Journal of Applied Sciences Research, 9(6): 3809-3819, 2013
ISSN 1819-544X
This is a refereed journal and all articles are professionally screened and reviewed

ORIGINAL ARTICLES

Influence of Using Lupine Flour as Binder on Quality Characteristics of Beef Burger Patties

Samaa M. El-sayed

Food Science and Technology Department, Faculty of Home Economic, AL-Azhar University, Tanta, Egypt

ABSTRACT

This research was aimed to use lupine flour as meat binder in processing of beef burgers by replacing meat with lupine seeds flour from two lupine varieties; sweet *(Lupinus albus)* (SLF) and bitter *(Lupinus termis)* (BLF) lupine seeds flour individually at different levels (5 and 7.5%). The effect of replacing meat ratio with lupine seed flour on the quality characteristics of beef burger patties was studied. The obtained results showed that lupine seeds flour of tested two varieties was richen with crude protein, crude fibers, leucine, isoleucine and aromatic amino acids (phenylalanine & tyrosine), and was considered a good source of lysine. The present results also evident that lupine seeds flour of tested varieties characterized with good function properties which making it useful in meat products, as well as promising binder for further development of lupine seeds flour utilization in producing of food products. The current results also revealed that the incorporation of lupine flour as a binder into beef burger patties by replacing of meat resulted in enhancing the physiochemical properties; total volatile basic-nitrogen(TVB-N), thiobarbituric acid (TBA) value, the pH value and water holding capacity (WHC), and cooking measurements **(**cooking yield, cooking shrinkage, moisture retention and fat retention) of beef burger patties having good sensory properties which did not significantly different from the control sample. The present results are recommended with that it should be incorporated of sweet lupine seeds flour into beef burger patties at the above mentioned replacing levels as a good functional and nutritional properties meat replacer resulted in producing burger patties without detrimental effect on the sensory attributes, besides improving the physiochemical properties and cooking measurements of the final product.

Key words: Lupine flour, Beef burger, Meat extender, Beef patties, Quality attributes, Meat binder.

Introduction

Processed meat products provide consumers with a wide variety of flavors and textures and allow efficient use of less desirable meat cuts and trim. The major ingredient in meat products is the skeletal muscle, however, other non-meat ingredients has been used as a partial replacement for meat protein since skeletal muscle is relatively expensive. These ingredients are often referred to as binders, extenders or fillers which are added to improve water binding capacity, meat granules binding ability, emulsion stability, cooking yield, slicing ability, and flavor in addition to reduce the formulation costs (Standish, 1992).

Inducing of plant seed flour as replacer of the meat component will depend on the price, technological, nutritional properties and consumer's acceptance of the used replacer (Sian and Ishak, 1991). Although soybean is still the major plant protein used in these foods, other grain legumes are currently in rapid development as protein sources, in particular pea and sweet lupine (Dijkstra *et al*., 2003). Legumes are usually recognized as the richest source of vegetable proteins, the high nutritional value of this plant is attributed to amino acid protein composition similar to the composition of animal proteins and a high nutritional value of lipid fraction, also legumes contain valuable compounds such as oligosaccharides, phenol compounds tocopherols, fiber and phytoestrogens (Duranti, 2006; Rochfort and Panozzo, 2007 and Pastor-Cavada *et al*., 2009.)

On the other hand in developed countries, plant proteins can now be regarded as versatile functional ingredients or as biologically active components more than as essential nutrients. This evolution towards health and functionality is mainly driven by the demands of consumers and health professionals ,the partial replacement of animal foods with legumes is claimed to improve overall nutritional status (Guillon and Champ, 1996).

New research approaches which rely strongly on biotechnology to improve growth and utilization of grain legumes have significant impacts on the nutritional quality of legumes. Lupine *(Lupinus spp.)* belongs to the Genisteae family, Fabaceae or Leguminosae (Pastor-Cavada *et al*., 2009).

Lupine is a good source of nutrients, not only proteins but also lipids, dietary fibre, minerals, and vitamins (Martenez-Villaluenga *et al*., 2006$_a$ and Zielinska *et al*., 2008). Lupin generally contains about twice the amount

Corresponding Author: Samaa M. Elsayed, Food Science and Technology Department, Faculty of Home Economic, AL-Azhar University, Tanta, Egypt.

of proteins found in those legumes that are commonly consumed by humans. There are variations in the protein content (28% to 48%) between species and cultivars as a result of the characteristics of the growing conditions and soil types (Sousa *et al*., 1996; Ogüt, 1998; Papavergou *et al*., 1999; Linnemann and Dijkstra, 2002; Mülayim *et al*., 2002; Sironi *et al*., 2005; Martenez-Villaluenga *et al*., 2006$_a$ and Capraroa *et al*., 2008).

Lupine seed has great interest due to its augmented availability in many countries in recent years, chemical composition (proteins amino acids, starch, sugars, fiber, lipids, fatty acids, vitamins, antinutritional compounds) and potential use of different lupine seed products; (flour, protein isolates, and concentrates) and thereupon lupine flour can be incorporated in production of different food products (Faeste *et al*., 2004 and Kohajdova *et al*., 2011). It can be added to pasta, crisps, bread and emulsified meat products to increase nutritional value and aroma, as well as modify the texture of the end products. Moreover, protein isolate produced from lupine seeds can be utilized for milk and meat imitation products. In the Middle East area, lupine seeds are consumed as a snack after they are soaked in water, scalded and dehulled. Additionally, in some European counties, pickle is produced from lupine seeds (Dervas *et al*., 1999).

The aim of the current research is evaluating the effect of incorporating lupine flour into beef burger production by replacing of meat on the quality physico-chemical and sensory characteristics, cooking measurements (cooking yield, cooking shrinkage, moisture retention, and fat retention) of beef burger patties.

Materials and Methods

Materials:

Lupine seeds:

Lupine seeds of both varieties; bitter (*Lupinus termis*) and sweet (*Lupinus albus*), were obtained from the local market at Tanta city, El-Gharbia Governorate, Egypt. The seeds were cleaned manually to remove foreign matter, immature seeds, damaged seeds and rendered free of dust, then stored in polyethylene bags at ambient temperature (25±3ºC).

