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Forwards

This report contains first results of characterization of quality and functionality of oil from Andean lupin, Lupinus mutabilis in comparison to oils of other lupin species suited for human consumption and from other commercially available oil crops.

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1 Introduction

1.1 General objectives

Project LIBBIO aims to develop and optimize the breeding and cropping of the Andean lupin *Lupinus mutabilis* in the European Union. Additionally, processing of the lupin seeds to obtain new and high value products both directly for consumers and as ingredients for incorporation into other products is a main part of the project. These products are intended to cover food usages as well as non-food applications like cosmetics and others. Main ingredients of lupin seeds which are in the focus of the project are oil, protein, alkaloids and soluble fibres.

1.2 Specific objectives

This report contains first data about properties, functionality and first prototype applications of lupin oil as one main components of the seeds of L. Mutabilis. Properties of this oil are compared to other important edible plant oils. For this purpose, well known commercially available soy bean oil, olive oil, rapeseed oil and palm oil were selected for comparison.

Despite the composition of the oils with respect to fatty acids, quality parameters like free fatty acids and peroxide numbers have to be considered for the comparison. Additionally, physicochemical properties of the oils which are relevant for their application in food and non-food uses (pharmaceutics, cosmetics) should be included to obtain a complete overview about the oil from L. mutabilis in comparison to the other oils already used for such applications.

Furthermore, first applications of the new lupin oil both in food matrices (mayonnaise) and cosmetics (lipsticks) are part of this report to demonstrate high added value applications which are developed within LIBBIO project further work within this workpackage.

2 Quality and functionality of plant oils

2.1 Oil composition and quality

Oils or, in the more general way, lipids are one of the three major nutrients for humans despite proteins and carbohydrates. Due to their high caloric value of about 9 kcal per gram, they are an important energy source in nutrition. They are not miscible with water because of their non-polar properties, but can form emulsions. They are soluble in organic solvents, e.g. hexane, which are used for the extraction of oils from the plant material in many cases (see below). Oils can contain non-polar aroma components and act as a flavour carrier in many foods, e.g. mayonnaise. They also contribute to structure, e.g. palm oil, and mouthfeel in food applications.

The main components of edible plant oils are the triglycerides consisting of three fatty acids and a glycerol backbone (Figure 1).

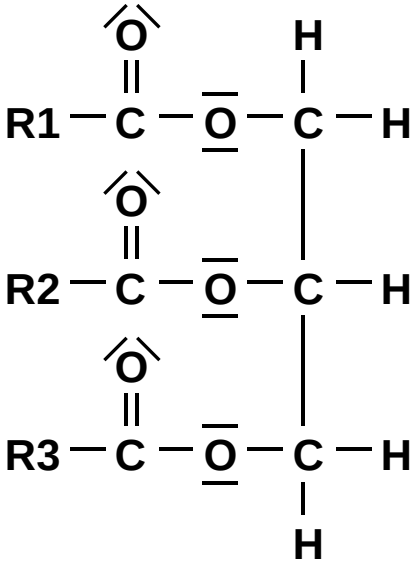

Figure 1: Composition of triglycerides (R1 to R3: fatty acid residuals).

The fatty acids in plant oils are mostly long-chain carboxylic acids with 16 to 22 carbon atoms. It can be distinguished between saturated fatty acids without any double bounds within the carbon chain, mono-unsaturated fatty acids with one double bound in the chain and poly-unsaturated fatty acids with two or more double bounds. The length of the carbon chain and the number of double bounds influence the chemical and physical properties of the oils as well as their nutritional value. Especially poly-unsaturated fatty acids are considered as more healthy compared to saturated fatty acids with some positive effects

on lowering inflammation and reducing cardiovascular risks (e.g. Chow 1992; Akoh und Min 2002; Calder 2006).

