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Quality Attributes of Beef Burger Patties Extended with Soybean Flour and Water melon Seed Cakes

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Abstract: The study was conducted to determine the effect of blending soybean flour (SF) and watermelon seed cake (WMSC) as meat extenders in the processing of beef burgers. The experiment was composed of five treatments: the control beef meat only, 10% SF, 20% SF, 10% WMSC and 20% WMSC. Several parameters were evaluated using subjective and objective measurements: proximate chemical analysis, pH and water holding capacity, cooking losses, color and sensory evaluation. The fat percentage of the four treatments increased with the level of SF and WMSC; while the control treatment had the lowest fat percentage and the highest cooking losses compared with the other treatments. The 20% WMSC had significantly ($P<0.05$) the lowest cooking losses and improved WHC. The addition of WMSC resulted in a significant ($P<0.05$) decrease in cooking losses compared with SF ($P<0.05$) WMSC was superior to SF in protein and mineral contents, water holding capacity and cooking losses. The color values of the burger were significantly different among treatments ($P<0.05$).

There was a significant improvement in the color, juiciness and tenderness of the extended burger with ($P<0.05$) and WMSC in comparison with the control. There were no significant difference ($P>0.05$) between SF and WMSC in color, tenderness and juiciness. However SF was superior to WMSC in flavor and overall acceptability.

This study revealed the possibility of adding WMSC as extender in beef burger formulation. However it was almost similar to SF that has been used as extender in burger formulation in different parts of the world. It is recommended to utilize WMSC as extender in ground beef patties formulation with 10% level at this stage.

Keywords: Quality, Attributes, Burger, Soybean, Watermelon, Cakes

المستخلص: أجريت الدراسة لمعرفة تأثير إضافة دقيق فول الصويا وكسب بذور البطيخ كمواد باسطة للحم في صناعة البيرقر البفرى. تضمنت الدراسة خمس معاملات لحم البقر فقط (المعاملة الشاهد) ، 10% دقيق فول الصويا، 20% دقيق فول الصويا، 10% كسب بذور البطيخ و 20%كسب بذور البطيخ. تم تقييم العديد من المتغيرات بإستخدام قياسات حسية وفعلية شملت: التحليل الكيميائى التقريبي، الأس الهيدروجيني، قابلية حمل الماء، فاقد الطهي، اللون والتقييم الحسي. زادت نسبة الدهن للمعاملات الأربع بزيادة مستويات دقيق فول الصويا وكسب بذور البطيخ بينما كانت المعاملة الشاهد الأقل فى نسبة الدهن والأعلى فى فاقد الطهى مقارنه ببقية المعاملات. معاملة 20% كسب بذور البطيخ كانت الاقل فى فاقد الطهى والأعلى فى نسبة البروتين وحسنت معنويا (P<0.05) القدرة

على حمل الماء مقارنة مع بقية المعاملات. إضافة كسب بذور البطيخ قللت معنويا (P<0.05) من فاقد الطهي مقارنة مع دقيق فول الصويا. إن كسب بذور البطيخ قد فاق دقيق فول الصويا في نسبة البروتين، نسبة المعادن، قابلية حمل الماء، وفاقد الطهي. اختلفت قيم اللون للبيرقر معنويا (P<0.05) بين المعاملات. كان هنالك تحسين معنوى (P<0.05) فى اللون والعصيرية والطراوة للبيرقر المضاف اليه دقيق فول الصويا وكسب بذور البطيخ مقارنة بالمعاملة الشاهد. لم توجد فروقات معنويه (P>0.05) بين دقيق فول الصويا وكسب بذور البطيخ فى اللون والطراوة والعصيرية. لكن دقيق فول الصويا كان أفضل من كسب بذرة البطيخ فى النكهة والقبول العام.

