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Fat and fatty acids of white lupin (*Lupinus albus* L.) in comparison to sesame (*Sesamum indicum* L.)

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Abstract

The study was undertaken to compare fat and fatty acid profiles in white lupin (*Lupinus albus* ssp. *albus*) and sesame (*Sesamum indicum* L.), representing two different families, Fabaceae and Pedaliaceae. Fat levels were 10.74% and 55.44% in seeds of white lupin and sesame, respectively. The results indicated that oleic, linolenic and arachidic acids in seed fat were higher in white lupin than in sesame cultivars. Oleic acid was the predominant fatty acid in white lupin, whereas linoleic acid was predominant in sesame. Fat content (%) was statistically significantly correlated with linoleic, linolenic and arachidic acids at the genotypic level. The fatty acid composition of white lupin is useful for human consumption. Although oil content of white lupin was lower than that of sesame, white sweet lupin could be improved.

Keywords: Fat; Fatty acids; Lupin; *Lupinus albus*; Sesame; *Sesamum indicum* L.

1. Introduction

Lupins (*Lupinus* spp.) belong to the Genisteae family, Fabaceae or Leguminosae. Commonly, four lupins (*L. albus* L., *L. angustifolius* L., *L. luteus* L. and *L. mutabilis* L.) are reported as cultigens in the world (Cowling, Buircell, & Tapia, 1998; Gladstones, 1998). 1,086,006 t of these lupins are produced in 1,107,018 ha harvested areas all over the world; however, there is no record of lupin statistics in Turkey (FAO, 2005). White or Mediterranean lupin (*L. albus* ssp. *albus* L) is mainly grown in the Mediterranean basin (Cowling et al., 1998; Gladstones, 1998; Huyghe, 1997), including Turkey. Lupins are used for many purposes, such as pasture improvement and ornamentation, and for erosion control or soil stabilization (Cowling et al., 1998). They have also been used as green manure and for fixing atmospheric nitrogen to soil (Howieson et al., 1998). Furthermore, they are mixed into the soil during the flowering period in greenhouses to control some pests in the south coastal region of Turkey, due to their alkaloids. The most commonly used part of the lupin is the seed. Lupin seeds are highly valuable as human food and animal feed, with high protein and dietary fibre (Cowling et al., 1998; El-Adawy, Rahma, El-Bedawey, & Gafar, 2001; Petterson, 1998).

Sesame (*Sesamum indicum* L.) is a member of the Pedaliaceae family (Ashri, 1998; Weiss, 1983). 3,321,458 t of sesame are produced in 7,554,200 ha areas in the world. In Turkey, it is grown in 43,000 ha areas and produces 23,000 t (FAO, 2005). Sesame is one of the oldest edible oil crops and its seeds are used as a food source (Ashri, 1995; Yermanos, 1980). It contains up to 60% fat in the seeds (Baydar, Marquard, & Turgut, 1999; Uzun, Ulger, & Cagirgan, 2002). The fat of sesame is of importance in the food industry due to its flavour and stability, and because it can be used to cook meals of high quality. The fat level in lupin is ranked third after groundnut (*Arachis hypogeae* L.) and soybean (*Glycine max* Merril) among

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legumes (Cowling et al., 1998; van der Maesen & Somaatmadja, 1992). White lupin is one of the neglected legumes with the highest protein content and also the fat is like sesame with a great amount of oil (60%) (Ashri, 1994). In this study, the fat and fatty acid composition of white lupin were compared with those of sesame as two neglected crops.

2. Materials and methods

2.1. Experimental materials

The experimental materials of the present study are a landrace of white lupin (*L. albus* ssp. *albus* L.) and four sesame cultivars (Tan, Golmarmara, Muganli and Ozberk) grown and released commercially in Turkey.

