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Physicochemical and Sensory Properties of Biscuit Fortified With Bitter Lupine

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Abstract

Bitter lupine is one of the legumes rich in protein and antioxidants but is not acceptable because of its bitter taste. The present work aimed to remove alkaloids from bitter lupine seeds by using different debittering methods and used for fortified the biscuit product. The proximate composition, protein digestibility, and phytochemical content of lupine flour were determined. The physical, chemical, and sensory properties of biscuits were done. Results showed that; debittering methods increased the protein content of lupine flour. The highest protein content was observed in bitter lupine which was boiled for one hour. The ash, fiber, fat, and total carbohydrate contents of lupine flour were decreased after debittering methods. *In vitro* protein digestibility was increased significantly by debittering methods, particularly in bitter lupine soaked for 12 h. Furthermore, alkaloids, phenols, and antioxidants are decreased by different debittering methods. Physical properties such as the diameter slightly decreased and a significant increase in thickness of biscuits with different debittering methods. On the other hand, there is a non- significant difference between the control sample and treated samples of biscuits for all the quality characteristics (appearance, odor, texture, taste, and overall acceptability). Finally, the obtained results could be useful for improving the biscuits processing and nutrition value by utilizing debittered lupine flour as a functional food.

Keywords: Bitter lupine, alkaloids, debittering methods, biscuits, chemical, physical, sensory properties.

Introduction

Legumes are important in the human diet because of their high protein content and health benefits. They provide energy, dietary fiber, protein, minerals, and vitamins required for human health **(Klupsaite and Juodeikiene 2015).** Legume seeds are food ingredients with high nutritional quality and a low glycemic index when compared to cereal **(Llavata *et al.*, 2019)**. It is also well known that the antioxidant phytochemicals which have many health benefits including the prevention of various diseases associated with oxidative stress such as cancer, cardiovascular disease, and diabetes (**Dalaram, 2017**). In 2019, the largest lupine producers were Australia (474,629 tons), Russian Federation (103,792 tons), and Poland (261,500 tons), while the production of lupine in Egypt was (255 tons) **(FAO, 2021).** Lupines can be divided into sweet lupine (which contains low levels of alkaloids) and bitter lupine (which contains higher levels of alkaloids). Debittering involves the elimination of anti-nutritional factors to improve the nutritive value **(Erbas, 2010 and Villacres *et al.*, 2020).** The debittered lupine seeds can be also referred to as sweet lupine when the alkaloid content has been reduced to less than 0.2 g/kg, which is the current maximum permitted concentration and adequate for safe consumption **(ANZFA, 2001)**. **Abeshu and Kefale (2017)** reported that cooking and soaking enhanced the nutrient contents and drastically reduced the main anti-nutrient of sweet and bitter lupine alkaloid content. Debittered lupine flour can be used in baking and in the production of pasta and a variety of other food products to increase their nutritional value and to improve aroma and texture **(Abd El-Maasoud and Ghaly, 2018)**. Also, lupine can be a good choice for vegetarians as regards protein abundance **(Lampart-Szczapa *et al.*, 2006; Martinez-Villaluenga *et al.*, 2006).** Biscuit consumption is in the list of top ten daily consumed foods, as they are easily available and convenient to be enjoyed as a snack **(Jauharah *et al.*, 2014)**. Biscuits are high in carbohydrates, fat, and calorie but low in fiber, vitamins, and minerals which make them unhealthy for daily use **(Serrem *et al.*, 2011)**. There is a growing interest to improve the nutritional qualities of biscuits, to produce more healthy, natural, and functional products. Biscuit requires a balanced nutritional value which can be enhanced by fortification and supplementation with a wide variety of protein-rich cereal and pulses **(Ahmad and Ahmed, 2014)**.

The aim of this study is to evaluate the impact of debittering methods on the chemical composition and phytochemical contents of bitter lupine seeds. Also, the influence of substituted wheat flour with 10% of debittered lupine flour on chemical composition, physical, and sensory properties of biscuits product.

Materials and methods

1. Materials:

Bitter lupine seeds “Giza II” was obtained from a Crop Research Institute, Agriculture Research Center (ARC), Giza, Egypt. Wheat flour (72% extraction) was obtained from the south Cairo company of milling. Baking ingredients (Sugar, baking powder, butter, and sodium chloride) were purchased from a local market in Cairo Governorate. Chemical and reagents such as 2,2-diphenyl-1-picrylhydrazyl (DPPH), Gallic acid, catechin, phenolic acid, and flavonoid standards were purchased from Sigma Aldrich Company, USA. Folin-Ciocalteu reagent was obtained from LOBA Chemie, India. All chemicals were of the analytical reagent grade.