خلاصة الأمر أن الدراسة قد أظهرت امكانية إضافة كسب بذور البطيخ كمادة باسطة في صناعة البيرقر. وهى بذلك تماثل دقيق فول الصويا الذى يضاف كمادة باسطة للبيرقر فى شتى أنحاء العالم. ويفضل فى هذه المرحلة اضافة 10% من كسب بذور البطيخ كمادة باسطة فى صناعة اللحوم_المفرومة

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Introduction

The importance of meat in the diet is that it is a source of protein which contains the essential amino acids in addition to fats, minerals and vitamins. Several factors have contributed to the change in meat consumption patterns; among these factors are changes in lifestyle, income, urbanization, demographic changes, food price changes improvements in meat processing, migration and the influence of the mass media. Increasing interest have been shown in partial replacement of meat with extenders, binders and fillers in order to minimize the product cost while improving or at least maintaining nutritional and sensory qualities of end products that consumers expect (Watters, 1990).

The blending of meat with cheaper plant products through manufacturing can create low-cost meat products and increase consumer's accessibility to animal protein products. Processed meat products provide consumers with a wide variety of flavors and textures and allow efficient use of less desirable meat cuts and trim.

Soy protein is the most widely used vegetable protein as meat extender in meat products. This protein has high biological value as well as good functional properties which lead to increasing the water binding capacity and improving the texture and the acceptability of the final product (Jooyandeh, 2011).

Worldwide, much research has focused on various sources of plant proteins that may help in increasing the nutritional value of food products at low cost. Sudan is rich in so many legumes such as, beans, peas etc. and oilseeds that can be used as meat extenders in meat products. One of the locally available oil seed in Sudan is watermelon seeds. Watermelon is grown extensively as both irrigated and a rain fed crop particularly in Western Sudan as a fruit and for its water content for humans and animals.

Gokovsky (1971) reported that Sudan is considered as the center of origin of watermelon especially Kordofan state, were it grows as a wild plant. Also watermelon grown in sandy soil, clay and graded soil in Darfur state on commercial basis (Abaker, 1990).

Watermelon (*Citrallus Lanatus*) is grown in different parts of Sudan particularly Kordofan and Darfur. It produces fruits of different sizes, varieties, colors, shapes and sweetness. The fruits are consumed by both human beings and animals. The seeds are of different sizes, colors and shapes. They are eaten roasted or crushed in a powder form. They are rich in crude protein content and could be used to enrich food products.

Watermelon seed protein was suggested to be useful as food additives and extenders because of their high capacity to bind fat (Gbenle and Onyekchi, 1995).

The objective of this research is to determine the quality characteristics of soy flour (SF) and watermelon seed cake (WMSC) as meat extenders in beef burgers formulations. That is to observe the effect on the physical, chemical and palatability characteristics.

Materials and methods

Experimental site

Watermelon seed cake preparation

Dried Watermelon seeds were obtained from the local market, manually screened to remove the damage ones and stones, manually dehulled by crushing and sieved to obtain the powder. Which was extracted using a local electric oil extractor to obtain the oil and cakes: The cakes obtained were dried, ground and kept in polythene bags at room temperature prior to use. On utilization the cake powder was hydrated in water at a ratio (1:2, watermelon seeds cake: water) for 30min before use.

The Soybean flour (textured) was obtained from Samar Meat Factory, Khartoum, Sudan. It was hydrated in water (1:2, soy: water) for 30 min before use.

Meat preparation

A total of 7 kg fresh lean beef from top round was obtained, trimmed to a minimum amount of fat and ground through ¼ plate using electric meat grinder. Beef fat was obtained separately ground and mixed with the lean meat (80: 20% lean: fat). The whole mixed meat and fat was thoroughly hand-mixed to give homogeneous sample. Then it was divided into five groups representing the treatments. Five replications were done for each treatment.

Treatments formulations

Rehydrated soybean and water melon seeds cakes were added to the ground meat to formulate five treatments as follows:

1. 100% meat (control).
2. 90% meat, 10% soybean.
3. 80% meat, 20% soybean.
4. 90% meat, 10% watermelon seeds cake.
5. 80% meat, 20% watermelon seeds cake.

All spices, salt, ice water were added equally to each treatment (Table 1).