2.2. Fat and fatty acids analyses

Two white lupin and five sesame seed samples, for each genotype, were subjected to oil extraction using Soxhlet apparatus. The oil content was determined by comparing the weights of approximately 5 g seed samples before and after removal by Soxhlet with petroleum ether for 4 h. The oil samples were then esterified according to the method of Marquard (1987). A 1 ml sample of oil was placed in a tube and 1 ml of Na methylate was added to the mixture. The sample was left at room temperature overnight, and then 0.25 ml isooctane was added. A 0.5 μl sample of the mixture was injected into the gas chromatograph. The composition of fatty acid was determined by gas liquid chromatography (GC) performed on a Fison GC equipped with a flame ionization detector (FID), and fitted with a fused capillary column FFAP-DF (25 m × 0.25 mm ID). The detector was operated at 260 °C and the injector at 250 °C. The column was ballistically heated from 150 to 200 °C at the rate of 5 °C min^{-1}. The carrier gas (helium) inlet pressure was 0.15 MPa and the flow rate was 1 ml/min. Fatty acids were identified by retention time relative to authentic standard (Sigma, 18918).

The data were statistically analysed using the MINITAB statistical programme.

3. Results

3.1. Fat content

Genotypic effect was statistically significant for fat and fatty acids ($P < 0.05$) (data not shown). The fat content of white lupin was 10.7%, while sesame cultivars ranged from 54.3% in Muganli to 56.1% in Golmarmara. The fat contents of Tan and Ozberk were 55% and 56%, respectively (Fig. 1).

3.2. Saturated fatty acids

The level of arachidic acid in fat of white lupin (3.5%) was above those of sesame cultivars, while contents of arachidic acid of Tan, Golmarmara, Muganli and Ozberk were 0.1% (Fig. 2). The percentage of palmitic acid varied from 7.6 in white lupin to 10 in sesame cultivars. The palmitic acid level was higher in sesame cul-

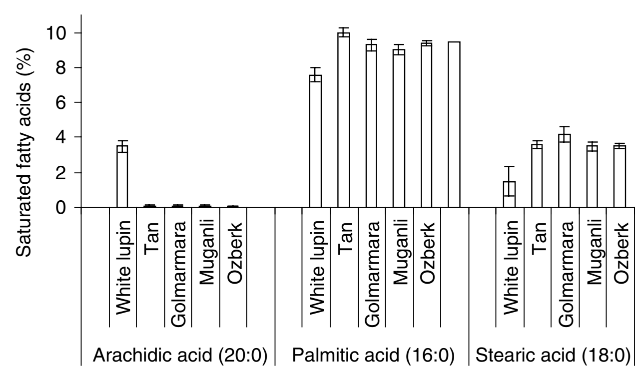

Fig. 2. Saturated fatty acids (% in oil) in fat content in white lupin and sesame cultivars grown in Turkey. Bars represent means ± standard errors. The number of samples is two and five in the white lupin and sesame, respectively.

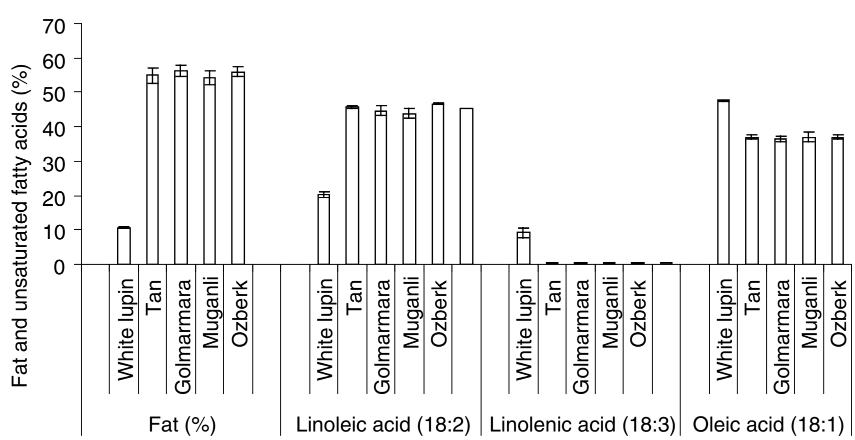

Fig. 1. Fat (% in seed) and unsaturated fatty acids (% in oil) in white lupin and sesame cultivars grown in Turkey. Bars represent means ± standard errors. The number of samples two and five in white lupin and sesame, respectively.