Beef meat:

Beef meat of binned quarter and beef back fat were purchased from the local butcher shop at Tanta city, El-Gharbia Governorate, Egypt. The meat was stored in a refrigerator at 5±1ºC overnight, before experiment.

Other ingredients:

Spices, rusk, and salt (sodium chloride) were obtained from the local market at Tanta city, El-Gharbia Governorate, Egypt. While, sodium tripolyphosphate, sodium ascorbate and sodium nitrite were obtained from Adwic Laboratory Chemicals Co., Cairo, Egypt. Refined sunflower oil was purchased from Cairo Company for Oils and Soap, Giza, Egypt.

Methods:

Preparation of lupine flour (LF):

Bitter lupine alkaloids have been removed from the seed by boiling for 30 min, then bitter lupine Steeping in running water for 3 days to remove the antinutritional substances according to the procedure of Rahma and Narsinga-Rao (1984). While, sweet lupine washed with running water for a few min. After that, lupine seeds were dried in an air- oven dryer at 60±2°C, then lupine seeds were milled into flour by using a laboratory disc mill (Braun AG Frankfurt Type: KM 32, Germany) for 2-3 min, and the resulting flours were ground in a laboratory mill to obtain the lupine seed flours to particles passing through 60 mesh sieve and kept in polyethylene bag until utilization and analysis.

Preparation of beef burger patties:

Three independent replicates of each batch were prepared in Laboratory of Food Science and Technology Department, Faculty of Home Economic , AL- Azhar Univ. Beef burger patties were formulated to contain 65% minced beef meat, 20% minced beef back fat, 10% (w/w) water (ice water), 1.5% (w/w) sodium chloride, 0.5 % spices and 3% rusk as control sample, while tested samples were formulated to contain 5% or 7.5% from either sweet lupine flour or bitter lupine flour individually by replacing meat. Curing salts were added by the following ratios of the final burger mixture, 0.3 Sodium tripolyphosphate, 0.03 Sodium ascorbate and 0.015 Sodium nitrite according to Dreeling *et al*. (2000) and Oroszvári, *et al*. (2005 *a & b*).

Cooking of beef burger patties:

The beef burger patties were cooked for measuring the diameter shrinkage and organoleptic evaluation for them. The beef burger patties were thawed at 4±1ºC overnight in a refrigerator before frying, and not directly from the frozen state. Whereas, 200 g for frying oil medium; refined sunflower oil, placed in stainless shallow-pan and firstly heated at 165±5ºC. then, the prepared beef burger patties were pan-fried individually at 165±5ºC for 6 min for each side; as described by Mansour and Khalil (1997); Dreeling *et al*. (2000) and Ou and Mittal (2006).

Analytical Methods:

(1). Physico-Chemical Analysis:

a) Proximate chemical composition estimation:

Proximate composition: Moisture, protein (Nx6.25), ether extract, ash, and fiber contents of bitter and sweet lupine seed flours and beef burger patties were determined using the methods of the A O A C (2000). Total carbohydrates content was calculated by differences in bitter and sweet lupine seeds flour and beef burger patties samples as followed:
% carbohydrates = 100- the sum of (% moisture + % protein + % fat + % ash).

b) Determination of amino acids composition:

Amino acids composition of tested sweet and bitter lupine seed flours was determined using HPLC-Pico-Tag method according to Millipore Cooperative as reported by Cohen *et al*. (1989).

c) Determination of some functional properties of lupine seed flours:

1. Water absorption capacity (WHC):

The procedure of Sathe *et al.* (1982) was used to determine the WHC value for lupine flour. In this procedure, 10 ml of water added to 1.0 g of each blend samples, the suspension was then stirred using magnetic stirrer for 5 min. the suspension was transferred into centrifuge tubes and centrifuged at 3,500 rpm for 30 min. the supernatant obtained was measured using a 10 ml measuring cylinder. The density of the water was assumed to be 1g/ml. The water absorbed was calculated as the difference between the initial water used and the volume of the supernatant obtain after centrifuging. The result was expressed as a percentage of water absorbed by the blends on %g/g basis.

2. Oil absorption capacity (OAC):

The procedure of Sathe *et al.* (1982) was used as described above. Instead of water used, refined soybean oil with density of 0.92g/ml was used. The oil and the flour blends (1g from blends in 10 ml oil) were mixed using a magnetic stirrer at 1,000 rpm for 5 min and then centrifuged at 3,500 rpm for 30 minutes, the amount of oil separated as supernatant was measured using 10 ml cylinder. The difference in volume was taken as the oil absorbed by the samples. The oil absorbed was expressed as % g/g of oil absorbed.

3. Protein solubility (PS):

Protein solubility (PS) was determined according to the method of Aluko and Yada (1993) with some modifications. Each sample was mixed with 0.01M sodium phosphate buffer, pH 7.0 to give a dispersion of approximately 1% (w/v) protein content, followed by shaking on a vortex mixer for 5 min and centrifugation at 10 000 × g and 10°C for 30 min. The resultant supernatant (S1) was analyzed for protein content according to the method of Markwell *et al*. (1978) and this was expressed as a percentage of the initial total protein content of the meal lupine seeds to obtain the percentage of the solubility.

4. Emulsifying capacity and emulsion stability:

Emulsifying capacity and emulsion stability were determined according to the method of Ockerman (1985) and Cserhalmi *et al*. (2001) as follow: 1g of sample was dispersed in 1 M sodium chloride in a blender to give 1 % w/v solution and corn oil was added to the dispersion by using a burette at the rate of 0.8-1ml /second and the buildup of viscosity was observed during mixing, when emulsion visually collapses (increasing the blender speed, decrease in emulsion viscosity and visual separation of emulsion was observed) the addition of oil was stopped and the total added amount determined and the emulsion capacity expressed as the amount of oil emulsified by 1 g of protein, the emulsion stability was determined by allowing the emulsions to stand at room temperature (25±3°C) for 30 min and the volume of emulsion after 30 min of standing divided by the initial emulsion volume and expressed as percentage.