2.2. Debittering of lupine seeds:

Bitter lupine seeds were divided into three groups. The first group (G1) was debittered by soaking for 12 h at room temperature, then boiled for 25 minutes, soaked in water at room temperature (at 1:3, seeds: water) with changing the water in 12 h intervals for 144 h. The second group (G2) was debittered by boiling for one hour, then soaked in water at room temperature (at 1: 3, seeds: water), with changing the water in 12 h intervals for 144 h. The third group (G3) was debittered by boiling for one hour, then soaking in 0.5% $NaHCo_3$ (Sodium bicarbonate) solution, with changing solution in 12 h intervals for 144 h. After debittering, the seeds were washed gently with water, then firmly dehulled manually, and finally dried in the oven at 60 °C overnight. Dried seeds were ground into flour to get particles around 0.45 mm, then kept in polyethylene bags in the refrigerator till analysis.

2.3. Preparation of biscuits:

A preliminary experiment was done with different substitution ratios of debittered lupine flour to replace 5, 10, and 15% of wheat flour (72% ext.). The biscuits were prepared according to the method of **AACC (2010)** as follows: butter and sugar were mixed for 2 min until creamy color formed using a Molineux mixer. The whole egg and vanilla were added with continued mixed for 1 min. The blended dry ingredients (flour and baking powder) were mixed and sifted then added to the mixture and beaten for 4 min. After that, the dough was flattened to 0.25 cm thickness, then cut using a 5 cm diameter round cutter. Biscuits were transferred to a baking tray and baked for 15 min at 175°C. After baking, biscuits were left to cool and packed.

2.4. Determination of protein digestibility (*in vitro*):

Protein digestibility (*in vitro*) of each lupine flour sample was determined according to the method of **Schlemmer *et al.* (2009**).

2.5. Chemical analysis:

The proximate composition, i.e., moisture, crude protein, ash, fiber, and fat contents of lupine flour was determined according to the methods of **AOAC (2016)**. Total carbohydrate was calculated by difference.

2.6. Determination of total phenolics content (TPC):

Total phenolic compounds were determined colorimetrically by using the Folin-Ciocalteau reagent according to the method of **Gao *et al*. (2002).** Gallic acid was used as a standard and total phenolics were expressed as mg GAE/100g sample (on dry weight basis).

2.7. Determination of total flavonoids content (TFC):

Total flavonoids content was determined according to the method described by **Zhishen *et al*. (1999)**.

2.8. Determination of carotenoids:

Carotenoids content was determined using the method described in the **AOAC (2016)**.

2.9. Determination of antioxidant activity by using DPPH (radical scavenging method):

The antioxidant activity was determined based on the radical scavenging ability in reacting with a stable DPPH free radical according to the method of **Brand-Williams *et al*. (1995).**

2.10. Determination of total alkaloids by spectrophotometric:

Total alkaloid content is determined by the spectrophotometric at 470 nm according to **Shamsa *et al* (2008).**

2.11. Physical properties of biscuits:

The diameter, thickness, and spread ratio of biscuits were determined according to **AACC (2010)**.

2.12. Color measurements:

The color of biscuits was measured according to the method outlined by **McGurie (1992)** using a hand-held Chromameter (model CR-400, Konica Minolta, Japan). The results were expressed in terms of *L* (lightness), *a* (redness-greenness), and *b* (yellowness -blueness).

2.13. Sensory evaluation:

Sensory evaluation of biscuit samples was carried out by ten trained panelists in the Food Technology Research Institute according to the method of **Sudha *et al.* (2007)**. The panelists were asked to use the control biscuits as the basis for determining acceptance by first assigning a score (1 to 10) of appearance, odor, texture, taste, and overall acceptability.

2.14. Statistical analysis:

The obtained data were exposed to the analysis of variance ANOVA (one-way analysis of variance). Duncan's multiple tests at the 5% level were used to compare the significant differences between means (**Steel *et al.* 1997**).