Table 1
Relationships between fat (% in seed) and fatty acids (% in oil) in white lupin and sesame cultivars grown in Turkey

	Fat content	Palmitic acid (16:0)	Stearic acid (18:0)	Oleic acid (18:1)	Linoleic acid (18:2)	Linolenic acid (18:3)
Palmitic acid (16:0)	0.676					
Stearic acid (18:0)	0.700	0.315				
Oleic acid (18:1)	−0.812	−0.512	−0.405			
Linoleic acid (18:2)	0.949*	0.746	0.636	−0.839		
Linolenic acid (18:3)	−0.949*	−0.661	−0.655	0.857	−0.938*	
Arachidic acid (20.0)	−0.958*	−0.634	−0.707	0.873	−0.957*	0.965**

* and ** are statistically significant 0.05 and 0.01, respectively.

tivars than in white lupin (Fig. 2). Stearic acid levels were 1.5 in white lupin, 3.6% in Tan, 4.2% in Golmarmara, 3.5% in Muganli and 3.5% in Ozberk. The stearic acid percentage was higher in sesame cultivars than in white lupin (Fig. 2).

3.3. Unsaturated fatty acids

As seen in Fig. 1, linoleic acid in fat was lower in white lupin (20.3%) than in sesame cultivars (45.3%). White lupin, Tan, Golmarmara, Muganli and Ozberk contain linolenic acid at 9.2%, 0.4%, 0.3%, 0.4% and 0.4%, respectively (Fig. 1). The linolenic acid level in fat was higher in white lupin than in sesame cultivars. Oleic acid percentages were higher in white lupin (47.6%) than in Tan (37%), Golmarmara (36.3%), Muganli (37%) and Ozberk (37%) (Fig. 1).

3.4. Correlations

Fat content (%) was statistically significantly correlated with linoleic, linolenic and arachidic acids at the genotypic level ($P < 0.05$). Linoleic acid was negatively related to linolenic and arachidic acids ($P < 0.05$), while linolenic acid was positively related to arachidic acid content ($P < 0.01$). Although there was no statistically significant relationship, oleic acid was negatively correlated with linoleic acid (Table 1).

4. Discussion

White lupin, as a food legume, had less fat (10.7%) than had sesame cultivars (55.4%) (Fig. 1). Although the crop belongs to the legumes and is not described as an oilseed crop, it has a considerable amount of oil in its seeds. Compared with sesame, which has the highest oil content of all oilseed crops, white lupin was lower in oil content. However, white lupin yielded approximately half of the oil content of sesame on a hectare basis (data not shown). The world averages of seed yield of sesame and white lupin are 440 and 1019 kg per hectare, respectively (FAO, 2005). A high amount of protein was also obtained, in addition to oil, because white lupin contained 35.8% protein (Cowling et al., 1998). White lupin has many advantages over sesame, such as easy harvesting and nitrogen fixation ability.

Fat content can be affected by genotype within the same species and also by environment. Garcia-Lopez et al. (2001) reported that the oil content fluctuated from 57 g/kg for *L. mexicanus* to 115 g/kg for *L. montanus*. They concluded that the oil contents and fatty acid profile of Mexican lupins were similar to those already reported for most lupin oils (Garcia-Lopez et al., 2001). Crochemore, Huyghe, Papineau, and Julier (1994) pointed out that the oil content of white lupin was influenced by the genotype but the stand density had no effect. The oil content of white coat sesame was 41.8% in Korean sesame and 43.3% in Chinese sesame (Kang, Choi, & Ha, 2003). Total oil content of sesame varied from 46.4% to 51.5% and irrigation affected oil content; row space had no significant effect (Alpaslan, Boydak, Hayta, Gercek, & Simsek, 2001). Baydar et al. (1999) reported that there were lines which yielded over 63% of oil content.

