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Influence of Using Moringa Meal Flour as Meat Extender on Quality Characteristics of Beef Burger Patties During Frozen Storage

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Abstract: This research aimed to use defatted-detoxified Moringa meal as meat extender in manufacture of beef burgers instead of soybean flour (SF). Effect of Moringa meal flour (MMF) addition at different levels (3,6,9 and 12%) on frozen storage stability for most important quality criteria of beef burger patties was studied. The incorporation of defatted-detoxified Moringa meal into beef burger patties instead of soybean flour increased the content of sulfur containing amino acids and caused an improvement or retention of physiochemical quality criteria (pH value, WHC, cooking shrinkage, TVN and TBA contents) during frozen storage, as well as improvement of the microbiological quality, when compared to control sample. Also, beef burger samples containing Moringa meal flour (MMF) exhibited a good sensory properties and better acceptability, especially those contained 9 and 12 %, even after frozen storage for 3 months.

Key words: Moringa meal · Beef burger · Meat extender · Frozen storage

INTRODUCTION

Meat extenders are added to the meat products formulation to lower the cost of products. 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 [1,2]. Replacing of the commonly used traditional extenders will depend on the price, technological, nutritional properties and consumers acceptance of the used replacer [3]. Moringa seeds are used to produce cosmetic oil [4]. Which leave a highly nutritious meal (protein 38.4-58.0 %) as a by-product. However, it requires to exclude the antinutritional and / or toxic factors which could interfere with the digestion and absorption of such nutrients which have negative effect on the metabolic processes in the human body [5]. Therefore, detoxification treatment of Moringa seeds meal is very important to produce a safe meal free from the antinutritional factors and may be utilized as meat extender. Therefore, the current research aimed to evaluate the effect of using Moringa meal in meat products as a replacement of soybean flour on the chemical, physiochemical, microbiological and sensory characteristics of beef burger patties during frozen storage.

MATERIALS AND METHODS

Materials

Moringa Seeds: Moringa seeds variety peregrine were obtained from the Desert Research Center, EL-Mataria, Cairo, Egypt.

Soybean Flour(SF): Soybean flour containing 48 % protein was obtained from food Technology Research Institute, Agriculture Research Center, Giza, Egypt.

Beef Meat: Beef meat of binned quarter, obtained from the local butcher shop in the day before each experiment was used in this investigation. The meat was stored in a refrigerator at 5±1°C overnight.

Another Ingredients: Spices, Fresh eggs, onion and salt (sodium chloride) were obtained from the local market. While, sodium tripolyphosphate, sodium ascorbate and sodium nitrite were obtained from Adwic Laboratory Chemicals Co., Cairo, Egypt.

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Methods:

Experimental Treatments: Preparation of Moringa meal flour (MMF): Moringa meal flour was prepared according to the method described by Sodini and Canella [6].

Detoxification Treatments of Defatted Moringa Meal: It was carried out according to Rokland *et al.*[7], after that the detoxified meal was soaked again in tap water for one hour then filtered, dried in oven under vacuum at 60±5°C, weighed, packed in polyethylene bags and stored at 5±1°C until utilized.

Preparation of Beef Burger Patties:

Beef Burger Formulation: Beef burger patties were formulated to contain 0 (Control, contain 12 % SF), 3, 6, 9 and 12% MMF by replacing SF with 25, 50, 75 and 100% MMF, respectively. Beef burger patties were formulated to contain the following ingredients 62% lean meat, 12% SF and / or MMF, 7% Fresh eggs, 7% Fresh onion paste, 1.5% salt, 10% Iced water, 0.5% spices, 0.3% Sodium tripolyphosphate, 0.03% Sodium ascorbate and 0.015% Sodium nitrite according to [8, 9].

Cooking of Beef Burger Patties: The patties were cooked for measuring cooking measurements and to sensory evaluate according to Ou and Mittal [10].

Analytical Methods: Beef burger patties were periodically analyzed every month during the frozen storage at-18 ± 2°C for 3 months as follows:

Chemical Analysis: Proximate composition was estimated according to A.O.A.C [11]. Amino acids composition were determined using HPLC-Pico-Tag method according to Millipore Cooperative [12]. Total volatile nitrogen (TVN) content and Thiobarbituric acid (TBA) value was estimated as described by Pearson [13].

