	17.83^{a}	15.82^{b}	20.14^{c}

$^{a-c:}$ Means with different superscript within the same row differ significantly at $P \leq 0.05$.

Table (2): Sensory panel scores for raw and cooked battered and breaded burger.

	Control	Soy-extended	Vegetable-extended
Raw product			
Color of coat	8.33^{a}	8.13^{a}	8.67^{b}
Adhesion	9.00^{a}	9.33^{b}	8.00^{c}
Texture	8.67^{a}	7.00^{b}	8.33^{c}
Hardness	3.33^{a}	7.00^{b}	3.13^{a}
Overall acceptability	8.67^{a}	7.13^{b}	8.00^{a}
Cooked product			
Bite	8.33^{a}	7.33^{b}	8.67^{a}
Tenderness	9.00^{a}	6.33^{b}	8.67^{a}
Flavor	9.16^{a}	6.00^{b}	9.00^{a}
Juiciness	9.67^{a}	7.16^{b}	9.33^{a}
Taste	8.33^{a}	6.33^{b}	8.00^{a}
Shape	8.00^{a}	7.67^{a}	8.33^{a}
Binding	7.33^{a}	7.00^{a}	7.00^{a}
Crispiness	7.00^{a}	7.67^{b}	7.00^{a}
Overall acceptability	8.33^{a}	7.00^{b}	8.33^{a}
Crumb loss%	1.00^{a}	0.50^{b}	2.50^{c}
Cooking loss%	7.70^{a}	3.26^{b}	7.11^{c}
Batter uptake %	28.82^{a}	29.74^{a}	25.93^{b}

$^{a-c:}$ Means with different superscript within the same row differ significantly at $P \leq 0.05$.

Table (3): Proximate chemical composition and total energy of coated and uncoated burger.

	Control		Soy formulated		Vegetable formulated	
	Uncoated	Coated	Uncoated	Coated	Uncoated	Coated
Uncooked product						
Moisture	60.75^{a}	60.32^{a}	61.80^{b}	60.50^{c}	61.56^{b}	60.20^{c}
Fat	20.00^{a}	20.50^{a}	14.90^{b}	16.00^{c}	12.60^{d}	14.50^{d}
Protein	14.95^{a}	13.50^{b}	15.73^{c}	15.09^{c}	14.50^{a}	14.30^{a}
Ash	2.50^{a}	3.36^{b}	3.50^{b}	4.00^{c}	5.42^{d}	4.90^{e}
Carbohydrates	1.81^{a}	2.32^{b}	4.07^{c}	4.41^{c}	5.92^{d}	6.10^{e}
Energy (Kcal)	247.10^{a}	247.74^{a}	212.98^{b}	221.73^{c}	194.60^{d}	211.60^{b}
Cooked product						
Moisture	54.91^{a}	52.48^{b}	55.80^{a}	47.60^{c}	54.80^{a}	54.90^{a}
Fat	22.34^{a}	24.90^{b}	18.40^{c}	26.50^{d}	17.00^{e}	17.75^{e}
Protein	18.45^{a}	17.32^{a}	19.20^{b}	19.00^{a,b}	18.70^{a}	18.50^{a}
Ash	3.50^{a}	4.00^{a}	4.50^{a}	4.60^{a}	6.50^{b}	5.65^{b}
Carbohydrates	0.80^{a}	1.30^{b}	2.10^{b}	2.30^{c}	3.00^{c}	3.20^{c}
Energy (Kcal)	278.33^{a}	298.76^{b}	250.91^{c}	323.76^{d}	236.97^{e}	246.50^{c}

$^{a-e:}$ Means with different superscript within the same row differ significantly at $P \leq 0.05$.

Such finding could be safely correlated to the deep fat frying, which also caused a concomitant increase in fat content of coated burger. The application of batter and breading resulted in a significant decrease in protein content, and increase in ash and carbohydrates contents due to the batter uptake. Moreover, the higher energy value of coated burger was probably due to oil absorption by the coating materials during deep-fat frying. Frying the coated control and vegetable extended burger resulted in decrease in moisture (6-7.8%) and carbohydrate (1-2.9%), as well as increase in fat (4.25-4.4%), protein (3.8-4.2%), and ash (0.6-0.75%). (Kolar *et al.,* 1985) correlated the significant increase in fat content of soy-extended burger after deep fat frying with the high fat binding capacity of soy proteins. Deep-fat frying of coated beef burger with subsequent fat absorption significantly increase the energy value, where the most pronounced value was that of soy-extended burger, while the vegetable extended burger was slightly affected.

Conclusions

From the results obtained during this study we may safely conclud that vegetable can be partially substituted fat and meat in production of beef burger patties to change the bad fast food concept and proved healthier for consumer with no detrimental impact on the sensory attributes of the product. Moreover, application of batter and breading improved the sensory quality of the burger patties especially that produced with vegetable.

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مدى جودة وقبول البرجر البقري عالي القيمة

تم دراسة معايير الجودة الحسية والقيمة الغذائية للبرجر البقري المصنع بدون إضافات كمجموعة ضابطة وكذا باستخدام فول الصويا أو الخضروات (البسلة والجزر) والذي تم تغطيته بطبقة بانية وكذا غير المغطى بالبانية. وقد لوحظ أن استخدام فول الصويا يؤثر سلبا علي الخواص الحسية للبرجر (اللون والنكهة) وأيضا استخدام الخضروات أدي إلي قلة الترابط, العصيرية والنكهة في المنتج عن المجموعة الضابطة. وقد سجلت نسبة الفقد نتيجة الطهي في البرجر بالخضروات (٢٠.١٤%) اعلي قيمة عن المجموعة الضابطة (١٧.٨٣%) و مجموعة البرجر بفول الصويا (١٥.٨٢%). وقد حسن استخدام البانية من الخواص الحسية لمجموعة البرجر بالخضروات مقارنة بالمجموعة الضابطة ولكن لم تؤدى إضافة طبقة البانية إلى تحسين ملحوظ في خواص مجموعة البرجر بالصويا الحسية. وبفحص القيمة الغذائية وجد إن استخدام الصويا أدي إلى زيادة نسبة الرطوبة, البروتين, الرماد والكربوهيدرات وخفض نسبة الدهون بشكل ملحوظ عن المجموعة الضابط أما استخدام الخضروات لم يؤدى لتغير نسبة البروتين عن المجموعة الضابط ,ولكن أدى إلى زيادة نسبة الرطوبة, الرماد والكربوهيدرات وانخفاض نسبة الدهن. وكانت مجموعة البرجر بالخضروات هي اقل المجموعات في السعرات الحرارية سواء مطهية أو غير مطهية مغطاة بالبانية أو غير مغطاة. ومن ذلك يمكن القول بان إضافة الخضروات إلى البرجر البقري اثر علي الخواص الحسية للمنتج عن المجموعة الضابطة ولكنه ظل مقبول بدرجة عالية كما أدى إلى تحسين القيمة الغذائية للبرجر وذلك بخفض نسبة الدهن وكذلك السعرات الحرارية.