5. Foam expansion and foam stability:

Foam expansion (FE) was determined according to the procedure described by Poole *et al*. (1984) and sadeghi and Bhagya (2009). Sample dispersions containing 1% (w/v) protein were prepared in 0.01M sodium phosphate buffer, pH 7.0 and homogenised for 30 s using a homogenizer (Braun AG Frank, 40-60 Hz /400W, Tipe MX 32, No. 4142, German) The volume of foam obtained was expressed as a percentage of the initial volume of the protein solution. To determine foam stability (FS), the volume of foam that remained after standing at ambient temperature (25±3°C) for 30 min was expressed as a percentage of the initial foam volume.

d) The pH value determination:

The pH value for beef burger patties was determined by using a calibrated pH meter (Beckman model 3550, USA) according to the procedure of Schoeni *et al*. (1991).

e) Estimation of water holding capacity (WHC):

Water holding capacity (WHC) was determined by filter press method described by Soloviev (1966).

f) Determination of total volatile basic- nitrogen (TVB-N) content:

The TVB-N content in prepared beef burger patties sample was determined by macro-distillation method as described by Pearson (1976).

g) Determination of thiobarbituric acid (TBA) value:

The TBA values of prepared beef burger patties were estimated by colorimetric method at 538nm using digital spectrophotometer Spekol 11 No. 849101 (as mg malonaldehyde / kg sample); according to the method of Pearson (1976).

h) Calculation of cooking measurements:

Cooking yield, fat retention and water retention values were calculated by the method described by Aleson-Carbonell *et al.* (2005). While, cooking shrinkage was calculated according to the method of El-Akary (1986).

(2). Sensory Evaluation:

Sensory evaluation of pan-fried meat burger patties containing sweet or bitter lupine flour were sensory evaluated according to the procedure of Lamond (1973) by panelists group of ten members randomly selected from the staff members of Food Sci. and Techn. Dept., Fac. of Home Economic, Al-Azhar Univ. Tanta, Egypt. Panelists were asked to score the color, flavor, tenderness, juiciness and overall acceptability properties according to 10-points hedonic scale.

(3). Statistical Analysis:

The obtained results are represented as mean ± standard error and were subjected to the analysis of variance (ANOVA). Statistical analysis was performed using Origin® 7.0 SR0, V 7.0220 (B220), the criterion for significance was $P < 0.05$; according the procedure of Gomez and Gomez (1984).

Results and Discussion

1. Gross Chemical Composition of Sweet and Bitter Lupine Seed Flours:

The gross chemical components; moisture, crude protein, crude fiber, ash and carbohydrate contents for lupine seeds flour of sweet and bitter varieties were determined, and the obtained results are tabulated as in Table (1).

Table 1: Proximate chemical analysis, on dry weight basis, of sweet and bitter lupine seed flours.

Tested Component (%)	Chemical Component % (M±SE*)	
	Sweet Lupine Flour (SLF)	Bitter Lupine Flour (BLF)
Moisture	14.34± 0.18 [a]	18.34± 0.23 [b]
Crude protein	34.56 ± 0.34 [a]	39.40± 0.34 [b]
Ether extract	13.63 ± 0.45 [a]	16.00± 0.14 [b]
Crude fiber	36.94 ± 0.27 [a]	24.72± 0.22 [b]
Ash	3.60 ± 0.18 [a]	2.63± 0.15 [b]
Carbohydrate	11.27 ± 0.22 [a]	12.28± 0.17 [a]

M±SE*: *Mean ± standard error for triplicate determinations of grass chemical component; the means within the same row having different superscripts are varied significantly (at p ≤ 0.05).*

As shown in Table (1), the moisture, crude protein, crude fat (ether extracts), crude fiber, ash and carbohydrate contents for sweet lupine seeds flour (SLF) were 14.34, 34.56, 13.63, 36.94, 3.06 and 11.27 %, versus 18.34, 39.40, 16.00, 24.72, 2.63 and 12.28 % for bitter lupine seeds flour (BLF), on dry weight basis; respectively. Therefore, the BLF contained moisture, crude protein, crude fat and carbohydrate at a significant ($p \leq 0.05$) higher contents than those in the SLF. In contrast, the SLF contained significant ($p \leq 0.05$) higher contents of ash and crude fiber than those in the BLF. These results are in agreement with those reported by Clark and Johnson (2002); Linnemann and Dijkstra (2002); Mülayim *et al* (2002); Hall *et al.* (2005); Sironi *et al. (*2005); Martenez-Villaluenga *et al.* (2006$_a$); Smith *et al.* (2006) Capraroa *et al.* (2008) and Kohajdova *et al.* (2011). In this concern, it has been reported that although lupine belongs to the legumes and is not described as an oil seed crop, its seeds contain a considerable amount of oil ranged between 5% and 20% crude oil of whole seed weight (Mohamed and Rayas-Duarte, 1995; Ciesolska *et al*., 2005 and Uzun *et al.*, 2007).

2. Amino Acids Composition of Sweet and Bitter Lupine Seed Flours:

Indispensable amino acids (IAAs) composition was determined and compared with the reference protein pattern of FAO/WHO (1973) as shown in Table (2).

Table 2: Indispensible amino acids (IAAs) composition (g/16gN) of sweet and bitter lupine seed flours.