Determination of Toxic/antinutritional Components: Total phenols and tannins were determined by the method described by Makkar *et al*. [14]. Lectins content was conducted by haemaglutination assay Gordon and Marquardt [15]. Phytate content was determined by the method of Hauag and Lantzsch [16]. Cyanogenic glucosides were determined according to Essers *et al*. [17]. Saponins were determined according to Hiai *et al*. [18]. Trypsin inhibitor activity (TIA) was calculated as number of trypsin inhibit units in milligram dry sample according to Smith *et al*. [19].

Physical Analysis: The pH value for beef burger patties was determined by using a calibrated pH meter (Beckman model 3550, USA) according to Schoeni *et al*. [20]. Water holding capacity (WHC) was determined by filter press method [21]. Calculation of cooking yield was determined according to Raharjo *et al*. [22], where cooking shrinkage was calculated according to Adams [23]. Also, moisture retention value was determined according to El-Magoli *et al*. [24]. while, fat retention was calculated according to the method described by Murphy *et al.* [25].

Microbiological Aspects: Total bacterial count (TBC), psychrophilic bacteria count, mold and yeast count and coliform bacteria count were determined according to FAO [26] and Oxoid [27].

Sensory Evaluation: cooked meat patties were sensory evaluated by twenty panelists and statistically analyzed according to Basker [28].

Statistical Analysis: Results other than sensory evaluation were analyzed using analysis of variance (ANOVA) and least significance difference (LSD) at a significance of probability 5 % to evaluate different burger samples [29].

RESULTS

Detoxification Treatments of Moringa Meal: Table 1 shows that raw Moringa seeds contained a considerable contents of total phenols, lectins activity, phytate, cyanogenic glucosides and saponins at ratio of 3.09 mg/100g, 1910 HU/10kg, 30.60 mg/g, 14.02 mg/kg and 12.41mg/g, respectively. Also, raw seeds had a negligible amount of tannins (0.78 mg/100g) and were free of trypsin inhibitor. The same table shows that the detoxification treatment completely eliminated tannins and saponins as well as about 79, 93, 90 and 91% of total phenols, Lectins, phytate and cyanogenic glucosides, respectively.

Chemical Analysis for Raw Kernel and Defatted Detoxified Moringa Meal: Table 2 shows that defatted detoxified Moringa meal contained 56.53% protein, 1.22% ether extract, 4.80 % crude fiber, 5.13% ash and 30.74% carbohydrate as compared with 31.27, 48.44, 3.11, 3.65 and 10.48%, for the raw kernel, respectively.

Nutritional Protein Quality of Detoxified Moringa Meal: It was evaluated according to its content of indispensable amino acids (IAAs) and comparison with soy protein

Table 1: Detoxification treatment of Moringa meal soaking at 70°C for 6 hr. in combined salt solution

Component	Total phenols (mg/100g)	Total Tannins (mg/100)	Lectins Activity (HU/10kg)	Phytate (mg/gm)	Cyanogenic Glucosides (mg/kg)	Saponins (mg/gm)	Trypsin inhibitor activity
Raw seeds(untreated)	3.09	0.78	1910	30.60	14.02	12.41	N.D
Treated meal	0.65	N.D	128	3.01	1.21	N.D	N.D

N.D: not detected.

Table 2: Chemical analysis (on wet weight basis) for raw kernel and defatted detoxified Moringa meal

Component (%)	Moisture	Crude protein	Ether extract	Crude fiber	Ash	Carbohydrate
Raw kernel	3.05	31. 27	48.44	3.11	3.65	10.48
Defatted detoxified meal	1.58	56. 53	1.22	4.80	5.13	30.74

Table 3: Amino acids composition of Moringa meal protein, compared to soy protein concentrate (SPC) and reference protein pattern of FAO/WHO

	Moringa meal		SPC		
Amino acids (IAA_s)	g/16gN	A.S*	g/16gN	A.S*	FAO/WHO
Lysine	2.42	44	6.11	112	5.44
Leucine	7.53	107	7.70	109	7.04
Isoleucine	4.56	114	4.91	122	4.00
Valine	4.51	91	6.28	127	4.96
Therionine	3.48	87	3.86	97	4.00
Meth +Cyst	6.96	205	2.52	74	3.40
Phen+Tyro	8.09	133	8.49	139	6.08
Tryptophan	1.57	157	1.24	124	1.00

A.S*: Amino acid score.

concentrate and the reference protein pattern of FAO/WHO as shown in Table 3.