Results and discussion

1. Chemical composition:

The chemical composition of bitter and debittered lupine flour samples is shown in **Table (1)**. The results demonstrated that the protein content of lupine flour significantly increased ($p < 0.05$) after different debittered processes compared with raw lupine flour. The highest protein content was 53.6 g/100 g in (debittered lupine flour; DLF2), while it was 42.4 g/100 g in the control sample. This increase is probably due to the loss of soluble carbohydrates, minerals, alkaloids, and flavonoids when the debittering liquid was changed. The fiber was significantly decreased ($p < 0.05$) after different methods compared with raw bitter lupine. Fiber content was decreased from 4.47% in BLF to 3.86% in DLF3. Fiber decreased in debittered lupine because of the separation of the softened husks and soluble material during the debittering process. Ash was significantly decreased ($p < 0.05$) after different treatments compared with raw bitter lupine. Ash content decreased from 3.14% in BLF to 2.52% in DLF2. This could be attributed to decreased crude fiber and mineral contents by soaking and boiling processes. Furthermore, fat content decreased slightly after different processes compared with raw bitter lupine and ranged from 9.88%-9.22%. This decrease is due to the removal of the lipid-rich embryo together with the detached husks. These results are in agreement with those obtained by **Awad-Allah and Elkatry (2013) and Abeshu and Kefale (2017)** who reported that debittering of lupine by soaking and boiling increased the protein content of bitter lupine. However, ash, fiber, and fat decreased by soaking and boiling. Carbohydrate content decreased after debittering processes compared to raw lupine. It decreased from 40.11% in BLF to 30.90 % in DLF3. This is due to the elimination of carbohydrates by changing water. These results are in agreement with **Villacres *et al.* (2020)** who reported decreased carbohydrate content of bitter lupine by soaking and cooking.

Table 1. Chemical composition of bitter and debittered lupine flour on dry basis (Mean ± SE).

Treatments	Components (%)					
	Moisture	***Protein**	***Ash**	***Fiber**	***Fat**	***Available carbohydrate**
BLF (Control)	**7.53±0.06[a]**	**42.40±0.14[c]**	**3.14±0.03[a]**	**4.47±0.11[a]**	**9.88±0.61[a]**	**40.11±0.38[a]**
DLF 1	**7.31±0.04[b]**	**52.80±0.13[b]**	**2.55±0.03[b]**	**4.45±0.03[a]**	**9.67±0.31[a]**	**30.53±0.24[b]**
DLF 2	**7.24±0.03[b]**	**53.60±0.07[a]**	**2.52±0.06[b]**	**4.35±0.04[a]**	**9.54±0.18[a]**	**29.99±0.10[b]**
DLF 3	**7.26±0.10[b]**	**53.40±0.03[a]**	**2.62±0.11[b]**	**3.86±0.03[b]**	**9.22±0.17[a]**	**30.90±0.34[b]**
LSD ($p < 0.05$)	**0.17**	**0.28**	**0.18**	**0.18**	**1.01**	**0.80**

BLF: raw bitter lupine flour, DLF 1: Bitter lupine soaked for 12 h then boiled for 25 minutes debittered by changing the water every 12 h at room temperature, DLF 2: Bitter lupine boiled 1 h, debittered by changing the water every 12 h at room temperature, DLF 3: Bitter lupine boiled 1 h, debittered by changing the water every 12 h at room temperature with 0.5% $NaHCO_3$.

* *on dry basis.*

The results of *in vitro* protein digestibility of bitter lupine before and after processes are summarized in **Table (2).** Results showed that *in vitro* protein digestibility significantly increase ($p < 0.05$) by debittering methods that increase from 80.55 in BLF to 82.5% in DLF1. Soaking and cooking reduce the presence of antinutrients. furthermore, heating denatures the proteins, making them more available for digestion as reported by **El-Hady and Habiba (2003)**. The findings are in agreement with those reported by **Cordova Ramos *et al.* (2020)** who reported that the debittering process significantly improved the in vitro digestibility of proteins.

Table 2. *In vitro* protein digestibility of bitter and debittered lupine flour (Mean ± SE).

Treatments	Protein digestibility (%)
BLF (Control)	**80.55±0.04[c]**
DLF 1	**82.5±0.04[a]**
DLF 2	**82.3±0.03[b]**
DLF 3	**82.25±0.06[b]**
LSD ($p < 0.05$)	**0.12**

BLF: raw bitter lupine flour, DLF 1: Bitter lupine soaked for 12 h then boiled for 25 minutes debittered by changing the water every 12 h at room temperature, DLF 2: Bitter lupine boiled 1 h, debittered by changing the water every 12 h at room temperature, DLF 3: Bitter lupine boiled 1 h, debittered by changing the water every 12 h at room temperature with 0.5% $NaHCO_3$

The results of alkaloid, flavonoid, total phenols, carotenoid, and antioxidant activity of raw bitter and debittered lupine flour samples are shown in **Table (3).** Results showed that alkaloids significantly decrease ($p < 0.05$) by different debittering methods. Total alkaloid decreased from 1.8 g/100 g in BLF to 0.11 g/100 g in DLF1. Since the alkaloids of lupine are water-soluble, removal of alkaloids occurs when debittering liquid was changed. The findings are in agreement with **Abeshu and Kefale (2017)** who reported that the alkaloid content of bitter lupine was significantly ($p < 0.05$) reduced by soaking and boiling. Also, **Awad-Allah and Elkatry (2013)** reported that the total alkaloids in bitter lupine were (1.47 g/100 g) and reduced to below the detection limit (0.03 g/100 g) by soaking and boiling.