Indispensable amino acids (IAAs)	The IAA content*				FAO/ WHO protein pattern
	Sweet Lupine Flour (SLF)		Bitter Lupine Flour (BLF)		
	g/16 gN	A.S*	g/16 gN	A.S*	
Lysine	4.47	81.27	4.56	82.90	5.5
Leucine	7.38	105	7.18	102	7.0
Isoleucine	4.60	115	4.46	111	4.0
Valine	3.70	74	3.62	72	5.0
Therionine	3.43	85	3.50	87	4.0
Meth +Cyst	1.93	55	1.88	53	3.5
Phen+Tyro	8.85	147	8.78	146	6.0
Total I.A.As	34.36	- -	33.98	- -	- -

IAA content*: *Mean of triplicate determinations for IAA content.* ***A.S*:*** *Chemical score for indispensable amino acid;* ***Meth + Cyst:*** *Methionine and Cysteine;* ***Phen + Tyro:*** *Phenylalanine and Tyrosine.*

From the obtained data (Table 2), it could be also observed that the sweet lupine seeds flour had higher amounts of leucine, isoleucine and aromatic amino acids (Phenylalanine and tyrosine) than bitter lupine seeds flour. The data in Table (2) also showed that the first limiting amino acid in lupine seeds flour (sweet and bitter) was the sulfur containing amino acids, while the second limiting amino acid was therionine and the third limiting amino acid was valine. These results are in agreement with those obtained by Kohajdova *et al.* (2011).

From the obtained data (Table 2), it could be also concluded that lupine seeds flour of the tested two varieties was rich with leucine, isoleucine and aromatic amino acids (Phenylalanine and tyrosine). It was considered to be a good source of lysine, and was generally poor in the sulfur-containing amino acids; methionine and cysteine (Martinéz-Villaluenga *et al*., 2006$_b$; Drakos *et al*., 2007; Gulewicz *et al*., 2008) and threonine (Pisarikova *et al*., 2008).

3. Functional Properties of Sweet and Bitter Lupine Seed Flours:

Table (3) shows some functional properties of flours produced from the tested two lupine seed varieties. From the former data (Table 3), it could be showed that produced from the bitter lupine seeds flour has higher values of the examined functional properties than those for the sweet lupine seeds flour. In general, the present results (Table 3) indicated that the lupine flour produced from the two lupine varieties had good functional properties which make it useful in meat products to enhance water and lipid binding capacities which resulted in high quality meat products. Lupine proteins possess important emulsifying properties and are expected to contribute to the stabilization of fat particles. Additionally, their gel-forming ability allowed them to strengthen the structure of a processed/cooked product and meat products. It has been that lupine protein concentrates have a better emulsifying capacity and poorer emulsion stability than whole flour (Pollard *et al.*, 2002). In this rank, Raymondo *et al*. (1998) increased the emulsion stability of lupine proteins by thermal treatments which favored protein binding, yielding the development of an entanglement network. The emulsifying properties are thus promising functional characteristics for further development of lupins utilization in producing of food products (Pollard *et al*., 2002 and Drakos *et al*., 2007).

Table 3: Functional properties of sweet and bitter lupine seed flours.

Tested Functional Property	Functional property (M±SE)*	
	Sweet Lupine Flour (SLF)	Bitter Lupine Flour (BLF)
Protein solubility (PS) %	55 ± 1.73 [a]	60 ±1.67 [b]
Water absorption capacity (g/100g)	210 ± 1.97 [a]	227 ± 2.08 [b]
Fat absorption capacity (g/100g)	285± 2.84 [a]	278± 2.41 [b]
Emulsion capacity (EC) (ml oil/g protein)	180 ± 2.83 [a]	185 ± 2.94 [b]
Emulsion stability (ES) %	78 ± 0.29 [a]	81.5 ± 0.35 [b]
Foam expansion (FE) %	112 ± 2.76 [a]	126 ± 2.99 [b]
Foam stability (FE) %	73.38 ± 0.57 [a]	78.46 ± 0.47 [b]

M±SE*: *Mean ± standard error for triplicate determinations of functional property; the means within the same row having different superscripts are varied significantly (at p ≤ 0.05).*

4. Gross Chemical Composition of Beef Burger Patties Containing Lupine Seed Flours:

Gross chemical components; moisture, crude protein, either extract, ash, crude fibers, carbohydrate contents for beef burger patties contained either sweet lupine flour (SLF) or bitter lupine flour (BLF) at either 5 % or 7.5 % related to meat weight used in burger pattie formulations and the control beef burger pattie sample no containing any lupine flour were shown in Table (4).

Table 4: Proximately chemical composition (%, on dry weight basis) of beef burger patties as affected by the addition of tested lupine seed flours.

Tested Component	Chemical component % (M±SE*)				
	Control	Tested Treatments			
		5% SLF	7.5% SLF	5% BLF	7.5% BLF
Moisture	63.65±0.28 [a]	61.86±0.31 [a]	60.47±0.32 [a]	62.06±0.29 [a]	60.77±0.33 [a]
Crude protein	45.50±0.33 [a]	45.02±0.23 [a]	45.21±0.11 [a]	45.88±0.10 [a]	45.49±0.28 [a]
Ether extract	28.47±0.10 [a]	28.52±0.17 [a]	28.98±0.19 [a]	29.45±0.19 [a]	29.56±0.18 [a]
Ash	6.16±0.17 [a]	6.12±0.12 [a]	6.21±0.14 [a]	6.11±0.11 [a]	5.96±0.13 [a]
Crude fibers	3.24±0.05 [a]	7.94±0.06 [b]	9.96±0.09 [c]	7.39±0.05 [b]	9.73±0.12 [c]
carbohydrate	9.63±0.20 [a]	9.33±0.21 [a]	9.61±0.11 [a]	9.54±0.15 [a]	9.78±0.14 [a]

M±SE*: *Mean ± standard error for triplicate determinations of chemical component; the means within the same row having different superscripts are varied significantly (at p ≤ 0.05).*
SLF: *Sweet lupine seeds flour* ***BLF:*** *Bitter lupine seeds flour.*
Component*: *Determined component based on dry weight basis.*

As shown in Table (4), the gross chemical components of all tested burger patties were not changed significantly (at p≤ 0.05), except crude fibers content which was increased from 3.24 % for the control beef burger pattie sample, no containing lupine seeds flour to 7.39 – 7.94 and 9.73 – 9.96 % in beef burger patties contained either 5 % or 7.5 % of lupine seeds flour; respectively. Whereas, the replacing of meat with lupine seed flours was reflected on the fiber content of the burger pattie samples containing lupine seed flour, since the fiber content increased by replacing of meat with lupine seed flour as the replacing level was increased.

