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Some Physical Properties and Nutritional Compositions of Lupin (*Lupinus albus* L.) Seed in Turkey

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ABSRACT

In this study, nutrient contents for human diet and some physical properties that are important for the design of equipments for sowing, harvesting, processing, transportation, sorting, separation and packaging of lupin cv. grown in Turkey were determined. Mineral contents of lupin seeds including P, K, Ca, Mg, Na, S and B, Cu, Fe, Mn, Zn were determined 0.14%, 0.4%, 0.04%, 0.06%, 0.02%, 0.06%, 22.3 ppm, 3.6 ppm, 11.9 ppm, 533.4 ppm,15.8 ppm respectively. The physical properties were evaluated as functions of moisture content in the moisture range from 7 to 35% d.b. for the rewetted lupin seed. As a result, the average length, width, thickness, the geometric mean diameter, sphericity, unit mass and volume were 9.5, 8.4, 4.9, 6.61 mm, 73.9%, 0.27 g and 0.18 cm3, respectively. The bulk density decreased from 727.2 to 678.8 kg/m3, true density decreased from 1428.5 to 1000 kg/m3, porosity decreased from 48.8 to 32.1%, one thousand seed mass increased from 230.7 g. to 327.4 g, the sphericity of lupin seed decreased from 73.9 to 71.5% while the moisture content of lupin seed increased from 7 to 35% d.b..

1. Introduction

Lupin is a leguminous crop with high protein content. It can be grown in marginal lands where no other legume crops can be grown. Protein content of lupins among temperate legumes, including soybean, ranging between 28.0-47.6% depending on the species (Sator, 1982).

Lupin cultivation in Turkey is solely based on a spring-sown bitter local landrace of *L. albus* (local population) grown mostly under dry conditions, specifically in a sub-region called Göller Bölgesi (Lakes Region). This sub-region which is surrounded by many lakes (Beyşehir, Akşehir, Eğridir Lakes), receives more annual mean rainfall, with neutral soil pH (7.0) and lower lime content of the soils than the rest of the region and the rest of Turkey, with 80% of soils high in pH (7.5–8.5) and mainly calcareous (Mulayim et al., 2002).

Lupins fix atmospheric nitrogen efficiently and can grow on poor soils where other grain legumes are not profitable (Sator, 1990). Hondelmann (1984) describes lupins as a model for low input plants, especially in areas with economic and agricultural problems. Lupins provide additional benefits for subsequent crops (e.g. potato) in a crop rotation system, improving the phytosanitary conditions in addition to the economic value of the lupin grain harvested (Mohr, 1986).

Deshpande, Bal, and Ojha (1993) found a linear decrease in true density, bulk density and porosity as the moisture content increased at 8.7-25% d.b. in soybeans. Çarman (1996) assessed some physical properties such as bulk density, porosity, projected area, terminal velocity and static and dynamic coefficients in lentil seeds. Ige (1977) measured the size and rupture strength of seeds of five cowpea varieties and determined relationship between rupture strength and the size of seeds. However, limited studies have been carried out on physical properties of lupin.

The physical properties of lupin are important for the design of equipments for sowing, harvesting, processing, transporting, sorting, separating and also packing. The currently used system has been designed without taking these criteria into consideration; the resulting designs lead to inadequate applications. This results in a reduction in work efficiency and an increase in product loss. The determination and consider-

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ation of these criteria therefore have an important role in making these machines.

The objective of the present investigation was to determine mineral contents, some chemical compositions and physical properties were determined of the white lupin (*L. albu*s L.) grown in Turkey.

2. Materials and Methods

2.1. Materials

Lupin seeds (local *L. albus* landrace) that had been cultivated in the Deştiğin district (37°59´ N, 31°25´ E) of Konya, Turkey, in 2005, were obtained from a local seller. After this transaction, the lupin seeds were desiccated and they were cleaned manually to remove all foreign matter such as dust, dirt, stones and chaff as well as immature, broken seeds.