Flavonoids, total phenols, and antioxidant activity significantly decrease ($p < 0.05$) by different debittering methods, from 51.50 to 46.12 mg CE/100 g, 248 to 238.73 mg GAE/100 g, and 29.22% to 25.62% in BLF and DLF 3 respectively. This is due to the weakening of the cell wall tissue of soybean during the soaking process which results in the solubilization of bound polyphenols. This results are in agreement with those obtained by **Santhirasegaram *et al.* (2016)** who reported a significant reduction in flavonoids, total phenols, and antioxidant activity in soybean samples after soaking and cooking. Carotenoid content significantly increases ($p < 0.05$) by different debittering processes. It increased from 27.5 mg/100g in BLF to 32.47 mg/100 g in DLF1. This could be due to the breakdown of the cellulose structure of the plant cell which improves the bioavailability of carotenoids. This results are in agreement with that reported by **Azizah *et al.* (2009)**. This study revealed that thermal treatment enhanced the availability of the carotenoid. **Van het Hof *et al*. (2000)** reported that the processing of vegetables resulted in the breakdown of the cellulose structure of the plant cell and thus improve the bioavailability of carotenoids.

Table 3. Phytochemical content and antioxidant activity of bitter and debittered lupine (Mean ± SE).

Treatments	Alkaloids g/100 g	Flavonoids (mg CE/100g)	Total phenols (mg GAE/100g)	Antioxidant activity DPPH (%)	Carotenoids (mg/100g)
BLF (control)	1.800±0.00[a]	51.50±0.01[a]	248.00±0.01[a]	29.22±0.04[a]	27.50±0.01[d]
DLF 1	0.011±0.00[b]	48.00±0.01[b]	245.88±0.74[b]	26.54±0.01[b]	32.47±0.02[a]
DLF 2	0.012±0.00[b]	47.48±0.06[c]	243.34±0.04[c]	26.39±0.04[c]	29.91±0.02[b]
DLF 3	0.012±0.00[b]	46.12±0.01[d]	238.73±0.03[d]	25.62±0.03[d]	29.35±0.00[c]
LSD (p < 0.05)	0.04	0.09	1.02	0.09	0.05

BLF: raw bitter lupine flour, DLF 1: Bitter lupine soaked for 12 h then boiled for 25 minutes debittered by changing the water every 12 h at room temperature, DLF 2: Bitter lupine boiled 1 h, debittered by changing the water every 12 h at room temperature, DLF 3: Bitter lupine boiled 1 h, debittered by changing the water every 12 h at room temperature with 0.5% NaHCO3

Data in **Table (4)** presented the physical properties including; diameter, thickness, spread ratio of biscuits made from wheat flour supplemented with 10 % raw bitter lupine and different methods. Results showed that the biscuits substituted with 10% lupine flour showed a significant increase ($p < 0.05$) in thickness and a significant reduction ($p < 0.05$) in spread ratio. on the other hand, the diameter slightly decreases in substituted biscuits. The thickness increased from 6.11 mm in the control sample to 6.69 mm in DLF2. On the other hand, the diameter decreased in control from 35.1 mm to 34.72 mm in DLF2. Also, the spread ratio decreased from 5.75 in the control sample to 5.19 in DLF2. This data are in agreement with **Chinma *et al*. (2012)**, who found that the addition of high protein flour sources causes a negative correlation between the diameter and spread of the cookie. Similar results had been reported by **Jayasena and Nasar-Abbas (2011)** who reported that increased the thickness and decreased the diameter and spread ratio in lupine flour incorporated biscuits.

Table 4. Physical properties of biscuits fortified with debittered lupine (Mean ± SE).

Treatments	Diameter (mm)	Thickness (mm)	Spread Ratio
Control	35.1±0.14[a]	6.11±0.01[b]	5.75±0.00[a]
DLF 1	34.76±0.01[b]	6.66±0.01[a]	5.22±0.01[b]
DLF 2	34.72±0.01[b]	6.69±0.03[a]	5.19±0.01[b]
DLF 3	34.73±2.09[b]	6.68±0.03[a]	5.2±0.03[b]
LSD (p < 0.05)	0.2	0.06	0.05

Control: 100% wheat flour, DLF 1: Bitter lupine soaked for 12 h then boiled for 25 minutes debittered by changing the water every 12 h at room temperature, DLF 2: Bitter lupine boiled 1 h, debittered by changing the water every 12 h at room temperature, DLF 3: Bitter lupine boiled 1 h, debittered by changing the water every 12 h at room temperature with 0.5% NaHCO3