5. Physico-Chemical Quality Criteria of Beef Burger Patties Containing Lupine Seed Flours:

The most important physico-chemical quality criteria including the pH, water holding capacity (WHC), total volatile basic-nitrogen (TVB-N) and thiobarbituric acid (TBA) values of tested beef burger patties as affected by the addition level from sweet and bitter lupine seed flours was investigated. The obtained results are recorded in Table (5)

Table 5: Physico-chemical quality criteria of beef burger patties as affected by the addition of tested lupine seed flours.

Tested Criterion	Physicochemical (M±SE*)				
	Control	Tested Treatments			
		5% SLF	7.5% SLF	5% BLF	7.5% BLF
PH value	6.72±0.07^{a}	6.82±0.03^{a}	6.84±0.06^{a}	6.78±0.03^{a}	6.82±0.04^{a}
WHC**	78.92±0.23^{a}	80.96±0.17^{b}	83.74±0.11^{c}	81.55±0.17^{b}	84.66±0.40^{c}
TVB-N content (mg/ 100g sample)	13.21±1.4^{b}	12.72±1.2^{a}	12.65±1.7^{a}	12.57±1.9^{a}	12.42±2.1^{a}
TBA value (mg/kg sample)	0.96±0.12^{c}	0.85±0.09^{b}	0.80±0.09^{a}	0.83±0.089^{ab}	0.79±0.078^{a}

M±SE*: *Mean ± standard error for triplicate determinations of physico-chemical quality characteristic; the means within the same row having different superscripts are varied significantly (at p ≤ 0.05).*
SLF*: Sweet lupine seeds flour;* ***BLF****: Bitter lupine seeds flour;* ***WHC**:*** *Water holding capacity;* ***TVB-N:*** *Total volatile basic-Nitrogen;* ***TBA:*** *Thiobarbituric acid.*

From the obtained results (Table 5), it could be noticed that the replacing of meat with lupine seed flour resulted in a slight non-significant increase in the pH values of lupine flour containing burger patties when compared to the pH value for the control sample no containing any flour (Oroszvári *et al*,. 2006$_{a}$)

As given in Table (5), it could be also observed that the water holding capacity (WHC) of beef burger samples increased significantly by replacing of meat with lupine seed flour. On the other hand, the incorporation of lupine seed flours into beef burger patties caused a significant (p≤ 0.05) increase in water holding capacity (WHC) value. Whereas, the increasing rate in the WHC of burger patties increased with increasing the added ratio from lupine flour, regardless of the lupine seed variety. In addition, the WHC values of samples containing bitter lupine flour were higher than the corresponding values for burger samples containing sweet lupine flour, this variation due to the higher water absorption ratio of bitter lupine seed flour as reported by Stahnke (1995).

From the same previous data (Table 5), it could be also observed that total volatile basic-nitrogen (TVB-N) content of beef burger patties as affected by incorporating sweet lupine flour and bitter lupine flour into the beef burger caused the reduction in their TVB-N contents, as the addition level of sweet lupine flour and bitter lupine flour was increased from 5 to 7.5 %. Beef burger patties contained sweet lupine flour and bitter lupine flour individually represented the TVB-N content of 12.42 – 12.72 mg/100g, versus 13.21 mg/100g for the control sample, on wet weight basis, and also noted that beef burger formulated by addition of bitter lupine flour contained lower content of total volatile basic-nitrogen (TVB-N) than that found in beef burger formulated by the addition of sweet lupine flour.

Concerning the thiobarbituric acid (TBA) value for prepared beef burger patties as a good indicator for the amount of malonaldehyde which is the most predominant product of the secondary oxidation in the food lipids, hence it is considered a good chemical constant for quality assurance and for measuring the extent of the secondary oxidation of edible lipids during processing and storage (Jeffery *et al*., 2003 and Podsedek *et al*., 2006). As shown in Table (5), the TBA values of the tested beef burger patties formulated by replacing of meat with 5 % and 7.5 % of either sweet lupine flour or bitter lupine flour were lower (0.79-0.85 mg malonaldehyde /kg wet weight of product) than that of control sample (0.96 mg malonaldehyde /kg wet weight of product). Meanwhile, beef burger containing bitter lupine flour contained lower amount of thiobarbituric acid (TBA) than that found in beef burger formulated by addition of sweet lupine flour. The formation of lower amount of thiobarbituric acid (TBA) in beef burger after processing could be attributed mainly to the auto-oxidation of beef burgers lipids bacteriologically and formation of some TBA-reactive compounds (Butler and Larick,1993), while the reduction in the increment rate of that value for beef burger samples containing lupine flour than the control sample could be attributed to some of antioxidant (phenol compounds) and tocopherols found in lupine seeds flour (Duranti, 2006; Rochfort and Panozzo, 2007 and Pastor-Cavada *et al.*, 2009.).

From previous discussion it could be seen that beef burger containing sweet or bitter lupine seed flour had a good quality, and the incorporation of the sweet or bitter lupine seed flour into the beef burger trials, as a substitute of meat, could be improved their physico-chemical quality criteria and nutritional quality with regards crude fiber content.

6. Cooking Measurements of Beef Burgers Containing Lupine Seed Flours:

Regarding cooking measurements **(**cooking yield, cooking shrinkage, moisture retention, and fat retention) which are considered one of the most important physical quality changes occur in beef burgers during cooking process due to protein denaturation and releasing of fat and water from beef burger patties **(**Stahnke, 1995 and Oroszvári *et al.*, 2005$_{b}$). Therefore, the impact of incorporating of sweet and bitter lupine seed flours individually at ratios of either 5 % or 7.5 % from meat weight used in burger formulation on cooking measurements;

including cooking yield, cooking shrinkage, moisture retention and fat retention of producing burger patties, compared to the control burger pattie was studied. The obtained results are tabulated as in Table (6).

Table 6: Cooking measurements of beef burger samples as affected by the addition of tested lupine seed flours.