Oleic and arachidic acids were predominant in white lupin compared to sesame cultivars (Figs. 1 and 2). Among essential fatty acids, white lupin oil contained linoleic and linolenic acids (Fig. 1). These results were in agreement with the earlier report of Petterson (1998). Table 2 shows that fatty acids of white lupin seed are composed of 77% unsaturated fatty acids and 12.6% saturated fatty acids. The amount of saturated fatty acids in white lupin was lower than those in sesame, groundnut and soybean (Table 2). Particularly, *L. mutabilis*, with the highest oil content (about 18%) and unsaturated fatty acids, is of great importance for human consumption (Cowling et al., 1998). Lupins, in addition to being a good source of protein, may also contain a considerable amount of useful vegetable fat.

Among unsaturated fatty acids, white lupin was higher in oleic and linolenic acid than was sesame; on the other hand, it was lower in linoleic acid. Velasco, Martin, and De Haro (1998) found that the seed oil from the main stem in white lupin had higher percentages of saturated fatty acids and oleic acid, and lower percentages of linoleic, linolenic, eicosenoic, and erucic acid than had the seeds from the branches. Oleic acid (47.6%) was the predominant fatty acid in white lupin and, because of the negative correlation between oleic and linoleic, white lupin oil contained less linoleic acid than did sesame.

There was a negative correlation between oleic and linoleic acids with a value of −0.839 (Table 1). Cowling and Tarr (2004) indicated that there was a strong negative

Table 2
Fat (% in seed) and fatty acids (% in oil) in lupins, peanut and soybean from Fabaceae and sesame from Pedaliaceae

	Fat content	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid	Linolenic acid
L. albus L.	10.7	7.6	1.5	47.6	20.3	9.2
L. angustifolius Sweet[a,b]	5.9	10.3	4.8	34.9	37.0	6.2
L.luteus L.[a,b]	5.6	5.3	1.5	31.5	46.9	4.2
L. mutabilis L.[a,b]	16.0	0.6	3.0	41.7	38.8	2.6
A. hypogaea L.[c]	45.51	5.26–10.4	2.18–4.36	52.8–82.2	2.88–27.1	–
G. max Merill.[d]	17.6–225	11.2–12.0	3.3–3.6	21.5–27.5	50.8-54.7	6.5–7.8
S. indicum L.	55.4	9.4	3.7	36.8	45.3	0.4

[a] Petterson (1998).
[b] Cowling et al. (1998).
[c] Andersen et al. (1998) and Swamy et al. (2003).
[d] Scott and Kephart (1997), Ruiz-Mhdez et al. (1997) and Chu and Kung (1998).

correlation between seed oil and seed protein in narrow-leafed lupin (*Lupinus angustifolius* L.) across the cultivars ($r = -0.96$) and experiments ($r = -0.522$). Jimenez, Cubero, and Deharo (1991) reported a negative correlation between protein and oil content. Oil content is strongly correlated with linoleic, linolenic and arachidic acid contents at the genotypic level.

The results in Table 2 show that the fatty acid composition of white lupin resembles that of groundnut and canola, in agreement with the literature (Erbas, Certel, & Uslu, 2005). Especially, erucic acid free canola have the same fatty acid profiles (Marikkar, Ghazali, Che Man, Peiris, & Lai, 2005) as white lupin. The two important unsaturated fatty acids, oleic and linoleic were higher in sesame, whereas only oleic acid was higher in white lupin and thus the two neglected crop have no resemblance. Overall, white lupin has a considerable oil content, which may also be improved by several breeding strategies. With a high proportion of unsaturated fatty acids, the crop is desirable for human nutrition. For the fatty acid composition, there is no recordable difference between white lupin and groundnut, which are widely consumed as oilseeds. Although oil content of white lupin was lower than that of sesame, white sweet lupin could be improved for a better oil content.

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