Table (1): % of Water, Salt and Spices Added to Each Treatment

Ingredients	**%***
Salt	1.5
Cardamom	0.1
Cinnamon	0.1
Coriander	0.1
Fennel	0.1
Nutmeg	0.1
Ice water	15

*All ingredients are percentage from the product formula.

Beef burger preparation

Beef burger treatments were prepared by adding equal amounts of ice water salt and spices. The whole mixture was mixed well by hand to give homogenous samples; then the burger patties were formed using a burger machine (100mm diameter). Each patty weight was about 50 g; then put in polystyrene plate and separated by pieces of polyethylene films, covered by plastic sheets and stored in a freezer set at- 18C°.

Proximate analysis:

Moisture, protein, fat and ash content of the watermelon seeds cake, soy bean flour and raw beef burger were determined according to AOAC (2000) methods. Carbohydrate was determined by difference.

pH measurements

One g of the beef burger sample was placed in a blender jar, and 10 ml of distilled water were added. The mixture was homogenized at high speed for 1 minute. The pH of the mixture was measured using a pH meter (Model L.pusl Munchen 15) which had been calibrated with two standard buffers (7 and 4).

Cooking losses

The frozen beef burgers to be used for determining cooking losses were randomly selected and thawed for 24 hrs in 4°C refrigerator. Five patties from every treatment were weighed separately and cooked by shallow frying. A cooking pan, greased with corn oil was used. The samples were cooked for 10 minutes, turned every minute to ensure even cooking. Samples were cooled to room temperature and then re-weighed. Cooking losses were expressed as a percent of pre-cooking weight.

$$\text{Cooking losses (\%)} = \frac{\text{raw weight} - \text{cooked weight}}{\text{raw weight}} \times 100$$

Water holding capacity

The water holding capacity (WHC) was determined by the filter Paper press method (Grau and Hamm, 1953). 1 g of the beef burger was placed on a humidified filter paper, Whatman No. 1 (kept in a desicator over saturated Kcl solution) and pressed between two plexiglass plates for 2 minutes at 25 kg load. The meat film area was traced with a ball pen and the filter paper was allowed to dry. Meat and moisture areas were measured with a compensating planometer. The resulting area covered by the moisture was divided by the meat film area to give a ratio expressed as water holding capacity of meat.

$$\text{WHC} = \frac{\text{moisture film area} - \text{meat film area}}{\text{Meat film area}} \times 100\%$$

Color measurements

The color of the raw beef burger was measured with a Hunter lab Difference Meter, Model D25. (Lightness, redness and yellowness), were measured. It was standardized with the white calibrated standard No C_2 136 (L= 93.4, a = -1.1and b = -1.9).

Sensory evaluation

The sensory evaluation was conducted in the sensory evaluation facilities of the Meat Production Department, Faculty of Animal Production, U of K to compare the sensory properties of the five treatments.

The frozen beef burger patties from each treatment were randomly selected thawed at 4C° overnight and then cooked using shallow frying for 10 minutes. A cooking pan, greased with corn oil was used. The samples were then cut into pieces and served warm.

Twelve semi-trained panelists were used to evaluate the treatments effects on color, flavor, tenderness juiciness, and overall acceptability of burger samples (Cross *et. al.*, 1978). The scale given to evaluate the burger samples was composed of eight points, where eight was extremely desirable, intense, tender, juicy, desirable, while one was extremely undesirable, bland, tough, dry and extremely undesirable for color, flavor, tenderness, juiciness and overall acceptability respectively.

Statistical analysis

The statistical analysis of the data was carried out using analysis of variance for completely randomized design (CRD) by general linear model using (SAS) statistic program version 8. Means separation were done by LSD and the values were expressed as means and standard error. The means considered significantly different at (P<0.05).

Chemical composition comparison of SF and WMSC

The chemical composition of (SF) and (WMSC) were showed in table (2). The results revealed that WMSC had significantly (P<0.05) higher moisture (2.28%) and protein contents (47.25%) than SF with (1.3%) and (42.25%) respectively. The fat (10.94%) and (1.31%) percentage of SF were not significantly (P>0.05) different from that of WMSC (11.45%) (1.23 %) respectively).