Color values (L, *a*, and *b*) of biscuits are represented in **Table (5).** The results showed that the *L* value significantly decrease ($p < 0.05$) in biscuits substituted with debittered lupine flour. The lowest value was observed in DLF1(79.46) relative to the control sample (83.44). While the *a* value demonstrated a significant increase ($p < 0.05$) in debittered lupine flour. The highest *a* value was observed in DLF1(1.58) relative to the control sample (0.13). As well as, the *a* and *b* values significantly increase ($p < 0.05$) in biscuits substituted with debittered lupine flour, and the highest observed ratio was (39.78) in DLF1 relative to the control sample (34.86). These results are in agreement with those obtained by **Jayasena and Nasar-Abbas (2011)** who reported that the replacement of wheat flour with lupine flour affected both dough and biscuit colors. Also, **Mota *et al.* (2020)** found that lightness *L* values decreased, generally, for the cookies supplemented with the lupine extract. They attributed these changes to the maillard reaction, as proteins and sugars initiate a complex cascade of reactions during heating (higher than 100 ºC), producing the darker color. **Taha *et al*. (2006)** reported that the *L* value of biscuits decreased and the *b* value increased when wheat flour was replaced with broad bean flour at a 12% level**.** Lupine flour is naturally yellower than wheat flour owing to its high carotenoid contents **(Wang *et al*., 2008).**

Table 5. Color measurement of biscuits fortified with debittered lupine flour (Mean ± SE).

Treatments	*L**	*a**	*b**
Control	**83.44±0.34[a]**	**0.13±0.04[c]**	**34.86±0.35[c]**
DLF 1	**79.46±0.56[d]**	**1.58±0.01[a]**	**39.78±0.26[a]**
DLF 2	**80.71±0.39[c]**	**1.32±0.12[b]**	**38.89±0.01[b]**
DLF 3	**81.96±0.04[b]**	**1.21±0.02[b]**	**38.09±0.13[b]**
LSD (p < 0.05)	**1.06**	**0.18**	**0.64**

Control: 100% wheat flour, DLF 1: Bitter lupine soaked for 12 h then boiled for 25 minutes debittered by changing the water every 12 h at room temperature, DLF 2: Bitter lupine boiled 1 h, debittered by changing the water every 12 h at room temperature, DLF 3: Bitter lupine boiled 1 h, debittered by changing the water every 12 h at room temperature with 0.5% NaHCO3

The chemical composition of biscuits formed from wheat flour and that substituted with 10% of debittered lupine flour is shown in **Table (6).** Moisture content significantly decreased ($p < 0.05$) in biscuits substituted with debittered lupine flour of different processes. It decreased from 5.82% in control to 4.93% in DLF 3. The protein content significantly increases ($p < 0.05$) in different processes. The protein content was increased from 9.82 % in control to 14.2% in DLF2. The Ash content increased significantly ($p < 0.05$) in different processes. The Ash content was increased from 0.62% in control to 0.82% in DLF3. The Fiber content also increased significantly ($p < 0.05$) in different processes. The fiber content was increased from 0.23 % in control to 0.72% in DLF2. As well as fiber content, the fat content increased significantly ($p < 0.05$) in different debittering processes. The fat content increased from19.29 % in control, while it increased to 19.77 % in DLF1. Results of carbohydrates showed it decreased significantly ($p < 0.05$) in different processes. it was 70.05% in control and it decreased to 64.65% in DLF1. These results are in agreement with that obtained by **Abd El-Maasoud and Ghaly (2018)** who found a significant increase in protein, ash, fiber, and fat and a decrease in carbohydrate in biscuit samples substituted with lupine flour.

Table 6. Chemical composition of biscuits fortified with debittered lupine flour (Mean ± SE).

Treatments	Components (%)					
	Moisture	***Protein**	***Ash**	***Fiber**	***Fat**	***Carbohydrate**
Control	**5.82±0.01[a]**	**9.82±0.01[c]**	**0.62±0.03[b]**	**0.23±0.03[c]**	**19.29±0.06[c]**	**70.05±0.05[a]**
DLF 1	**4.97±0.03[b]**	**14.12±0.00[b]**	**0.81±0.00[a]**	**0.65±0.00[b]**	**19.77±0.03[a]**	**64.65±0.03[b]**
DLF 2	**4.96±0.01[b]**	**14.20±0.00[a]**	**0.81±0.03[a]**	**0.72±0.03[a]**	**19.65±0.04[b]**	**64.67±0.03[b]**
DLF 3	**4.93±0.03[b]**	**14.18±0.03[a]**	**0.82±0.03[a]**	**0.64±0.00[b]**	**19.56±0.01[b]**	**64.80±0.07[b]**
LSD (p < 0.05)	**0.06**	**0.04**	**0.07**	**0.06**	**0.11**	**0.14**