On the other side, poly-unsaturated fatty acids are more susceptible to lipid oxidation compared to saturated fatty acids. This means that lipids with high content on saturated and mono-unsaturated fatty acids are more stable for storage and more suitable for high temperature applications of oils for example during deep-frying (Chaiyasit et al. 2007; Marmesat et al. 2012).

With respect to structuring in food matrices, e.g. chocolate compounds, plant oils with a higher amount of long-chain saturated fatty acids are favourable, because such lipids have a higher melting point and, therefore, possess a high amount of solid fat content at room temperature.

edible plant oils contain next to the triglycerides many minor components which are relevant for their stability (antioxidants) und functionality, e.g. phospholipids. One important group of antioxidants in plant oils is formed by the tocopherols. Their basic composition is shown in Figure 2.

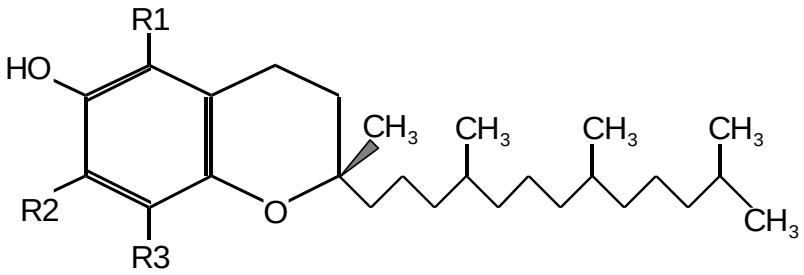

Figure 2: Composition of tocopherols (R1 to R3: Hydrogen or hydroxyl groups).

Depending on residuals R1 to R3, tocopherols can be distinguished in α-, β-, γ - and δ-tocopherols. These variations in composition result in differences in their antioxidant functionality (Rossi et al. 2007; Warner & Moser 2009). Especially, α-tocopherol is confirmed to contribute to health effects in the human body with respect to radical scavenging (Schneider 2005). On the other hand, γ- and δ-tocopherols are more important for their antioxidant activity in the oils itself to protect them from lipid oxidation (Belitz et al. 2009). Studies demonstrated that also γ-tocopherol has several positive effects with respect to trapping lipophilic electrophiles and reactive nitrogen and oxygen species. Any difference in activity between the two E-vitamers can be explained by the lack of the methyl group from position 5 of the chroman ring and attributes related to this difference in structure. This causes a difference in the lipophilicity of the two molecules, which might also be relevant to the difference in bioavailability of the two E-vitamers. γ-Tocopherol can

be considered as antioxidant for lipids and lipid-containing food, so γ-tocopherol has properties which are complementary to α-tocopherol (Wagner et al. 2004).

Another minor component which is especially relevant for the functionality of oils is the group of phospholipids, sometimes called lecithin. Their composition is quite similar to the triglycerides, but one of the outer fatty acids at the glycerol backbone is replaced by a phosphate group together with an alcohol, the so-called head group. Depending on this head group, phospholipids can be separated in phosphatidyl choline, phosphatidyl ethanolamine, phosphatidyl serine and others (Schneider 2001). The main portion of the phospholipids is removed during the refining procedure of plant oils (see below). Phospholipids have an influence of the surface properties of the oils which are relevant for emulsification and dispersing.

Other minor components which also modify the surface activity are the partial glycerides. They are also close to the triglycerides with respect to their composition, but they have only two (diglycerides) fatty acids or only one (monoglycerides) fatty acid (see Figure 1). These substances are the result of the activity of the lipases from the plant matrix. Additionally, to the partial glycerides, free fatty acids can be found in the oils.

With respect to the physico-chemical parameters, the surface tension of the oils as already mentioned is of relevance for emulsification. Also the viscosity of the oils plays a role for their application, e.g. in creams.

Quality of plant oils can be described by several parameters. Most of them are chemical parameters characterizing undesired changes in the oils which results in deterioration of the oil either during storage or during usage, e.g. frying.