Tested measurement	Cooking measurement value (%; M±SE*)				
	Control	Tested Treatments			
		5% SLF	7.5% SLF	5% BLF	7.5% BLF
Cooking yield	68.66 ^{a}	76.81 ^{c}	78.57 ^{d}	73.91 ^{b}	79.86 ^{d}
cooking Shrinkage	33.37 ^{e}	28.00 ^{d}	26.33 ^{c}	24.59 ^{b}	22.69 ^{a}
Moisture retention	66.15 ^{a}	70.41 ^{b}	71.76 ^{b}	71.72 ^{b}	72.11 ^{b}
Fat retention	69.84 ^{a}	72.80 ^{b}	75.87 ^{c}	72.83 ^{b}	75.32 ^{c}

M±SE*: *Mean ± standard error for triplicate determinations of cooking measurement; the means within the same row having different superscripts are varied significantly (at p ≤ 0.05).*
SLF*: Sweet lupine seeds flour;* ***BLF****: Bitter lupine seeds flour.*

From the obtained results (Table 6), it could be noticed that the cooking yield percentage of beef burger samples containing lupine flours at levels of 5 and 7.5 % was significantly higher (P<0.05) than that for the control sample. The cooking yield increased with increasing the level of lupine flour incorporated into beef burger pattie from 5 to 7.5% in each lupine flour burger pattie containing, these results are similar to those obtained by Stahnke (1995). From the same Table, it could be noticed that cooking shrinkage percentage of beef burger samples containing lupine flour were lower (P<0.05) than the control, also, cooking shrinkage percentage decreased as the level of added lupine flour increased from 5 to 7.5 % in each lupine treatment. These results are in accordance with those found by Oroszvári *et al*. (2005_a) and Oroszvári *et al*. (2006_a *and* $_b$).

Also, From the same results (Table 6), it could be showed that moisture retention and fat retention values of beef burger samples increased with incorporate lupine flour into the beef burger patties, also the values of moisture and fat retention were increased with increasing lupine flour level in beef burger samples, which were attributed to the high water and oil binding capacities of lupine flour. These results are in accordance with those found by Lopez *et al*. (1991); Aluko *et al*. (2005) and Sadeghi and Bhagya (2009).

7. Sensory Quality Criteria of Beef Burgers Containing Lupine Seed Flours:

The organoleptic quality properties of meat products are greatly affected by the ingredients used in processing treatments and correlated significantly with physico-chemical quality criteria of these products. Sensory evaluation, together with estimation the former criteria have been used extensively to assess the quality of meat products. Therefore, the organoleptic quality criteria (Color, flavor, tenderness, juiciness, overall acceptability) of beef burger containing sweet and bitter lupine seed flours were evaluated sensory and the obtained data are recorded in Table (7).

Table 7: Sensory quality properties score for prepared beef burger patties containing the tested lupine seed flours.

Sensory property	Sensory property score (M±SE*)				
	Control	Tested Treatments			
		5% SLF	7.5% SLF	5% BLF	7.5% BLF
Color	8.1 ± 0.07*a*	8.3 ± 0.10^{a}	8.3 ± 0.09^{a}	8.1 ± 0.13^{a}	8.1 ± 0.19^{a}
Flavor	7.9 ± 0.11*b*	8.6 ± 0.13^{c}	9.1 ± 0.14^{d}	7.7 ± 0.10^{ab}	7.4 ± 0.06^{a}
Tenderness	8.3 ± 0.14*ab*	8.3 ± 0.09^{ab}	8.5 ± 0.06^{b}	8.1 ± 0.07^{ab}	7.9 ± 0.13^{a}
Juiciness	7.6 ± 0.12*a*	7.9 ± 0.05^{ab}	8.4 ± 0.12^{b}	7.6 ± 0.04^{a}	8.2 ± 0.10^{b}
Overall acceptability	8.0 ± 0.11*a*	8.3 ± 0.09^{ab}	8.6 ± 0.10^{b}	7.9 ± 0.11^{a}	7.9 ± 0.12^{a}

M±SE*: *Mean ± standard error for sensory quality property; the means within the same row having different superscripts are varied significantly (at p ≤ 0.05).*
SLF*: Sweet lupine seeds flour;* ***BLF****: Bitter lupine seeds flour.*

As illustrate from sensory evaluation results (Table 7), the control and lupine flours containing beef burger patties exhibited very good or excellent sensory quality and better acceptability; especially those containing sweet lupine seed flours which had judging score ranged between 7.9 and 9.1 for all organoleptic quality properties.

Generally, it could be concluded that the incorporation of sweet lupine seed flour into beef burger patties, as a good functional and nutritional properties meat replacer, at the tested levels; 5 & 7.5 % of meat weight used in burger pattie formulation resulted in producing burger patties without detrimental effect on the sensory attributes besides improving physiochemical properties and cooking measurements of the product.

References

AOAC., 2000. Official Methods of Analysis. 17th ed. of the Association of Official Analytical Chemists. Gaithersburg, Maryland, USA.

Aleson-Carbonell, L., J. Fernandez-Lopez., J. A. Perez-Alvarez and V. Kuri, 2005. Characteristics of beef burger as influenced by various types of lemon albedo. Innovative Food Science and Emereging Technolgics, 6:247-255.

Aluko, R. E. and R. Y. Yada, 1993. Relationship of hydrophobicity and solubility with some functional properties of cowpea *(Vigna unguiculata)* protein isolate. J Sci. Food Agric., 62:331–335.

Aluko, R.E., T. McIntosh and F. Katepa-Mupondwa, 2005. Comparative study of the polypeptide profiles and functional properties of *Sinapis alba* and *Brassica juncea* seed meals and protein concentrates. J. Sci. Food Agric., 85: 1931-1937.

Butler, A.J. and D.K. Larick, 1993. Effects of antioxidants on the sensory characteristics and storage stability of aseptically processed low –fat beef gels. Meat Sci., 35: 355 – 369.