Control: 100% wheat flour, DLF 1: Bitter lupine soaked for 12 h then boiled for 25 minutes debittered by changing the water every 12 h at room temperature, DLF 2: Bitter lupine boiled 1 h, debittered by changing the water every 12 h at room temperature, DLF 3: Bitter lupine boiled 1 h, debittered by changing the water every 12 h at room temperature with 0.5% NaHCO3.
** on dry basis.*

3.2. Organoleptic characteristics:

Organoleptic characteristics of biscuits formed from wheat flour and that substituted with 10% of debittered lupine flour are shown in **Table (7).** Results showed that there were non-significant differences (p>0.05) between the control sample and biscuits substituted with debittered lupine flour samples in appearance, odor, texture, and taste. The score ranged from 9.4 to 9.8, 9.3 to 9.8, 9.2 to 9.7, and 8.5 to 9.8 in DLF3 and control samples, respectively. However, a non-significant difference for the overall acceptability between the control sample (9.7) and debittered biscuit samples DLF1 (9.35), and DLF2 (9.05). Except for DLF3 which had the least overall acceptability (8.35). Results are in agreement with those obtained by **Abd El-Maasoud and Ghaly (2018**) who reported that biscuits formed from the replacement of wheat flour with SLF up to level 8% had good sensory properties. While, **Abdelrahman, (2014)** found that sensory acceptability of the cake formed from the replacement of wheat flour with lupine flour was satisfactory up to 10% concentration of lupine flour.

Table 7. Sensory evaluation of biscuits fortified with debittered lupine flour (Mean ± SE).

Treatments	Appearance (10)	Odor (10)	Texture (10)	Taste (10)	Overall acceptability (10)
Control	9.8±0.42[a]	9.8±0.42[a]	9.7±0.67[a]	9.8±0.42[a]	9.7±0.48[a]
DLF 1	9.7±0.42[a]	9.5±0.71[a]	9.65±0.47[a]	9.35±0.82[ab]	9.35±0.67[a]
DLF 2	9.45±0.68[a]	9.5±0.85[a]	9.2±0.89[a]	8.8±1.03[b]	9.05±0.80[a]
DLF 3	9.4±0.70[a]	9.3±1.25[a]	9.2±0.92[a]	8.5±0.97[b]	8.35±0.88[b]
LSD ($p < 0.05$)	0.52	0.78	0.69	0.77	0.66

Control: 100% wheat flour, DLF 1: Bitter lupine soaked for 12 h then boiled for 25 minutes debittered by changing the water every 12 h at room temperature, DLF 2: Bitter lupine boiled 1 h, debittered by changing the water every 12 h at room temperature, DLF 3: Bitter lupine soaked for 12 h then boiled for 25 minutes debittered by changing the water every 12 h at room temperature

Conclusion

In this study, the effect of different debittering methods on chemical composition and phytochemical in bitter lupin seeds was evaluated. Debittering led to a significant increase in protein content, while the ash, fiber, fat, available carbohydrate, and alkaloids contents of lupine flour were decreased**.** Also, *in vitro* protein digestibility significantly increased in DLF1. The biscuits made from DLF treatment had good overall acceptability with a non-significant difference in appearance, odor, texture, and taste than that made from the control sample, furthermore it was a high nutritional value.

References

AACC (2010). American Association of Cereal Chemists. Approved Methods of the AACC; St. Paul, M. N. 2010.

Abd El-Maasoud, S.B. and Ghaly, M.S. (2018). Influence of addition sweet lupine flour on quality and antioxidant characteristics of biscuits. Journal of Food and Dairy Science, Mansoura Univ, 9(5): 163–170.

Abdelrahman, A.R. (2014). Influence of chemical properties of wheat–lupine flour blends on cake quality. American Journal of Food Science and Technology, 2: 67–75**.**

Abeshu, Y. and Kefale, B. (2017). Effect of some traditional processing methods on nutritional composition and alkaloid content of lupin bean. International Journal of Bioorganic Chemistry, 2(4): 174-179.

Ahmad, S. and Ahmed, M. (2014). A Review on Biscuit, a Largest Consumed Processed Product in India, Its Fortification and Nutritional Important. International Journal of Science Inventions Today, 3: 169-186.

ANZFA (Australia New Zealand Food Authority) (2001). Lupin alkaloids in food – a toxicological review and risk assessment. Technical Report Series No 3: 1-21.