Despite all analytical parameters, edible oils have to meet the sensory requirements with respect to typical flavour with the absence of undesired off-flavours like fishy, rancid, metallic bitter and others. To enhance the objectivity of the quality evaluation of edible oils, several chemical parameters have been established.

The first one is the content of **free fatty acids**. A higher amount of free fatty acids indicates a higher lipase activity before oil extraction. Oils with many free fatty acids are less stable in heating processes and can develop off-flavour (rancidity) (Frega et al. 1999). Therefore, the concentration of free fatty acids is one main parameter in specifications of edible plant oils. With respect to limits in the concentration it has to be distinguished between refined and non-refined oils, because this quality parameter is distinctly reduced during refining. According to German regulations for edible oils, a maximum content of 2 g/100 g is allowed for non-refined oils, whereas only 0.3 g/100g is set for refined oils.

With respect to the oxidation state, both **peroxide number** and **anisidine number** are the relevant quality parameters. The peroxide number is related to the amount of peroxides in the oil which indicate the first stages of lipid oxidation. The higher the peroxide number,

the more the lipid oxidation is proceeded. In the case of an oil experienced an advanced stage of oxidation, the peroxide number decrease because of further reactions of the unstable peroxides. In this phase the ansidine number is more relevant, since this parameter correlates with the amount of aldehydes which are formed at later stages of lipid oxidation and are more stable.

Special parameters which are relevant for the quality and quality changes in oils used for deep-fat frying are the amount of **polymerized triglycerides** in the oil and the amount of **polar compounds**. Polymerized triglycerides are formed in the oil at higher temperatures due to cross linking of the triglycerides. These compounds lead to deposits on the fryer walls and increase the oil viscosity. The other parameter reflects the amount of substances in the oil which are not as non-polar as the triglyceride molecules. Examples of these compounds are the mono- and diglycerides. For both parameters, recommendations for maximum levels in frying oils exist (Gertz et al. 2014).

2.2 Oil functionality in food processing and cosmetics

Edible plant oils are not only consumed in their natural state as pure oils, but are also used as an ingredient in many food and non-food preparations.

First of all before the oils can be used in any application, there storage stability is important. As described above, oils which naturally contain a lot of unsaturated fatty acids can be deteriorated due to lipid oxidation. With respect to food processing, storage stability of the oils should be high enough to prevent sensory defects within the typical period of consumption.

Especially plant oils are often used in food emulsions where they form the disperse phase distributed within a continuous aqueous phase (oil-in-water-emulsions). Typical examples for such systems are mayonnaises or spreads. This oil phase in such systems gives the food the right taste, mouth feeling and consistency. To prepare such systems, the oil has to be distributed in fine droplets (<10 µm) by homogenizers. With respect to oil functionality, its surface tension and viscosity are relevant for this process.

A total different system, but although also a kind of an emulsion, is the margarine. In this case fine water droplets are distributed within a continuous lipid phase. To obtain the desired consistency, the lipid phase is a mix of a hard fat, e.g. palm fat, and oil. The functionality of the oil in such systems is described by their ability to interact with the hard fat in crystallization and to form stable crystals.

With respect to cosmetics the functionality of oils in disperse systems like emulsions is also relevant. But here, suspensions where small solid particles are distributed within the

continuous oil phase, e.g. creams, are of interest. Also in such matrices, the surface properties of the oil are relevant for its application.

2.3 Oil extraction and processing

Depending on the water content in the oil-containing plant material and the amount of oil in the plant material different techniques are applied to get the oil out of the plant. In systems where the oil is in the fruit part with a high-water content, e.g. olives or palm fruits, a slurry is prepared where the liquid oil-water-mix is separated by decanters or presses. In a next step the water is separated from the oil due to density differences (centrifugation). In the systems with low water content (seeds) like rape seed, sunflower seeds, soy bean or lupin seeds, the oils are separated either by expeller pressing (higher oil contents) or by solvent extraction (lower oil contents) or also a combination of both (rape seed). Solvent extraction is either petroleum-derived (e.g hexane) or with green extraction solvents like supercritical CO2. These processes are more comprehensively described in upcoming reports, deliverable 3.2.