Table (2): Proximate Chemical Composition of Soy flour (SF) and watermelon Seed Cake (WMSC)

Parameter (%)	Sample		
	Soy Flour	**Watermelon seed cake**	**SE**
Moisture	1.3^{b}	2.28^{a}	±0.100
Crude protein	42.25^{b}	47.25^{a}	±0.88
Crude fiber	14.37^{b}	27.2^{a}	±0.19
Fat	10.94^{a}	11.45^{a}	±0.19
Ash	1.31^{a}	1.23^{a}	±0.05

[ab] Means with different superscripts within the same row are significantly different (P<0.05)

SE: Standard error of means

Proximate chemical composition of beef burger treatments:

The results (Table 3) showed that increasing the percentage of SF and WMSC significantly (P<0.05) increased the protein and fat percentages of the treatment samples. The 20% WMSC had the highest protein content compared with the other treatments. However the control treatment recorded the highest moisture and the lowest fat percentages compared to the other treatments.

Physical measurements of beef burger treatments

pH

The results (Table 4) showed that increasing the added level of SF and WMSC significantly (P<0.05) increased the pH values. Beef burger extended with 20% SF and 20% WMSC had significantly (P<0.05) the highest pH value compared with the control. The 10%WMSC had significantly (P<0.05) higher pH compared with 10%SF.

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Table 4: Physical Properties of beef burgers manufactured with different levels of SF and WMSC

Parameters		Treatments				
	Control	**10% SF**	**10%WMSC**	**20% SF**	**20%WMSC**	**SE**
pH	5.65^{d}	5.75^{c}	5.94^{b}	6^{a}	6.02^{a}	±0.02
WHC	1.24^{a}	0.96^{ab}	0.94^{ab}	0.65^{b}	0.33^{c}	±0.15
C.L	31^{a}	24.25^{b}	22.58^{d}	20.79^{c}	15.29^{e}	±1.02

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

WHC: Water holding capacity

C.L: Cooking losses

Water holding capacity (WHC):

Water holding capacity (Table 4) was significantly ($P<0.05$) improved by the addition of different levels of WMSC and SF. The 20%WMSC significantly improved the water holding capacity than the other treatments and showed the lowest value while the control treatment has the highest value.

Cooking losses

The addition of SF and WMSC to the beef burger resulted in a significant decrease ($P<0.05$) in cooking losses.

The control sample had significantly ($P<0.05$) the highest cooking losses, while the 20% WMSC had significantly the lowest cooking losses compared with the other treatments. Cooking losses of the 20% WMSC was significantly ($P<0.05$) lower (15.2%) than 20% SF (20.7%). The addition of WMSC resulted in a significant ($P<0.05$) decrease in cooking losses compared with SF.

Table 5 showed that the color values were significantly different ($P<0.05$) among treatments. The results indicated that the control sample had the lowest color value, 29.74, 19.98& 8.66 for l a and b respectively while the sample containing 20% WMSC had the highest L& a values (38.70 and 26.6) respectively. This result shows that WMSC increased lightness and redness in the treatments. The highest values of (b) were observed in 10 and 20% SF. These results show that soy increases yellowness in the treatments.

Sensory evaluation

The sensory evaluation results of the beef burger samples (Table 6) showed that the addition of 10 and 20% SF and WMSC improved the color, tenderness and juiciness. The control samples had the lowest scores for color, tenderness and juiciness.

There was no significant ($p>0.05$) difference between the addition of 10 and 20% SF level except in the flavor. However the addition of 10% WMSC produced acceptable product while the 20% WMSC negatively affected the flavor.

The results showed that the 10% added level of SF and 10% WMSC did not differ significantly ($p>0.05$) in color, tenderness and juiciness scores.

The results indicated that the flavor decreased significantly ($p<0.05$) with increasing the levels of SF and WMSC content from 10 to 20%. The 20% level of WMSC had the lowest score in flavor followed by 10% WMSC level.