AOAC (2016). Official Methods of Analysis of Association of Official Analytical Chemists International. 20th Ed. Association of Official Analytical Chemists. (Ed. George, W. Latimer), Gaithersburg, Maryland, USA.

Awad-Allah, M.A.A. and Elkatry, H. (2013). Effect of debittering process on the characterization of Egyptian lupine seeds oil (*Lupinus albus*). Australian Journal of Basic and Applied Sciences, 7: 728–734.

Azizah, A. H.; Wee, K.C.; Azizah, O. and Azizah, M. (2009). Effect of boiling and stir-frying on total phenolics, carotenoids and radical scavenging activity of pumpkin (*Cucurbita moschato*). International Food Research Journal, 16: 45-51.

Brand-Williams, W.; Cuvelier, M.E. and Berset, C. (1995). Use of a free radical method to evaluate antioxidant activity. LWT- Food Science and Technology, 28: 25-30.

Chinma, C.E.; James, S.; Imam, H.; Ocheme, O.B. and Anuonye, J.C. (2012). Biscuit making potential of tiger nut (*Cyperus esculentus*) and pigeon pea (*Cajanus Cajan*) flour blends. Nigerian Journal of Nutritional Science, 32: 55-62.

Cordova-Ramos, J.S.; Glorio-Paulet, P.; Camarena, F.; Brandolini, A. and Hidalgo, A. (2020). Andean lupin (*Lupinus mutabilis* Sweet): processing effects on chemical composition, heat damage and in vitro protein digestibility. Cereal Chemistry, 97: 827–835.

Dalaram, I.S. (2017). Evaluation of total polyphenol content and antioxidant capacity of different variety lupin seeds. Potravinarstvo Slovak Journal of Food Sciences, 11: 26-34.

El-Hady, E.A. and Habiba, R.A. (2003). Effect of soaking and extrusion conditions on antinutrients and protein digestibility of legume seeds. LWT-Food Science and Technology, 36: 285-293.

Erbas, M. (2010). The effects of different debittering methods on the production of lupin bean snack from bitter (*Lupinus albus* L.) seeds. Journal of Food Quality; 33: 742–757.

FAO (2021): FAOSTAT. Crops and Livestock Products. Food and Agriculture Organization of the United Nations.

Gao, L.; Wang, S.; Oomah, B.D. and Mazza, G. (2002). Wheat quality: Antioxidant activity of wheat millstreams. In: “Wheat Quality Elucidation”. (Eds. Ng, P. and Wrigley, C. W.) AACC International: St. Paul, MN. pp. 219-233.

Jauharah, A., Rosli, W. and Robert, S. (2014). Physicochemical and Sensorial Evaluation of Biscuit and Muffin Incorporated with Young Corn Powder. Sains Malaysiana, 43: 45-52.

Jayasena, V. and Nasar-Abbas, S.M. (2011). Effect of lupin flour incorporation on the physical characteristics of dough and biscuits. Quality Assurance and Safety of Crops and Foods, 3(3): 140-147.

Klupsaite, D. and Juodeikiene, G. (2015). Legume: composition, protein extraction, and functional properties. A review. Chemical Technology,1(66): 5-12.

Lampart-Szczapa E.; Konieczny P.; Nogala-Kalucka, M.; Walczak, S.; Kossowaka, I.; and Malinowska, M. (2006). Some functional properties of lupin proteins modified by lactic fermentation and extrusion. Food Chemistry, 96 (2): 290–296.

Llavata, B.; Albors, A. and Martin-Esparza, M.E. (2019). High fiber gluten-free fresh pasta with tiger nut, chickpea, and fenugreek: Techno functional, sensory, and nutritional properties. Foods, 9(1),11:1-15.

Martinez-Villaluenga, C.; Sirtori, E.; Vidal-Valverde, C. and Duranti M. (2006). Effect of oligosaccharides removing procedure on the protein profiles of lupin seeds. European Food Research and Technology, 223: 691–696.

McGuire, R. G. (1992). Reporting of objective color measurements. HortScience, 27(12): 1254-1255.

Mota, J.; Lima, A.; Ferreira, R. and Raymundo, A. (2020). Lupin seed protein extract can efficiently enrich the physical properties of cookies prepared with alternative flours. Foods, 9(8): 1064.

Santhirasegaram, V.; George, D.S.; Anthony, K.K.; Singh, H.K.B.; Saruan, N.M.; Razali, Z. and Somasundram, C. (2016). Effects of soybean processing and packaging on the quality of commonly consumed local delicacy tempe. Journal of Food Quality, 39: 675–684.