From Table 3, it could be observed that Moringa meal protein contained most of IAA_s at higher concentration than in reference protein pattern of FAO/WHO, with exception of lysine, threonine and valine. Since, the amino acid score (A.S) for these three amino acids was lower than 100 (44, 87 and 91, respectively) and was higher than 100 for the other indispensable amino acids. The comparison between the IAA_s composition of Moringa meal protein and soy protein concentrate revealed an almost similar pattern of all IAA_s for the two kinds of protein, But Moringa meal protein was deficient in lysine and contained a high content of amino acids-containing sulfur (Meth +Cyst) in contrary the soy protein concentrate.

Frozen Storage Stability for Quality Criteria of Beef Burgers:

A-Gross Chemical Composition of Beef Burgers Containing MMF: As shown in Table 4, there was a negligible alteration in moisture content of all beef burger patties containing MMF when compared with the control.

From Table 4, it could be noticed that protein and fiber contents of beef burgers containing MMF obviously increased ($P< 0.05$) with increasing MMF levels, as compared with control beef burger sample containing soy flour only. On the other hand, a gradual decrease in protein content of all beef burger samples was observed during frozen storage up to 3 months. While, fiber content increased with increasing frozen storage time in all burger samples. Also, a slight decrease in fat and ash contents of these samples was noticed when compared with control sample, these contents were affected during frozen storage periods in all samples. While, there was a negligible alteration in carbohydrate content of all beef burger samples.

B-Nutritional Protein Quality of Beef Burgers Containing MMF: From Table 5, it could be noticed that the increasing MMF level in beef burger samples result in decreasing the content of lysine and valine acids and increasing the content of sulfur amino acids (Meth + cyst) of beef burger samples, especially in burger sample containing 12 % MMF.

Table 4: Chemical composition of beef burger samples as affected by addition different levels of Moringa meal flour (MMF) during frozen storage at-18 ± 2°C for 3 months

Treatment	Control	3% MMF	6% MMF	9% MMF	12% MMF
Storage (months)			% Moisture		
0	70.93	70.83	70.87	70.90	70.22
1	70.64	70.54	70.75	70.55	70.00
2	70.50	70.31	70.51	70.33	69.72
3	69.94	69.88	70.37	69.84	69.46
			% Protein *		
0	56.41^{c}	57.18^{b}	57.50^{a}	57.79^{a}	58.18^{a}
1	54.94^{c}	56.08^{b}	57.12^{a}	57.30^{a}	57.91^{a}
2	54.24^{c}	55.44^{b}	55.95^{a}	56.02^{a}	56.38^{a}
3	52.82c	54.18^{b}	55.45^{a}	55.77^{a}	55.98^{a}
			% Fat *		
0	14.82^{a}	14.67^{a}	14.55^{a}	14.53^{a}	14.20^{b}
1	14.66^{a}	14.58^{a}	14.49^{a}	14.41^{a}	14.08^{b}
2	14.53^{a}	14.46^{a}	14.42^{a}	14.37^{a}	13.90^{b}
3	14.41^{a}	14.40^{a}	14.37^{a}	14.30^{a}	13.82^{b}
			% Ash *		
0	12.83^{a}	11.81^{b}	11.80^{b}	11.72^{b}	11.58^{b}
1	14.27^{a}	13.13^{b}	12.20^{c}	12.10^{c}	12.00^{c}
2	14.71^{a}	13.77^{b}	12.32^{c}	12.20^{c}	12.14^{c}
3	14.73^{a}	14.37^{b}	12.58^{c}	12.36^{c}	12.26^{c}
			% Fiber *		
0	0.89^{c}	1.02^{c}	1.64^{b}	2.19^{a}	2.36^{a}
1	0.96^{c}	1.04^{c}	1.69^{b}	2.28^{a}	2.51^{a}
2	0.98^{c}	1.11^{c}	1.72^{b}	2.53^{a}	2.67^{a}
3	1.03^{c}	1.19^{c}	1.89^{b}	2.66^{a}	2.86^{a}
			% Carbohydrates *		
0	15.05^{a}	15.32^{a}	14.51^{b}	13.77^{c}	13.68^{c}
1	15.17^{a}	15.17^{a}	14.50^{a}	13.91^{b}	13.50^{b}
2	15.54^{a}	15.22^{a}	15.59^{a}	14.88^{a}	14.91^{a}
3	16.01^{a}	15.86^{a}	15.71^{a}	14.91^{b}	15.08^{b}

