ALTERING LUPINE FLOUR FOR THE FOOD INDUSTRY

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ABSTRACT

About 10 years ago Firma LI Frank, which is part of the Barentz Group, introduced lupine flour into the European food market. In these 10 years lupine flour has proven its benefits in various food applications creating a specific market share in e.g. bread, biscuits, wafers and battered products. Arguments to use lupine as a food ingredient are the non-GMO status as well as improved freshness and structure, longer shelf life and its emulsifying capacity. In this study improvement of the specific functionalities of lupine flour with environmental friendly processing was investigated. From dehulled toasted lupine flour the fibre fraction was removed mechanically, creating a fibre and protein enriched flour with a low energy input. Secondly different flours were extracted with pressurised CO_2 to remove the oil without using an organic solvent. The protein concentration of the flour was increased from 40 to 60% in the mechanical separation process. After the oil was extracted, the flour reached a protein content of 67%, with a remaining oil content of 1%. Β-carotene, a component responsible for the yellow colouration of the flour was extracted from the flour together with the oil. This oil also has a high concentration of tocopherols and sterols, in comparison with other vegetable oils. The altered lupine flours were tested for standard functionalities and in specific product applications.

KEYWORDS

Lupinus angustifolius, functional properties, protein shift, oil extraction

INTRODUCTION

In 1950 firma Frank was one of the first European companies to start soy processing for the food industry and it became its main business. In the late nineties Firma Frank was forced to look for alternatives due to reduction of profit margins and introduction of GMO soy into the food market and therefore investigated lupine. From that time on, lupine applications in the food industry increased rapidly. Firstly only as a substitute for soy, but later also by its more specific functionalities. Lupine flour appeared to have an improved impact on freshness and structure of bakery goods, increasing their shelf life.

In this study we tried to improve those specific functionalities of lupine flour by environmentally friendly processing. The process should have a low energy input and no need for organic solvents.

In collaboration with Agrotechnology & Food Innovations (A&F, the Netherlands) a dry protein enrichment method for oilseeds was developed. This method is based on an industrial scale available enrichment process for starch rich feed materials [1]. This is a very low energy input system, but it removes only the fibre fraction from the flour. For certain applications it can be desirable to remove also fat and colour (β-carotene). Pressurised CO_2 extraction, which is able to extract oil and colorant [2, 3], is an environmentally friendly process with currently still relatively high costs. Therefore a project named EXTRA was started to build a continuous high pressure CO_2 extractor, with the aim to reduce extraction costs.

MATERIALS AND METHODS

Figure 1 shows the process scheme which is used to produce the different kind of lupine flours from *Lupinus angustifolius*. The main product is currently toasted, dehulled lupine flour (Fralu-T). To increase the protein content in the flour a patented dry classifying process was used to remove the high fibre part of the lupine flour, resulting in a flour with a high (Fralu-CON) and low protein flour (Fralu-T$^+$) [4].

The above given process can be applied to non-toasted lupine too, but the separated flour is only commercial for the toasted flours. During the entire year of 2007 the dehulling, milling and dry separation process was monitored.

To reduce the oil content and colour of the lupin products, 3 x 1.5 kg (toasted flour, non-toasted flour and concentrate Fralu-CON) were extracted with 14 kg CO_2/kg at 350 bar and 40°C at NateCO_2 (Germany).

The processed samples were analysed on moisture (24 h at 104°C), protein (N_Kjeldhal x 6.25) and oil content (soxhlet with hexane).

To determine the colour reduction of the oil extracted samples, 1 gram of flour was mixed with 10 mL of hexane, mixed and centrifuged for 10 min at 2000 rpm. Extinction of the cleared liquid was measured at 450 nm against a reference. The colour reduction was determined by the reduction in extinction between the flour before and after extraction.

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The water binding was determined by mixing 2 gram of sample with 20 mL buffer (glycine/HCl 0.01M pH3 en 0.1M NaCl). The mixture was heated for 30 min in a 80°C water bath. After cooling the formed gel was centrifuged at 200 g. After removal of the supernatant the water binding capacity was determined by weighing the gel. The viscosity of flour/water mixtures were measured by mixing intensively 45 gr flour with 150 mL tap water. The mixtures were either kept at 25°C for 1 hour or cooked for 2 min and than cooled to 25°C. Subsequently the viscosity of the mixture was determined with a spindle viscosity meter (speed 10, spindle dependent on viscosity)

RESULTS AND DISCUSSION

Table 1 shows the composition of dehulled milled lupin beans and the dry separation process which is currently running in our factory. The dry separation process can achieve a lupine concentrate of 60% protein, whereby the protein reduction in the fibre stream is limited to 10%. Controlling the separation process is not as easy as for starch-rich products, but with the correct control actions it is possible to guarantee a minimum deviation of the protein level. The protein content of the non-toasted lupine flour is slightly lower than that of toasted flour. This is due to the fact that the dehulling of non-toasted beans is less efficient, resulting in more remaining hulls in the cotyledon before milling.