Most of the commercially used oils especially for further applications in food and cosmetics are subjected to a refining procedure including several steps. This refining enables the manufacturing of clear and stable oils with neutral taste and color as well as low amounts of contaminations, e.g. pesticides. The refining procedure includes a degumming step, where the phospholipids are removed by addition of acids for their precipitation and subsequent centrifugation. In a next step, the bleaching process, bleaching earth is added to the oil to remove small particles and undesired substances by adsorption. The deodorization step as the final process in oil refining applies high temperatures (> 200 °C) and very low pressure (about 4 mbar) to remove volatiles by evaporation. This removing of volatiles is supported by stripping of the oil with steam.

Native cold pressed oils including olive oil are not refined to maintain their characteristic taste and flavour. Normally, these oils are not used as ingredients in the industrial food production, but in households and restaurants for cooking.

3 Material and methods

3.1 Oils considered for the characterization

To get an overview about the properties and functionality of the oil from Lupinus mutabilis in comparison to other edible plant oils, different types of oil were considered.

First of all, oil from Lupinus mutabilis was included as Andean lupin oil, cv. Branco. This oil was obtained by extraction from the ground lupin seeds of L.mutabilis cv. Branco with hexane in laboratory scale (See also deliverable 3.2). After removing the hexane from the oil in a rotary evaporator, no further steps were carried out with respect to refining.

As first comparison, a commercial white lupin oil from *Lupinus Albus* (Laboratories Expanscience, Epernon, FR) was included in the investigations.

Furthermore, soy bean oil which was extracted from soy beans in same way as described above for the Branco oil as well as olive oil (native extra oil La Espanola, purchased in a local supermarket) and palm oil (palm oil red, organic, Ölmühle Solling, Boffzen, DE) were considered in the investigation.

Additionally, data measured for a non-refined rapeseed oil were included in the comparison. These data were measured on rapeseed oils from previous projects at DIL.

3.2 Chemical characterization of oils

3.2.1 Fatty acid distribution

The fatty acid distribution of the oils was analysed according to the Unified German Methods for Fats and Oils (DGF C V 11d). For this purpose the triglycerides in the oils were completely hydrolysed and the single fatty acids were chromatographically separated.

3.2.2 Phospholipids

The amount of phospholipids was measured as the concentration of phosphorous in the oil. Based on this value, the phospholipid content can be calculated. The phosphorous content is determined after incineration of the oil by Inductively Coupled Plasma - Mass Spectrometry (ICP-MS).

3.2.3 Tocopherols

Tocopherol concentration in the oils was determined by HPLC according to the Unified German Methods for Fats and Oils (DGF F II 4a).

3.2.4 Free fatty acids

To determine the amount of free fatty acids, the acid number of the oil was measured by titration of the oil with KOH according to Unified German Methods for Fats and Oils (DGF C V 2). Concentration of free fatty acids was calculated as oleic acid.

3.2.5 Peroxide number

Peroxide number was determined by titration of the oil with iodine according to the Unified German Methods for Fats and Oils (DGF C VI 6a).

3.2.6 Total polar matter

The total amount of polar substances in the oil was determined by separating the polar and non-polar compounds on solid phase columns. After removing the solvent, the masses of all fractions were determined and portion of polar compounds was calculated (Schulte 2000).

3.2.7 Polymerized triglycerides

Polymerized triglycerides can be separated from the triglycerides in the oil by high pressure liquid chromatography (HPLC) (Weisshaar 2014). This method also allows the determination of the amount of mono- and diglycerides in the oil.

3.2.8 Antioxidative potential

The antioxidative potential of all substances in the oil which have positive effect on retarding oil oxidation, e.g. tocopherols of phytosterols, was measured with the TEAC assay (Dachtler et al. 2003).