Capraro, J., C.H. Magni, M. Fontanesi, A. Budelli and M. Duranti, 2008. Application of two-dimensional electrophoresis to industrial process analysis of proteins in lupin-based pasta. LWT-Food Science and Technology, 41: 1011–1017.

Ciesiołska, D., P. Gulewicz, C. Martinez-Villaluenga, R. Pilarski, M. Bednarczyk and K. Gulewicz, 2005. Products and biopreparations from alkaloid-rich lupin in animal nutrition and ecological agriculture. Folia Biologica, 53: 59–66.

Clark, R.L. and S. J. Johnson, 2002. Sensory acceptability of foods with added lupin (*Lupinus angustifolius*) kernel fiber using pre-set criteria. Journal of Food Science, 67: 356–362.

Cohen, S. A., M. Mewyes and T. L. Travin, 1989. The Pico Tag Method. In: "A Manual of Advanced Techniques for Amino Acid Analysis", Millipore, USA.

Cserhalmi, Z.S., Z. Márkus, B. Czukor, A. Baráth and M. Tóth, 2001. Physico-chemical properties and food utilization possibilities of RF-treated mustard seed. Innovative Food Sci. and Emerging Techn., 1: 251-254

Dervas, G., G. Doxastakis, S. Zinoviadi and N. Triandatafillakos, 1999. Lupine flour addition to wheat flour dough's and effect on rhelogical properties. Food Chem., 42: 67-73.

Dijkstra, D., A. Linnemann and T. Van-Boekel, 2003. Towards sustainable production of protein-rich foods: Appraisal of eight crops for Western Europe. PART II:Analysis of the technological aspects of the production chain. Critical Reviews in Food Science and Nutrition, 43(5): 481–506.

Drakos, A., G. Doxastakis and V. Kiosseoglou, 2007. Functional effects of lupine proteins in comminuted meat and emulsion gels. Food Chemistry, 100: 650–655.

Dreeling, N., P. Allen and F. Butler, 2000. Effect of the degree of comminution on sensory and texture attributes of low-fat beef burger. LWT - Food Science and Technology, 33: 290-294.

Duranti, M., 2006. Grain legume proteins and nutraceutical properties. Fitoterapia, 77: 67–82.

El-Akary, M. O., 1986. The technology and characteristics of beef burger containing plant substitutes. M.Sc. Thesis, Dept. food Sci. ad Technol., Fac. of Agric., Alex. Univ., Egypt.

Faeste, Ch. K., M. Løvik, H.G. Wiker and E. Egaas, 2004. A case of peanut cross-allergy to lupine flour in a hot dog bread. Int. Arch. Allergy. Immunol., 135: 36–39.

FAO/WHO., 1973. Energy and protein requirements. Report of a Joint FAO/WHO expert committee, Food and Agriculture Organization of the United Nations, pp. 57 – 62.

Gomez, K. A. and A. A. Gomez, 1984 . Statistical Procedures for Agricultural Research, 2nd Ed. John Wiley and Sons Ltd., New York.

Guillon, F. and M. Champ, 1996. Grain legumes and transit in humans. Grain Legumes, AEP(ed.),11:18.

Gulewicz, P., C. Martenez-Villaluenga, J. Frias, D. Ciesiołka, K. Gulewicz and C. Vidal-Valverde, 2008. Effect of germination on the protein fraction composition of different lupine seeds. Food Chemistry, 107: 830–844.

Hall, R.S., S.K. Johnson, A.L. Baxter and M.J. Ball, 2005. Lupin kernel fiber-enriched foods beneficially modify serum lipids in men. European Journal of Clinical Nutrition, 59: 325–333.

Jeffery, E.H., A.F. Brown, A.C. Kurilich, A.S. Keck, N. Mastusheski, B.P. Klein and J.A. Juvik, 2003. Variation in content of bioactive components in broccoli. J. Food Composition and Analysis, 16: 323 – 330.

Kohajdova, Z., J. Karovičova and Š. Schmid, 2011. Lupin Composition and Possible Use in Bakery– A Review. J. Food Sci., 29(3): 203–211.

Larmond, E., 1973. Methods of Sensory Evaluation of Foods. Dept. of Agric. Ottawa Canada, KIAOC, 7.

Linnemann, A. R. and D. S. Dijkstra, 2002. Toward sustainable production of protein-rich foods: appraisal of eight crops for Western Europe. Part I. Analysis of the primary links of the production chain. Critical Reviews in Food Science and Nutrition, 42: 377–401.

Lopez, O. P., C.O. Falomir and M. R. Vazauez, 1991. Chickpea protein isolates: physiochemical, functional and nutritional characteristics. J. Food Sci., 56: 726.

Mansour, E. H. and A. H. Khalil, 1997. Characteristics of low-fat beef burger as influenced by various types of wheat flours. Food Research Int., 3 (314): 199 – 205.

Markwell, M. A. K., S. M. Haas, L. L. Bieber and N. E. Tolbert, 1978. A modification of the Lowry procedure to simplify protein determination in membrane and lipoprotein samples. Anal. Biochem., 87:206–210.

Martinez-Villaluenga, C., J. Frias and C. Vidal-Valverde, 2006$_a$. Functional lupin seeds (*Lupinus albus* L. and *Lupinus luteus* L.) after extraction of α-galactosides. Food Chemistry, 98: 291–299.

Martinez-Villaluenga, C., E. Sironi, C. Vidal-Valverde and Duranti, M. 2006$_b$. Effects of oligosaccharide removing procedure on the protein profiles of lupine seeds. European Food Research and Technology, 223: 691–696

Mohamed, A. A. and P. Rayas-Duarte, 1995. Composition of *Lupinus albus.* Cereal Chemistry, 72: 643–647.

Mülayim, M., A. Tamkoc and M. Babaoglu, 2002. Sweet white lupins versus local bitter genotype: agronomic characteristics as affected by different planting densities in the Goller region of Turkey. European Journal of Agronomy, 17: 181–189.

Ockerman, H.W., 1985. Quality Control of Postmortem Muscle Tissue, 2nd edn, Vol. 2, The Ohio State University, Columbus.