Schlemmer, U.; Frolich, W.; Prieto, R.M. and Grases, F. (2009). Phytate in foods and significance for humans: food sources, intake, processing, bioavailability, protective role, and analysis. Molecular Nutrition and Food Research, 53(2): 330-375.

Serrem, C.; Kock, H. and Taylor J. (2011). Nutritional quality, sensory quality and consumer acceptability of sorghum and bread wheat biscuits fortified with defatted soy flour. International Journal of Food Science and Technology, 46(1): 74-83.

Shamsa, F.; Monsef, H.; Ghamooshi, R. and Verdian-rizi, M. (2008). Spectrophotometric determination of total alkaloids in some Iranian medicinal plants. Thai Journal of Pharmaceutical Sciences, 32: 17-20.

Steel, R.G.D., and Torrie, J.H. (1997). Principles and procedures of statistics. A biometrical approach. McGraw-Hill Book Co., New York, USA, 633p.

Sudha, M.L.; Vetrimani, R. and Leelavathi, K. (2007). Influence of fiber from different cereals on the rheological characteristics of wheat flour dough and on biscuit quality. Food Chemistry, 100(4): 1365-1370.

Taha, M.R.; Majdi, A.A. and Khalil, I.E. (2006). Effect of chickpea, broad bean, or isolated soy protein additions on the physicochemical and sensory properties of biscuits. Journal of Food Science, 71(6): S438–S442.

Van het Hof, K.H.; de Boer, B.C.J.; Tijburg, L.B.M.; Lucius, B.R.H.M.; Zijp, I.; West, C.E.; Hautvast, J.G.A.J. and Weststrate, J.A. (2000). Carotenoid bioavailability in humans from tomatoes processed in different ways determined from the carotenoid response in the triglyceride-rich lipoprotein fraction of plasma after a single consumption and in plasma after four days of consumption. Journal of Nutrition, 130: 1189–1196.

Villacres, E.; Alvarez, J.; and Rosell, C.M (2020). Effects of two debittering processes on the alkaloid content and quality characteristics of lupin (*Lupinus mutabilis* Sweet). Journal of the Science of Food and Agriculture, 100: 2166-2175.

Wang, S.; Errington, S. and Yap, H.H. (2008). Studies on carotenoids from lupin seeds. In J.A. Palta, and J.B. Berger (Eds.), Lupins for Health and Wealth (Fremantle, Western Australia ed., Vol. 1, pp. 198-202). International Lupin Association.

Zhishen, J.; Mengcheng, T. and Jianming, W. (1999). The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals. Food Chemistry, 64: 555-559.

الخواص الفيزيوكيميائية و الحسية للبسكويت المدعم بالترمس المر

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يعتبر الترمس المر واحدا من البقوليات الغنية بالبروتين و مضادات الأكسدة و لكنه غير مقبول بسبب مرارته. لذا تستهدف هذه الدراسة التخلص من القلويدات الموجودة في الترمس المر بعدة طرق مختلفة و استخدامه في انتاج البسكويت. تم دراسة الخواص الفيزيائية و الكيميائية و القابلية لهضم البروتين لدقيق الترمس المر. أظهرت النتائج أن جميع طرق التخلص من المرارة أدت إلى حدوث زيادة معنوية في محتوى البروتين لدقيق الترمس. كما لوحظ أعلى محتوى من البروتين في دقيق الترمس المر الذي تم غليه لمدة ساعة. و قد حدث انخفاض ملحوظ في محتوى الرماد والألياف والدهون والكربوهيدرات في دقيق الترمس بعد عمليات نزع المرارة وكانت هناك زيادة معنوية في قابلية هضم البروتين خاصة في الترمس المر المنقوع لمدة ١٢ ساعة. علاوة على ذلك حدث انخفاض ملحوظ في محتوى القلويدات، الفينولات و مضادات الأكسدة من خلال طرق نزع المرارة المختلفة. أوضحت الخصائص الفيزيائية لعينات البسكويت المدعم بالترمس منزوع المرارة نقص غير معنوي في القطر و زيادة معنوية في السمك. كما أظهرت نتائج الخصائص الحسية للبسكويت عدم وجود فروق معنوية بين عينة الكنترول و العينات المدعمة بالترمس منزوع المرارة في جميع الخصائص الحسية (المظهر، الرائحة، القوام، الطعم والقبول العام). أظهرت النتائج أن استخدام دقيق الترمس منزوع المرارة في انتاج البسكويت أدى الي تحسين الخصائص الحسية و زيادة القيمة الغذائية للبسكويت.

الكلمات الدالة: الترمس المر، القلويدات، طرق نزع المرارة، البسكويت، الخصائص الفيزيائية، الكيميائية، الحسية.