3.3 Physico-chemical characterization of the oil

3.3.1 Oxidative stability

The oxidative stability of the oils was determined by a forced storage test at elevated temperature (Marquez-Ruiz et al. 2000). For this purpose, air flows through the oil at a temperature of about 100 °C initiating oxidation process. Volatile substances formed during the first steps of oxidation and discharged by the air are collected in a water bath. An increase in electric conductivity of the water bath indicates the beginning of oxidation processes in the oil. The time which is required for the change in conductivity is a measure of oil stability (induction time). The higher the induction time, the better is the stability of the

oil. Within the project, a commercial rancimat (892 Professional Rancimat, Metrohm, Stuttgart, DE) was used.

3.3.2 Surface tension

The parameter surface tension describes the work per surface area which is necessary to generate a new surface of the liquid. In the project, surface tension was determined by the static plate measuring method according to Wilhelmi where the force is measured for the wetting of the vertically hanging Wilhelmi plate. The static tensiometer K12 (Krüss, Hamburg, DE) was used for the analysis.

3.3.3 Viscosity

Viscosity of oils does not depend on the shear rate (Newtonian fluid), because oils are quite simple materials without different phases. Therefore, viscosity of the oils as a function of temperature was determined for the same shear rate of 50 s^{-1}. A rheometer AR 2000 (TA instruments, New Castle, DE, USA) equipped with a cylindrical measurement system (1mm gap size, diameter of the inner cylinder 21 mm). Temperature ramp from 20 to 90 °C was used with 5 °C/min. Only the viscosity of the palm oil was determined at higher temperatures (> 40 °C) because of its higher melting temperature compared to the other oils. Therefore, viscosity of this oil at 20 °C could not be measured.

3.3.4 Density

Density of the oils was measured using a pycnometer. A defined volume of the oil was filled into the pycnometer and the resulting mass was measured. Density can be calculated by dividing mass by volume.

3.4 Functionality of the oils in selected applications

3.4.1 Functionality in mayonnaise

A standard classical mayonnaise with a fat content of about 80 % was prepared from two oils a standard commercial oil bought in the local supermarket and unrefined Andean lupin oil. The recipe of the mayonnaise is shown in Table 1. Eggs, vinegar, salt, mustard and sugar were purchased in a local supermarket.

Table 1: Standard recipe of the mayonnaise for testing sensory oil qualities.

Component	Andean lupin Oil	Commercial vegetable oil
Edible plant oil (ml)	250	275
Whole egg	1	1
Vinegar	q.s*	q.s
Salt (g)	2	2
Mustard (g)	14	14
Sugar (g)	14	14

* q.s. quantum satis

Preparation of the mayonnaise was with a kitchen grade immersion blender. All the ingredients were put in a high and small container where the mustard, egg, sugar, vinegar and salt were added first. After that the oil was poured into the container. The immersion blender was put on the bottom of the container and slowly moved up, allowing the ingredients to be mixed thoroughly. When the mayonnaise was thickened the blending was stopped.

Mayonnaises were tested with respect to their sensory properties and stability on plates.

Figure 3: Raw materials and resulting mayonnaise.

3.4.2 **Functionality in cosmetics**

Functionality of the lupin oil was also tested in tested in lipsticks. For this purpose, the basic basic mass for the lipstick with a recipe according to Table 2 was prepared. Lipids and waxes were melted together at a temperature of 91C and mixed with a high shear device (Ultra Turrax IKA T25). Pigments were added during the cooling phase and stirred with a propeller stirrer (IKA). Lipsticks were passed into an aluminium mould and allowed to cool before putting into lipstick tubes (Figure 4 Table 2).

Figure 4: Preparation of the lipsticks.

Table 2: Generic recipe of the lipsticks for testing lupin oil functionality.