* on dry weight basis, $^{a, b}$ and ^{c} means in the same row with different superscripts are different significantly ($P \leq 0.05$)

Table 5: Amino acids composition* of beef burger samples as affected by addition different levels of Moringa meal flour (MMF) at zero time

Amino acids IAAs (g/16gN)	Control	3% MMF	6% MMF	9% MMF	12% MMF
Lysine	5.22^{a}	5.18^{a}	5.12^{a}	5.00^{b}	4.66^{b}
Leucine	6.78^{a}	6.76^{a}	6.73^{a}	6.72^{a}	6.70^{a}
Isoleucine	4.10^{a}	4.08^{a}	4.05^{a}	4.03^{a}	4.01^{a}
Valine	5.43^{a}	5.24^{a}	5.00^{b}	4.76^{b}	4.62^{b}
Therionine	3.62^{a}	3.54^{a}	3.48^{a}	3.44^{a}	3.41^{a}
Meth + cyst	3.28^{c}	3.89^{b}	4.29^{b}	4.86^{a}	5.22^{a}
Phen + tyro	7.62^{a}	7.60^{a}	7.57^{a}	7.53^{a}	7.51^{a}
tryptophan	1.25^{a}	1.27^{a}	1.28^{a}	1.31^{a}	1.35^{a}

* Means in the same row with different superscripts are different significantly ($P \leq 0.05$)

C-Physicochemical Quality Criteria of Beef Burgers Containing MMF: As shown in Table 6, the replacing of SF resulted in a slight decrease in the samples pH values when compared with pH value of control sample. On the other hand, pH value increased continuously in all beef burger patties during frozen storage. The increment rate in that value was decreased with increasing of MMF level. From the same table, it could be also observed that water holding capacity (WHC) of beef burger samples increased by increasing MMF level from 3 to 12 %. During frozen

Table 6: Physiochemical properties* of beef burger samples as affected by addition different levels of Moringa meal flour (MMF) during frozen storage at-18 ± 2°C for 3 months

Treatment	Control	3%MMF	6%MMF	9%MMF	12%MMF
Storage(months)		PH value			
0	6.90^{a}	6.89^{a}	6.86^{a}	6.71^{b}	6.68^{b}
1	7.18^{a}	7.03^{a}	6.97^{a}	6.83^{b}	6.79^{b}
2	7.41^{a}	7.23^{a}	7.16^{a}	7.02^{b}	6.98^{b}
3	7.54^{a}	7.45^{a}	7.41^{a}	7.33^{b}	7.27^{b}
		Water Holding Capacity (WHC) % bound water			
0	83.27^{a}	80.33^{c}	81.73^{b}	83.64^{a}	84.96^{a}
1	82.56^{a}	79.66^{c}	80.58^{c}	82.38^{b}	83.77^{a}
2	81.75^{a}	79.13^{c}	80.00^{c}	81.24^{b}	82.85^{a}
3	80.44^{b}	78.71^{c}	79.53^{c}	80.25^{b}	82.23^{a}
		Total Volatile Nitrogen (TVN) mg/ 100g sample			
0	4.20^{c}	6.72^{a}	6.16^{a}	5.60^{b}	4.48^{c}
1	5.04^{c}	7.28^{a}	7.00^{a}	6.44^{b}	5.32^{c}
2	6.16^{c}	8.16^{a}	8.00^{a}	7.84^{a}	6.44^{b}
3	8.40^{b}	9.80^{a}	9.52^{a}	8.24^{b}	7.84^{c}
		Thiobarbituric acid value (TBA) mg/kg sample			
0	0.2340^{b}	0.3120^{a}	0.1715^{c}	0.1404^{c}	0.1350^{c}
1	0.4290^{b}	0.5380^{a}	0.3270^{b}	0.2960^{c}	0.2830^{c}
2	0.5928^{b}	0.6942^{a}	0.4919^{c}	0.4680^{c}	0.4290^{c}
3	0.7800^{b}	0.8970^{a}	0.7332^{b}	0.7020^{c}	0.6240^{c}