The highest ($p<0.05$) score of overall acceptability was obtained by the addition of 10% and 20% soy flour for beef burger formulation. The most pronounced effect was the negative effect of the WMSC on the flavor and overall acceptability

Table 6: Sensory evaluation of beef burgers processed with SF and WMSC as meat extenders

Parameters	**Treatments**					
	Control	**10%SF**	**10%WMSC**	**20%SF**	**20%WMSC**	**SE**
Color	5.8^{b}	6.6^{a}	6.3^{a}	6.7^{a}	6.3^{a}	±0.27
Flavor	5.9^{c}	7^{a}	5.3^{d}	6.4^{b}	4.6^{e}	±0.24
Tenderness	5^{b}	6.7^{a}	6.3^{a}	6.7^{a}	6.7^{a}	±0.28
Juiciness	5.3^{b}	6.4^{a}	6.4^{a}	6.6^{a}	6.8^{a}	±0.25
Overall acceptability	5.3^{b}	6.8^{a}	5.7^{b}	6.4^{a}	4.7^{c}	±0.25

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

Discussion

The moisture content of WMSC was lower than (4.4%) reported by Mahala, *et al*. (2010). This could be due to differences in varieties of the watermelon, drying methods or both. The moisture content of SF was lower than (5.69%) as reported by Ammar (2012), which could be attributed to differences in the sunflower types

The protein content of WMSC was higher than (25.4%) reported by Mahala *et al.* (2010) and 37.25%this reported by Naser, (2004) who used free fat watermelon (*Citrullus vulgaris*) seed kernels in preparing high protein biscuits. He found that free fat watermelon seed flour can be used to prepare high protein biscuit at (40-50%) level either with wheat flour or in mixture with other cereal sources, corn, rice and chickpea flours. These results were also higher than (28.66%) reported by Ubbor and Akobundu, (2009) who studied the quality characteristics of cookies from composite flours of watermelon seed, cassava and wheat. The result of protein content of soy flour (42.25) was lower than (44.74%) reported by Ammar (2012). The difference in findings between the studies may be attributable to the type of watermelons, methods of extractions or all these factors combined. The crude fiber of WMSC (27.2) was in line with those (27.4) reported by Mahala *et al. (2010).* The fat content of WMSC (1.23) was in line with (1.03) reported by Nasr (2004) and higher than 0.64 reported by Ubbor and Akobundu (2009). However it was lower than (7.8) reported by Mahala *et al (2010)*. The ash content of WMSC (11.45) was higher than (2.7) reported by Mahala *et al* (2010) 2,6 and 3.8% reported by Nasr (2004).

There were significant differences (P<0.05) in the proximate chemical composition of the treatments (Table 3). The control samples had the highest moisture content compared with the other treatment samples. These differences could be related to the higher moisture content of the raw meat compared with the low moisture content of soy and watermelon seed cake. These results were in agreement with the results of Sumia (2005) who utilized Sudanese pigeon pea as binder in the manufacture of beef burger; and Omer (2000) who studied the effect of substituting chick pea on the chemical and palatability aspects of sausages. The protein content increased with the increasing levels of SF and WMSC. These results agree with the results of Omer (2000) who studied the effect of substituting chick pea on the chemical and palatability aspects of sausages; and reported that the protein content was significantly different (P<0.05) between the control and the extended samples. There were significant differences (P<0.05) in fat content which increased with the increasing levels of SF and WMSC from 10 to 20 %. This may be due to the ability of SF and WMSC to bind fat. The result agreed with that reported by Rao *et al.* (1984) who found that fat increases with the increasing level of soya in the sample, and were not in agreement with the findings of Darwish *et al.* (2011), who found that the addition of textured soy (15 and 22.5%) reduced the fat content of beef burger patties to 13.50 and 13% respectively.

The crude fiber of WMSC (27.2) was in line with those (27.4%) reported by Mahala *et al.* (2010).

The fat content of WMSC 11.45% was similar to 11.38% reported by Shadia (2017) who utilized sesame cakes in beef burger formulation. However it was higher than (7.8 %) reported by Mahala, *et al.*, (2010).