Notation

D_p	geometric mean diameter, mm
R^2	coefficient of determinate
L	length, mm
T	thickness, mm
W	width, mm
M_c	moisture content, % d.b.
ε	porosity, %
ρb	bulk density, kgm^{-3}
ρt	true density, kgm^{-3}
Φ	sphericity, %
M_{1000}	1000 seed mass, g

2.2. Methods

The moisture content was determined by drying the seeds at 70 ºC until a constant weight was obtained (AOAC, 1984). The initial moisture content of the seeds was 7 % dry basis (d.b.). The lupin samples of the desired moisture levels were prepared by adding calculated amounts of distilled water, thorough mixing and then sealing in separate polyethylene bags. The samples were kept at 4°C in a refrigerator for 7 days for the moisture to distribute uniformly throughout the sample. Before starting the test, the required quantities of the seed were allowed to warm up to room temperature (Deshpande, Bal & Ojha, 1993; Çarman, 1996). All the physical properties of the lupin seeds were assessed at moisture levels of 7, 14, 21, 28 and 35% d.b. with three replications at each level.

2.2.1. Determination of chemical properties

The chemical properties of the lupin seeds were analyzed according to AOAC (1984). The moisture content was determined by drying the seeds at 70 ^{o}C until a constant weight was obtained. Crude protein content was calculated by converting the nitrogen content, determined by Kjeldahl's method (6,25×N). Oil content was determined by the method described by the using the Soxhlet system. Ash content was determined in a muffle furnace at 550 ^{o}C for 5 h. Crude fibre was determined in a Tecator Fibertec System M1020 Hot extractor (AOAC, 1984). Vitamin C content was determined using the HPLC method described by Rückemann (1980). Carbohydrates were calculated as "Nitrogen free extract" according to the formula: Carbohydrates = 100 – (% moisture+%protein + %crude fibre + % fat + %ash). Energy (kcal) was calculated according to the formula: Energy = (% protein × 4) + (% carbohydrates×4) + (% fat × 9). Organic matter (%) was calculated according to the formula: Organic matter = 100 - %ash.

2.2.2. Determination of mineral contents

About 0.5 g dried and ground sample was put into burning cup and 10 mL pure HNO3 was added. The sample was incinerated in MARS 5 Microwave oven under the 170 psi at 200 ºC temperature and solution diluted to the certain volume (25 ml) with water. Samples were filtered in fitler paper, and were determined with an ICP-AES (Skujins,1998).

Working conditions of ICP-AES:
Instrument: ICP-AES (Varian-Vista; Australia)
RF power: 0.7–1.5 kW (1.2–1.3 kW for axial)
Plazma gas flow rate (Ar): 10.5–15 L/min (radial)
15 L/min (axial)
Auxiliary gas flow rate (Ar): 1.5 L/min
Viewing height: 5–12 mm
Copy and reading time: 1–5 s (max. 60 s)
Copy time: 3 s (max. 100 s)

2.2.3. Determination of physical properties

To determine the average size of the seed, a sample of 100 lupin seed was randomly selected. Measurement of the three major perpendicular dimensions of the lupin was carried out with a micrometer to an accuracy of 0.01 mm. (Table 1) .

The geometric mean diameter D_p of the seed was calculated by using the following relationship (Mohsenin, 1970): $D_p = (LWT)^{1/3}$

Where L is the length, W is the width and T is the thickness (Fig.1).

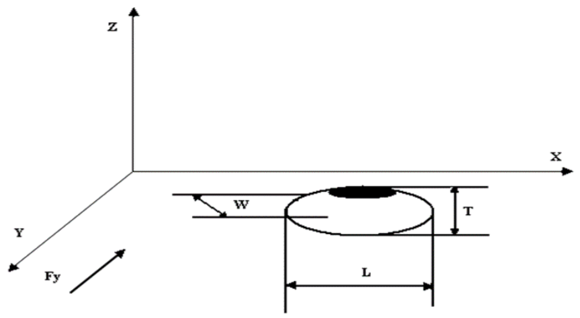

Figure1
Axis and three major perpendicular dimensions of lupin seeds

According to (Mohsenin, 1970), the degree of sphericity Φ can be expressed as follows:

$$\Phi = [(LWT)^{1/3} / L] \times 100$$

This equation was used to calculate the sphericity of both the lupin seed in the present investigation. To obtain the mass, each lupin was weighed by a chemical balance reading to 0.0001 g.(Table 1). The true density is defined as the ratio of the mass of a sample to its solid volume (Deshpande, Bal & Ojha, 1993). The lupin seed volume was determined using the liquid displacement method. Toluene (C_7H_8) was used in place of water because it is absorbed by lupin seeds to a lesser extent. Also, its surface tension is low so that it fills even shallow dips in a lupin seed and its dissolution power is low (Sitkei, 1986; Ögüt, 1998). The bulk density is the ratio of the mass of a sample of a lupin seed to its total volume. It is a moisture-dependent property. The bulk density was determined with a weight per hectoliter tester which was calibrated in kilogram per hectoliter (Deshpande, Bal, and Ojha, 1993). The porosity of lupin seed at various moisture contents was calculated from bulk and true densities using the relationship given by Mohsenin (1970) as follows:

$$\varepsilon = [(\rho t - \rho b) / \rho t] \times 100$$

Where ε is the porosity in %, ρb is the bulk density in kg/ m3 and ρt is the true density in kg/m^3.

3. Results and Discussion

Lupins contain in their seeds or vegetative organs some anti-nutritional factors similar to other grain legumes (Table 2,3). The oil content of lupin seeds varies from 5% in *L. angustifolius* and 11%, 19% in *L. albus* and *L. mutabilis* respectively (Gross, 1988) and can be regarded as an intermediate position between those of soybean and peanut. Although lupins have a high protein content, amounting to 37-50% of their dry matter, which is comparable to soybean protein content, this is believed to be overestimated because of the presence of considerable amounts of non-protein nitrogen. It has been suggested that the conversion factor (N x 6.25) should be determined according to the alkaloid content of the seed (Keeler R F., Gross R.,1980).

Table 1 shows the means and standard errors of the lupin seeds. The average values of geometric mean diameter and sphericity were calculated 389.47mm and 14.66%, respectively.

Table 1
Dimensional properties of Lupin seed

Properties	Values
Length, (mm)	9.52±0.56
Width (mm)	8.39±0.55
Thickness (mm)	5.86±0.33
Geometric mean diameter (mm)	389.47
Sphericity (%)	14.66
Mass (g/1000grain)	310

Table 2
Chemical properties of Lupin seed

Properties	Values*
Moisture (%)	7.00±0.10
Crude oil (%)	9.98±0.37
Crude cellulose (%)	10.40±0.2
Ash (%)	3.04±0.02
Organic matter (%)	96.96±0.02
Acidity (%)	0.40±0.02
Vitamin C (mg $100g^{-1}$)	14.8±0.15
Water-soluble extract (%)	30.01±0.57
Alcohol-soluble extract (%)	7.76±0.18
Ether-soluble extract (%)	6.44±0.08

*Dry Weight Basis

Table 3
Mineral content of Lupin seed

Macro Minerals	Values (%)
P	0.14±0.01
K	0.40±0.04
Ca	0.04±0.01
Mg	0.06±0.00
Na	0.02±0.00
S	0.06±0.01
Micro Minerals	**Values (mg kg^{-1})**
B	22.30±5.60
Cu	3.63±0.14
Fe	11.91±1.55
Mn	533.37±19.98
Zn	15.79±1.41

As a result of the study, porosity and density change curves due to moisture content were obtained. Porosite appears to decrease in spite of the increase in moisture content. The density appears to decrease in spite of the increase in moisture content. Effects of moisture content on porosity and density were shown inFigures,2-3.