* Means in the same row with different superscripts are different significantly ($P \leq 0.05$)

Table 7: Cooking measurements* of beef burger samples as affected by addition different levels of Moringa meal flour (MMF) during frozen storage at-18 ±2°C for 3 months

Treatment	Control	3%MMF	6%MMF	9%MMF	12%MMF
Storage(months)		% Cooking yield			
0	74.17^{b}	73.50^{c}	74.24^{b}	84.79^{a}	87.11^{a}
1	73.83^{b}	73.00^{c}	74.00^{b}	84.16^{a}	86.66^{a}
2	73.77^{b}	72.66^{c}	73.77^{b}	83.67^{a}	86.23^{a}
3	73.58^{b}	72.46^{c}	73.15^{b}	83.25^{a}	85.75^{a}
		% Cooking Shrinkage			
0	37.50^{a}	37.37^{a}	36.40^{a}	27.63^{b}	26.66^{b}
1	37.84^{a}	37.63^{a}	36.71^{a}	27.92^{b}	26.83^{b}
2	38.20^{a}	38.14^{a}	37.92^{a}	28.12^{b}	27.00^{b}
3	38.88^{a}	38.46^{a}	38.00^{a}	28.64^{b}	27.37^{b}
		% Moisture retention			
0	37.16^{c}	37.19^{c}	38.11^{c}	45.71^{b}	48.81^{a}
1	37.00^{c}	37.01^{c}	37.85^{c}	45.37^{b}	48.46^{a}
2	36.67^{c}	36.69^{c}	36.89^{c}	45.13^{b}	48.14^{a}
3	36.38^{c}	36.48^{c}	36.54^{c}	44.83^{b}	47.90^{a}
		% Fat retention			
0	64.84^{c}	66.80^{b}	66.87^{b}	68.83^{b}	75.32^{a}
1	64.57^{c}	66.39^{b}	66.40^{b}	68.38^{b}	75.00^{a}
2	64.15^{c}	66.00^{b}	66.10^{b}	67.90^{b}	74.77^{a}
3	63.75^{c}	65.72^{b}	65.78^{b}	67.53^{b}	74.25^{a}

* Means in the same row with different superscripts are different significantly ($P \leq 0.05$).

Table 8: Microbiological counts * (log cfu /g) of beef burger samples as affected by addition different levels of Moringa meal flour (MMF) during frozen storage at-18 ± 2°C for 3 months

Treatment	Control	3% MMF	6% MMF	9% MMF	12% MMF
Storage(months)	Total bacterial count (TBC)				
0	4.59[a]	4.56[a]	4.46[b]	4.38[b]	4.27[c]
1	4.64[a]	4.62[a]	4.53[b]	4.46[b]	4.38[c]
2	4.73[a]	4.70[a]	4.63[b]	4.55[b]	4.49[c]
3	4.85[a]	4.80[a]	4.71[b]	4.68[b]	4.62[c]
	Psychrophilic bacteria				
0	3.26[a]	3.14[a]	3.02[b]	2.93[c]	2.88[c]
1	3.42[a]	3.30[a]	3.16[b]	3.08[c]	2.98[c]
2	3.60[a]	3.42[a]	3.30[b]	3.28[b]	3.16[c]
3	3.74[a]	3.58[a]	3.43[b]	3.32[c]	3.29[c]
	Coliform group				
0	2.78[a]	2.74[a]	2.60[b]	2.54[c]	2.50[c]
1	2.79[a]	2.77[a]	2.52[b]	2.49[c]	2.41[c]
2	2.84[a]	2.78[a]	2.53[b]	2.48[c]	2.44[c]
3	2.90[a]	2.84[a]	2.56[b]	2.51[c]	2.50[c]
	Molds and yeasts				
0	3.62[a]	3.58[a]	3.49[b]	3.42[b]	3.38[c]
1	3.74[a]	3.72[a]	3.60[b]	3.58[b]	3.50[c]
2	3.96[a]	3.90[a]	3.79[b]	3.72[b]	3.62[c]
3	4.10[a]	4.00[a]	3.91[b]	3.86[b]	3.70[c]