The CO_2 extraction was efficient. The remaining oil content was in all cases 0.9% (Table 2). The solvability of the oil in the CO_2 was approximately 7 g/kg CO_2. The fatty acid composition of the oil before and after extraction was not altered significantly. The tocopherol and sterol concentrations in the extracted oil are high compared to other vegetable oils, like those from soy and rapeseed (Table 3). The dark yellow colour of the oil is caused by the presence of β-Carotene. It is possible that part of the β-Carotene is oxidised during extraction by the O_2 impurities in the used CO_2 [5]. The flours had a light yellow appearance and the hexane soluble colorant was reduced between 85 and 93%.

In the water binding of the dry enriched products there seems to be an inversed relationship between the protein content and the water binding (Table 4). The fibres in the flour are likely to have a large influence on the water binding.

As expected the water binding of the non-toasted products are higher than those of the toasted products, but none of the samples could reach the level of the soy concentrate.

The viscosity of the water/flour mixture largely depends on the flour treatment. Where the fibre enriched flour (T^+) showed an increase of viscosity compared to the normal toasted flour (T), the concentrate (CON) showed the opposite. This is observed for both cold and heated mixtures, equivalent to what was measured onwater binding. The viscosity of the non-toasted flour was for the cold mixture comparable with normal toasted flour (T) for the cold mixture. However, after heating the viscosity increased more compared to the toasted flour and was in the same range of the T^+ mixture after heating.

The oil extraction increased the viscosity, except for the heated CON mixture. For T and NT the increase of viscosity was between 250 and 1400% after de-oiling. No influence of the extraction solvent used (CO_2 or hexane) was measured.

Lupine flour has more to offer then only its NON-GMO status. Compare to soy it gives an improved shelf life and it can influence the structure of the product differently. Increasing the protein content of the flour with the dry separation process results in more specific functionalities. The concentrate (Fralu-CON) is therefore applied in batters for an improved stickiness and an increased period of crunchiness of fried products. It is also used in a meat replacer (Meatless, The Netherlands) with a superior 'meat like' bite and it can replace functional animal proteins as egg and milk up to 70% in bakery goods (e.g. cakes). Its counter part, the fibre enriched flour (Fralu-T^+), has an added value when water adsorption or improves flow ability is required (e.g. flowing agent in spices mixture, aroma carrier).

The extracted flours and concentrate can be applied in pink meat products (Frankfürther sausages) and course minced meat. β-Carotene present in non-extracted flour could otherwise give the product an undesirable colour. The higher water binding of extracted flour can make addition interesting.

ACKNOWLEDGMENT

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Table 1. Composition of lupine products (average and standard deviation) in 2007.

Process	Product*	Moisture (%)	Protein (%dm)	Fat (%dm)
Feed		10.3 ± 0.5	38.1 ± 1.2	7.5 ± 0.5
De-hulling/milling	Fralu-NT	5.8 ± 1.2	40.8 ± 1.2	7.4 ± 0.3
Toasting/de-hulling/milling	Fralu-T	6.1 ± 1.2	43.1 ± 0.8	8.1 ± 0.4
Fiber reduction	Fralu-CON	5.2 ± 0.7	60.8 ± 2.0	10.3 ± 0.4
Fiber enrichment	Fralu-T+	6.2 ± 1.1	38.4 ± 2.4	7.6 ± 0.5

* NT: non-toasted, T: toasted, CON: concentrate (protein enriched); +: fibre enriched.

Table 2. Composition and efficiency of the CO_2 extraction of different lupine flour products.

Product*	Type of extraction	Protein (%dm)		Fat (%dm)		Colour-reduction [%]
		Feed	Product	Feed	Product	
Fralu-NT	CO_2	40.7	42.8	7.2	0.9	85
Fralu-T	CO_2	41.2	43.2	7.7	0.9	93
Fralu-T	Hexane	41.2	42.8	7.7	1.4	83
Fralu-CON	CO_2	60.9	66.8	9.5	0.9	90

* NT: non-Toasted, T: toasted, CON: concentrate (protein enriched).

Table 3. Phytonutrients of oil extracted from toasted and non-toasted lupine flour with CO_2 (data from De Smet-Ballestra, Belgium).

Parameter	Oil from toasted lupine flour (Fralu-T)	Oil from non toasted lupine flour (Fralu-NT)
Total Tocopherol (ppm)	1566	1346
β-Carotene (ppm)	300	346
Total sterols (ppm)	25261	24365

Table 4. Water binding capacity after heating 80°C of different lupine products compared with soy concentrate.

Product*	Protein [% d.m.]	Water binding [$g_{water}/g_{product}$]
Fralu-T	42	5.6
Fralu-NT	40	6.2
Fralu-T+	37	6.1
NT+	34	6.9
Fralu-CON	59	4.9
NT-CON	61	5.9
UNICO Soy Concentrate	60	9.0

* NT: non-Toasted, T: toasted, CON: concentrate (protein enriched); + : fibre enriched.