Component	Lupin lipstick Portion (%w/w)	Conventional lipstick Portion (%w/w)
Lupin oil	5	
Castor oil	58	58
Jojoba oil	12	17
Shea butter	10	10

Candelilla wax	15	15
pigments	pm*	Pm*
total	100	100

* pm pro memoria, pigments are added according to manufacturer's preferences ..

4 Results and discussion

4.1 Chemical composition

The fatty acid composition of all edible plant oils considered for this deliverable are summarized in Table 3. Only fatty acids with concentrations > 0.1 g/100g are included. Additionally, portions of the main three groups of fatty acids (saturated, mono- und poly-unsaturated) are displayed in Figure 5.

Table 3: Fatty acid distribution in g/100 g of different edible plant oils

Fatty acid	Lupin oil, Andean lupin cv. Branco	Lupin oil, White lupin	Soy bean oil	Palm oil	Olive oil	Rapeseed oil
Myristic acid (C14:0)	0.1	0.1	< 0.1	0.9	< 0.1	< 0.1
Palmitic acid (C16:0)	11.1	6.4	10.7	41.9	13.4	4.9
Palmitoleic acid (C16:1)	0.2	0.3	< 0.1	0.2	1.4	0.3
Stearic acid (C18:0)	7.0	1.6	5.02	5.2	2.6	1.6
Oleic acid (C18:1)	45.5	56.9	23.2	40.0	70.9	60.4
Linoleic acid (C18:2)	31.7	14.6	53.2	10.7	9.9	18.9
Linolenic acid(C18:3)	2.5	8.4	6.51	0.4	1.0	10.0
Arachidic acid (C20:0)	0.7	1.0	0.45	0.4	0.4	0.7
Eicosenic acid (C20:1)	0.2	4.8	< 0.1	< 0.1	< 0.1	1.7
Eicosadienoic acid (C20:2)	< 0.1	0.3	< 0.1	< 0.1	< 0.1	< 0.1
Behenic acid (C22:0)	0.8	3.1	0.45	< 0.1	0.1	0.4
Eruic acid (C22:1)	< 0.1	1.4	< 0.1	< 0.1	< 0.1	0.5
Lignoceric acid (C24:0)	0.2	0.7	< 0.1	< 0.1	< 0.1	< 0.1