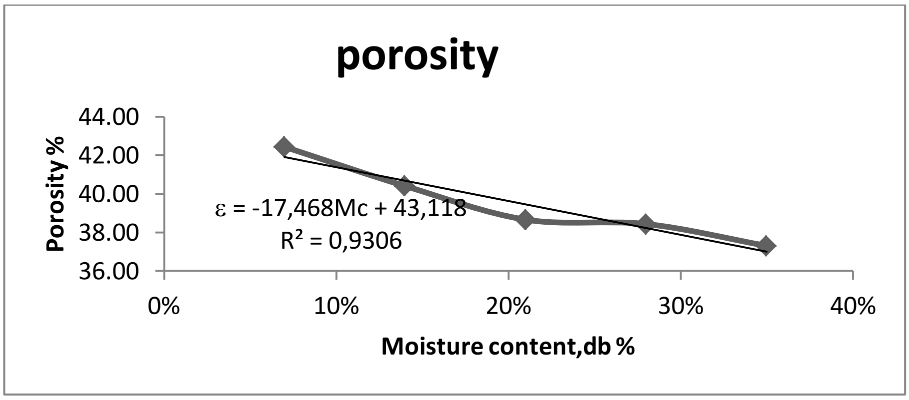

Figure 2

Change of porosity to against moisture content.

Since the porosity depends on the bulk and true densities, the magnitude of variation in porosity depends on these factors only. Thus, the porosity of lupin seeds was found to decreased from 48.8 to 32.1%, with increasing moisture content from 7% to 35 % (Fig. 2).

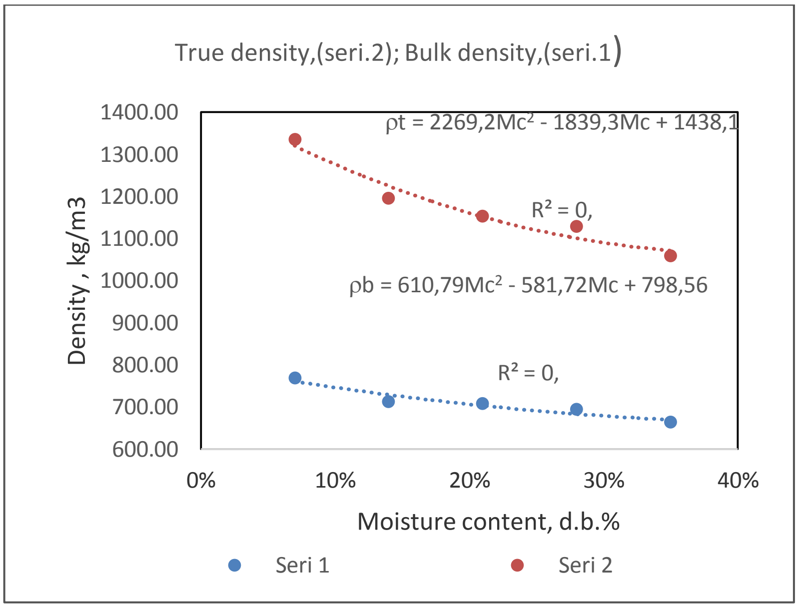

Figure 3
Change of density to moisture content.

The bulk density of lupin seeds at different moisture levels varied from 727.2 to 678.8 kg/m3and indicated a decrease in bulk density with an increase in moisture content (Fig. 3). The negative linear relationship of bulk density with moisture content was also observed by Shepherd and Bhardwaj (1986) and Visvanathan et al. (1996) for pigeon pea and neem nut, respectively. The statistical analysis of experimental data showed that relationship between bulk density and moisture content was significant ($p < 0.05$).

The true density of lupin seeds at different moisture levels in the experimental range varied from1428.5 to 1000 kg/m3. The effect of moisture content on the true density of lupin seeds showed a decrease with moisture content (Fig. 3). Deshpande, Bal and Ojha (1993) also observed the linear decrease in true density with increase in grain moisture in the range 8.7-25% d.b. for J.S.-7244 soybean. The similar results have been reported by Aydın (2002) for hazelnuts.

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