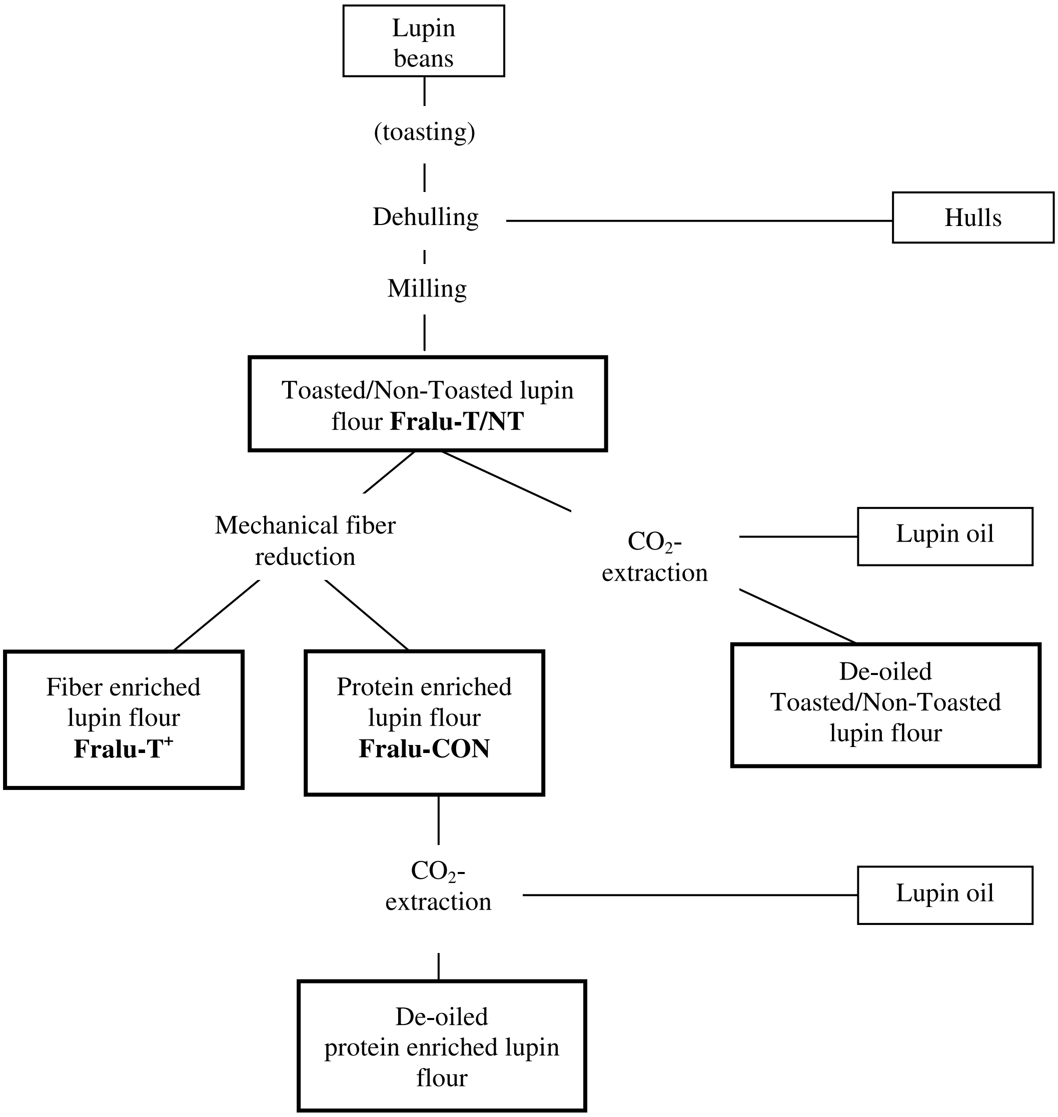

Fig. 1. Schematic presentation of the production of different lupin products.

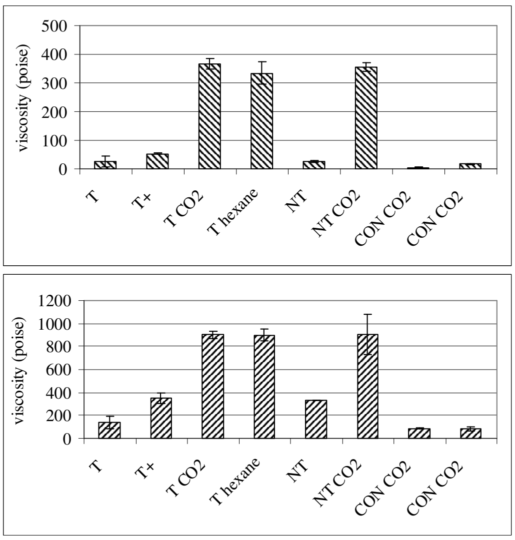

Fig. 2. Viscosity of lupine/water mixtures. Top: after 1 hour at 25°C, bottom: after cooking and cooling.* NT: non-Toasted, T: toasted, CON: concentrate (protein enriched), + : fibre enriched, CO2: extracted with CO_2. Hexane: extracted with hexane. The error bars represent the 95% confidence limits.