* Means in the same row with different superscripts are different significantly ($P \leq 0.05$)

storage, WHC values reduced continuously in all beef burger samples with progressing of storage period. The same table, showed that samples containing MMF were higher (P<0.05) than control in its content of TVN. Also, sample containing 3 % MMF was higher (P<0.05) than control in its content of TBA. While the increasing of MMF into beef burgers from 6 to 12 % resulted in high reduction of TVN and TBA contents than control sample. Table 6, also shows that TVN and TBA contents of all beef burger increased gradually during frozen storage up to 3 months.

D-Cooking Measurements of Beef Burgers Containing MMF: As shown in Table 7, cooking yield percent of beef burger samples containing MMF at levels of 9 and 12 % was higher (P<0.05) than the control, while sample contain MMF at level of 3 % had lower cooking yield percent than control, but cooking yield percent of the sample contain 6 % was in equal with the control. The cooking yield decreased with increasing frozen storage time in all burger samples. With regard to % cooking shrinkage of beef burger samples containing MMF at levels 9 and 12 % were lower (P<0.05) than the control and the samples contain 3 and 6 % were almost in equal with control. In addition, cooking shrinkage increased linearly for all beef burger samples during frozen storage, but it was more evident in control sample than other samples containing MMF. Also, the same table shows that moisture retention and fat retention values of beef burger samples increased (P<0.05) with the increasing level of MMF in beef burger samples. However, these values decreased during frozen storage linearly in all samples.

E-Microbiological Quality Criteria of Beef Burgers Containing MMF: Table 8, illustrates that the total bacterial, Psychrophilic bacteria, coliform bacteria group and mold and yeast counts of beef burger samples slightly decreased with increasing the addition level of MMF, also, the count of microorganisms increased with progressing the storage time, especially for the sample containing 3 % MMF and control.

F-Sensory Quality Criteria of Beef Burgers Containing MMF: Beef burger samples were sensory evaluated and compared to the control sample as shown in Table 9. Data show that there were no significant differences among

Table 9: Sensory evaluation (rank sums)* of beef burger samples as affected by addition different levels of Moringa meal flour (MMF) during frozen storage at-18 ±2°C for 3 months.

Treatment	Control	3% MMF	6% MMF	9% MMF	12% MMF
Storage (months)			Color		
0	56^{a}	62^{a}	75^{a}	55^{a}	52^{a}
1	53^{a}	61^{a}	76^{a}	55^{a}	55^{a}
2	55^{a}	62^{a}	77^{a}	52^{a}	53^{a}
3	55^{a}	62^{a}	74^{a}	57^{a}	52^{a}
			Taste		
0	58^{a}	62^{a}	70^{a}	57^{a}	53^{a}
1	57^{a}	63^{a}	71^{a}	55^{a}	54^{a}
2	60^{a}	61^{a}	72^{a}	55^{a}	52^{a}
3	61^{a}	64^{a}	65^{a}	57^{a}	53^{a}
			Flavour		
0	50^{a}	66^{a}	74^{a}	56^{a}	54^{a}
1	50^{a}	65^{a}	75^{a}	55^{a}	55^{a}
2	52^{a}	67^{a}	76^{a}	52^{a}	53^{a}
3	49^{a}	66^{a}	73^{a}	58^{a}	54^{a}
			Tenderness		
0	46^{a}	75^{b}	96^{b}	43^{a}	40^{a}
1	45^{a}	74^{b}	93^{b}	44^{a}	44^{a}
2	41^{a}	76^{b}	95^{b}	45^{a}	43^{a}
3	43^{a}	78^{b}	94^{b}	43^{a}	42^{a}
			Juiciness		
0	44^{a}	74^{b}	99^{b}	42^{a}	41^{a}
1	44^{a}	73^{b}	98^{b}	41^{a}	44^{a}
2	43^{a}	76^{b}	94^{b}	45^{a}	42^{a}
3	46^{a}	75^{b}	89^{b}	44^{a}	46^{a}
			Appearance		
0	55^{a}	69^{a}	73^{a}	53^{a}	50^{a}
1	57^{a}	70^{a}	70^{a}	52^{a}	51^{a}
2	50^{a}	70^{a}	72^{a}	55^{a}	53^{a}
3	54^{a}	69^{a}	74^{a}	54^{a}	49^{a}
			Overall acceptability		
0	50^{a}	68^{ab}	83^{b}	52^{a}	47^{a}
1	53^{a}	64^{ab}	82^{b}	53^{a}	48^{a}
2	55^{a}	67^{ab}	80^{b}	51^{a}	47^{a}
3	52^{a}	70^{a}	75^{a}	54^{a}	49^{a}