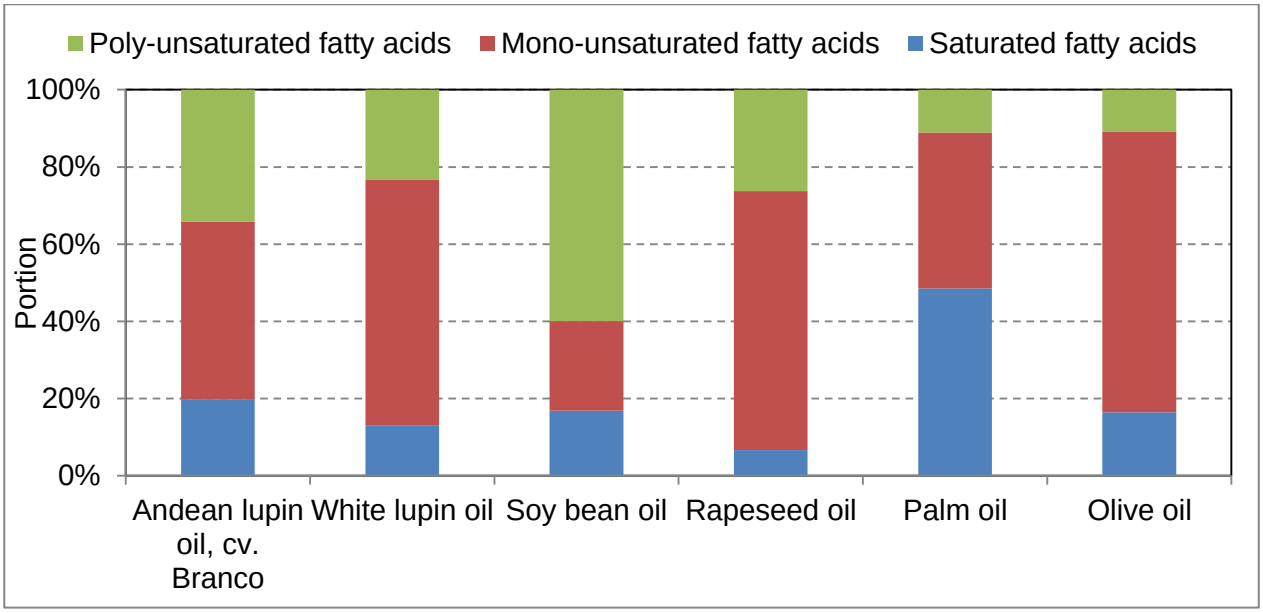

Figure 5: Portion of fatty acid groups in different edible plant oils.

Comparing the oil from the two varieties of lupins, there are distinct differences in the fatty acid distribution. The oil from cv. Branco contains much more palmitic and linoleic acid than the oil from L. Albus. On the other hand, oil from L. Albus possess higher amounts of oleic and linolenic acid and, in total, a higher portion of very long-chain fatty acids with 20 and more carbon atoms. With respect to the different groups of fatty acids, oil from cv. Branco is higher in saturated and poly-unsaturated fatty acids whereas the oil from L. Albus is higher in mono-unsaturated fatty acids.

Compared to the other edible plant oils included in this investigation, oil from cv. Branco possess distinctly more saturated fatty acids compared to rapeseed, soy bean and olive oil, mainly due to its higher amount in stearic acid. An exception is the palm oil with a very high content in saturated fats due to the palmitic acid portion. With respect to human consumption, a higher content of stearic acid as the saturated fatty acid has positive effects on health compared to other saturated fatty acids (Hunter et al. 2010). Additionally, lupin oil from cv. Branco is quite high in poly-unsaturated fatty acids compared to the other edible plant oils which is also positive with respect to health effects.

The tocopherol contents (Vitamin E) of the different edible oils are shown in Figure 6.