Ogüt, H., 1998. Some physical properties of white lupine. Journal of Agricultural Engineering Research, 69: 273–277.

Oroszvári, B. k., I. Sjohölm and E. Tornberg, 2005$_a$. The mechanisms controlling heat and mass transfer on frying beef burgers. 1. The influence of the composition and comminution of meat raw material. J. of Food Engineering, 67: 499 – 506.

Oroszvári, B. k., E. Bayod, I. Sjohölm and E. Tornberg, 2005$_b$. The mechanisms controlling heat and mass transfer on frying beef burgers. 2. The influence of the pan temperature and patty diameter. J. of Food Engineering, 71: 18 – 27.

Oroszvári, B. k., C.S. Rocha, I. Sjöholm and E. Tornberg, 2006$_a$. Permeability and mass transfer as a function of the cooking temperature during the frying of beef burgers. J. Food Engineering, 74; 1 – 12.

Oroszvári, B. k., E. Bayod, I. Sjohölm and E. Tornberg, 2006$_b$. The mechanisms controlling heat and mass transfer on frying beef burgers. III. Mass transfer evolution during frying. J. of Food Engineering, 76: 169 – 178.

Ou, D. and G. S. Mittal, 2006. Double-sided pan-frying of unfrozen / frozen hamburgers for microbial safety using modelling and simulation. Food Research International, 39 : 133-144.

Papavergou, E. J., J.G. Bloukas and G. Doxastakis, 1999. Effect of lupine seed proteins on quality characteristics of fermented sausages. Meat Science, 52: 421–427.

Pastor-Cavada, E., R. Juan, J. E. Pastor, M. Alaiz and J. Vioque, 2009. Analytical nutritional characteristics of seed proteins in six wild Lupinus species from Southern Spain. Food Chemistry, 117: 466–469.

Pearson, D., 1976. Chemical Analysis of Food, 7th Ed., pp. 6 – 26. Longman Group Limited, London.

Pisarikova, B., Z. Zraly, F. Bunka and M. Trckova, 2008. Nutritional value of white lupine cultivar Butan in diets for fattening pigs. Veterinarni Medicina, 53: 124–134.

Podsedek, A., D. Sosnowska, M. Redzynia and B. Anders, 2006. Antioxidant capacity and content of *Brassica oleracea* dietary antioxidants. Itern. J. Food Sci. and Techn., 41: 49-58.

Pollard, N.J., F.L. Stoddard, Y. Popineau, C.W. Wrigley and F. MacRitchie 2002. Lupine flours as additives: Dough mixing, breadmaking, emulsifying and foaming. Cereal Chemistry, 79: 662–669.

Poole, S.; S. I. West and C. L. Walters, 1984. Protein–protein interactions: their importance in the foaming of heterogeneous protein systems. J. Sci. Food Agric., 35:701–711.

Rahma, E. H. and M. S. Narsinga-Rao, 1984. Effect of debittering treatment on the composition and protein components of lupine seed *(Lupinus termis)* flour. Journal of Agricultural and Food Chemistry,32: 1026–1030.

Raymondo A., J. Franco, C. Gallegos, J. Empis and I. Sousa, 1998. Effect of thermal denaturation of lupine protein on its emulsifying properties. Nahrung/Food, 42: 220–224.

Rochfort, S., and J. Panozzo, 2007. Phytochemicals for health, the role of pulses. Journal of Agricultural and Food Chemistry, 55: 7981–7994.

Sadeghi, M. A. and S. Bhagya, 2009. Effect of recovery method on different property of mustard protein. World Journal of Dairy & Food Sciences, 4 (2): 100-106.

Sathe, S.K., S.S. Desphande and D.K. Salunkhe, 1982. Functional properties of lupine seed (*Lupinus mutabilis*) protein and protein concentrates. Journal of Food Science, 47: 491-497.

Schoeni, J. L., K. Brunner and M.P. Doylle, 1991. Rates of thermal inactivation of *Listeria monocytogenes* in beef and fermented beaker sausage. Journal of Food Protection, 54: 334 -337.

Sian, N. K. and S. Ishak, 1991. Effect of pH on formation, proximate composition and rehydration capacity of bean and soybean protein-lipid film. Journal of Food Science, 55: 261.

Sironi, E., F. Sessa and M. Duranti, 2005. A simple procedure of lupin seed protein fractionation for selective food applications. European Food Research and Technology, 221: 145–150.

Smith, S.C., R. Choy, S.K. Johnson, R. H. Hall, A.C.M. Wildeboer-Veloo and G.W. Welling, 2006. Lupine kernel fiber consumption modifies fecal microbiota in healthy men as determined by RNA gene fluorescent in situ hybridization. European Journal of Nutrition, 45: 335–341.

Soloviev, A. A., 1966. Meat aging. In: "Food Industry" Pub. (Moscow) 53 -81, 82 -164, 242 -303.

Sousa, I. M. N., P.J. Morgan, J. R. Mitchell, S.E. Harding, and S.E. Hill, 1996. Hydrodynamic characterization of lupin proteins: Solubility, intrinsic viscosity and molar mass. Journal of Agricultural and Food Chemistry, 44: 3018–3021.

Stahnke, L. H., 1995. Dried sausage fermented with *Staphylococcus xylosus* at different ingredient levels. Part I. Chemical and bacteriological data. Meat Sci., 41(2): 179-191.

Standish, J., 1992. Functional properties of non-meat binders in comminuted meat products. M.SC. Thesis, Faculty of Graduate and Search, Alberta University, Canada.

Uzun B., C. Arslan, M. Karhan and C. Toker, 2007. Fat and fatty acids of white lupin (*Lupinus albus L*.) in comparison to sesame (*Sesamum indicum* L.). Food Chemistry, 102: 45–49.

Zielinska, D., J. Frias, M.K. Piskuła, H. Kozłowska, H. Zielinski and C. Vidal-Valverde, 2008. Evaluation of the antioxidant capacity of lupin sprouts germinated in the presence of selenium. European Food Research and Technology, 227: 1711–1720.