* Rank sums with different superscripts in the same row are significantly different, The critical difference among the samples is 27.3.

beef burger samples in color, taste, flavor and appearance. Also, the same table shows that there were no significant differences among control and samples containing 9 and 12 % MMF in both tenderness and juiciness, but the samples containing 3 and 6% of MMF were significantly different ($P < 0.05$) as compared with the other samples.

With regard to the Overall acceptability, the sample containing 6 % of MMF was the lowest acceptable sample, while the other samples were not significantly different as compared with control.

DISCUSSION

Detoxification treatment of Moringa seeds by soaking in combined salt solution was greatly effective in elimination of antinutritional components from Moringa seeds, since the low residue level do not produce any adverse effects [14]. Proximate composition showed increased protein, fiber, ash and carbohydrate contents of detoxified Moringa meal, this might be due to the concentration effect resulted from oil extraction [5]. The amino acids composition revealed that Moringa meal protein had a high contents of all IAAs (except, lysine, threonine and valine) when compared with soy protein concentrate and the reference protein pattern of FAO/WHO [30]. Therefore, incorporation MMF into meat products increased sulfur amino acids content These results are in agreement with those reported by Jahn [4] and Oliveira *et al.* [5]. Generally, beef burger containing MMF had a good nutritional quality even after frozen storage for 3 months with regards ash and crude fiber contents.

Physiochemical quality criteria of beef burger samples such as pH value, WHC and TVN contents were obviously affected by increasing levels of MMF and frozen storage periods. Degradation of beef burgers protein during storage resulting in formation of some basic compounds such as volatile nitrogen compounds, amines and hydrogen sulfide, leading to increase pH value [31]. WHC value were reduce continuously in all beef burgers with extending the frozen storage periods as the result of breakdown hydrogen bonding between the water molecules and gross chemical components of beef burgers [9]. Concerning TVN content of beef burgers containing MMF, it was clearly decreased with increasing level of MMF. Generally, these results were in accordance with those found by Oroszvári *et al.* [31]. On the other hand, the TBA values of beef burger samples increased gradually during frozen storage, this increase could be mainly attributed to the oxidation of beef burger lipids and formation of some TBA-reactive compounds during the storage period as reported by Stahnke [32].

Regarding, cooking shrinkage which is considered one of the most important physical quality changes that occurs in beef burgers during cooking process due to protein denaturation and releasing of fat and water from beef burger patties [33]. Moisture retention and fat retention values of beef burger samples increased with the increasing level of MMF in beef burger samples, which was attributed to the high water and oil binding capacity of MMF [34].

Microbiological quality criteria of beef burger samples containing MMF were affected by increasing level of MMF at either the initial time or at any frozen storage period. Results indicated that TBC, Psychrophilic bacteria, coliform bacteria group and mold and yeast counts decreased with increasing level of MMF, which may be due to the reducing of free water resulting from the high water binding capacity of MMF [31]. Generally, microbial quality criteria of all beef burger samples were within permissible counts reported by E.O.S [35], which recommend that the total bacterial and coliform group counts not exceed 5 and 3 log cfu /g, respectively.

Sensory evaluation of beef burgers revealed that, beef burgers with 9 and 12 % MMF have the highest level of acceptance for all sensory characteristics, there were no significant differences could be detected among these samples and control, even after frozen storage for 3 months.

It could be concluded that, using of MMF into beef burger patties instead of soybean flour as a good functional and nutritional properties replacer resulted in improving the nutritional, physiochemical, microbiological and sensory quality criteria with lowering the product cost.

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