The Ash content of WMSC (1.23) was lower than (2.7%) reported by Mahala, *et al*., (2010), 2.6% and 3.80% reported by Nasr, (2004). These discrepancies could be due to the verities used, methods of extraction or both.

The control sample had higher ash content than the treatments with 10% added SF and 20% WMSC. However the ash content of 20% WMSC (2.06%) was not significantly different from the control (2.36).

This particularly agrees with Rao *et al.*, (1984), who found that, ash content was not significantly different among treatments.

Physical measurements:

There were significant differences ($P<0.05$) among the treatment samples in pH values (Table 4). The control samples had the lowest pH values while the samples containing 20 % of SF and WMSC had the highest pH values. These differences could be due to the levels of plant protein added. These results agreed with those reported by Sumia (2005), who mentioned that the pH value increased with the increasing levels of pigeon pea in beef burger. WHC was significantly ($P<0.05$) superior with the increase of WMSC and SF levels. That might be caused by the increasing levels of the protein content with the addition of WMSC and SF protein. These results agree with the result of Sumia (2005) who reported that the WHC improved with the increasing level of pigeon pea in the formulation. The result is also in agreement with Babji *et al*., (1986**).** They found that the addition of textured soy protein (TSP) to beef burger at a substitution levels of 20, 30, 40, 50 % lead to significant improvement ($P<0.05$) in WHC of soy-beef burger.

Cooking loss is a measurement of how much water and drippings are lost during cooking. The lower the percentage the better the product, as it will be juicier because the moisture is retained. Cooking losses values of beef burger treatments were significantly different ($P<0.05$). They decreased with th increasing levels of SF and WMCS added. There were lower cooking losses in the extended samples than the control. This is obviously due to the ability of soy and WMSC to hold more water during cooking. These results are in agreement with that reported by Nagla (1995) who reported that there were significant differences ($P<0.05$) among treatments for cooking losses; sausages containing 20% and 40% chick pea, faba bean and pigeon pea sustained significantly lower cooking losses than did the control.

The color of the beef burger samples prepared from different treatments in the experiment was significantly affected by the SF and WMSC added levels. The lightness (L), increased with the increasing levels of SF and WMSC in the treatments. As the SF is yellow in color it is expected that the burger should have more (b) yellowness color value on replacement meat by SF. Also the WMSC is pale yellow in color; the burger should become lighter on replacement meat by WMSC. These results are in agreement with those reported by Sumia (2005) who recorded that lightness (L) value increases with the increase of pigeon pea level in the beef burger formulations. Omer**,** (2000) who worked in chick pea and Maha (1996) who worked in cow pea also reported the same results. The replacement of meat by SF or WMSC increased the redness color (a) value. Amna (2003) reported that the control sample had relatively the lowest values among the treatments but not at a significant level.

There were significant differences ($P<0.05$) in all sensory attributes, particularly flavor (Table 5) Moreover, there was a significant improvement in the color, Juiciness and tenderness of burger which was formulated with SF or WMSC.

The most pronounced result was the negative effect of the WMSC on the flavor and overall acceptability. This may be due to the beany flavor detected by the panelists in the WMSC. More over spices levels could be increased with WMSC treatment and that might improve the flavor. These findings are in agreement with Darwish *et al*. (2011) who found that increasing the level of substitution of textured soy granules and sweet potatoes significantly reduced the sensory panel scores for nearly all the investigated parameters especially on the flavor and overall acceptability.

Conclusion

Watermelon seed cake has processing properties similar to soybean to be used as meat extender in burger production. The incorporation of textured soy and watermelon seed cake significantly improved the nutritional value, WHC and cooking yield. Moreover, there was a significant improvement in the color, juiciness and tenderness of burger. However on the other hand increasing the substitution level of WMSC to 20% negatively affected the flavor of the product. It is recommended to utilize WMSC as an extender in ground beef patties formulation at 10% level. If 20% level is used, flavor enhancement such as more spices levels or Roburst beef like flavor should be added.

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