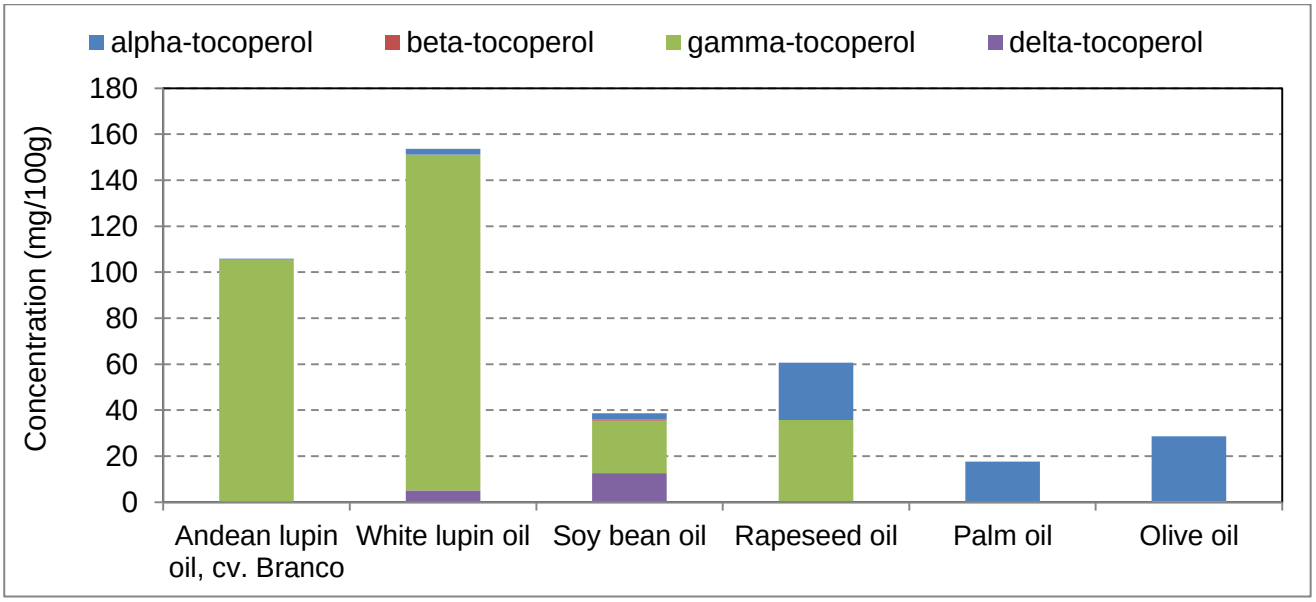

Figure 6: Tocopherol contents in different edible plant oils.

Compared to the other edible oils, oils extracted from lupin seeds contain a quite high amount of γ-tocopherol and nearly negligible concentrations in α-tocopherol. This means these oils have a high antioxidative potential, especially with respect to trapping lipophilic electrophiles and reactive nitrogen and oxygen species. (comp. chapter 2.1). The other edible plant oils contain much more of the α-tocopherol indicating a higher vitamin E effect of these oils.

4.2 Quality parameters

A summary of the quality parameters of all oils considered in the project is listed in Figure 6. The parameters could not be analysed for the oil from white lupin because of limited amount of sample material for this oil. Therefore, a comparison of the two different lupin oils is not possible.

Table 4: Quality parameters of different edible plant oils

Parameter	Lupin oil, cv. Branco	Rapeseed oil	Soy oil	Palm oil	Olive oil
Peroxide number (mval/kg)	0.87	0.6	3.72	4.0	9.98
Polymer triglycerides (g/100g)	< 1	< 1	< 1	< 1	<1
Monoglycerides (g/100g)	0.07	0.16	0.03	0.5	0.9
Diglycerides (g/100g)	2.35	2.14	1.23	6.2	1.9
Free fatty acids (g/100g)	0.87	0.6	0.6	3.94	0.41
Total polar matters (g/100g)	n.m.	3.5	2.8	10.1	2.3

With respect to oxidation state indicated by the peroxide number, the Andean lupin oil cv. Branco shows a very good quality, because the peroxide number is low and with the range for a good quality native plant oil (see chapter 2.1). Amount of mono- and diglycerides is in the same range as for the other oils despite the palm oil. This results show that there is no additional activity of lipase in the lupin seeds. Because the palm oil is an oil originating from the palm fruits, there is a much higher lipase activity resulting in a higher amount of especially diglycerides. Because the palm oil is not refined, also free fatty acids can be found there in a higher concentration. This is also reflected by the parameter total polar matter, because the partial glycerides and the free fatty acids are the main part of polar compounds in the oils.

4.3 Functionality of the oil

The viscosities of the oils at different temperature are shown in Table 5. Also in this case the amount of sample from the lupin oil from L. Albus was not sufficient to measure the viscosity for this oil.

Table 5: Viscosity of edible plant oils in mPas at different temperatures

Temperature	Lupin oil, cv. Branco	Rapeseed oil	Soy oil	Palm oil	Olive oil
20 °C	77.5	54.8	66.2	-	80.2
50 °C	33.0	28.1	29.4	51.3	33.2
80 °C	15.2	14.5	14.1	15.3	15.2

The viscosity of the lupin is in the range of viscosities determined for the other oils except the palm oil. Its viscosity at 50 °C is higher which can be correlated to the differences in composition compared to the other oils. Due to the higher melting range of the palm oil, viscosity measurement at 20 °C was not possible. However, at highest temperature of 80 °C the viscosities of all oil are very close to each other.

4.4 Application examples of the oil

4.4.1 Mayonnaise

Mayonnaise was prepared as described above. Andean lupin mayonnaise needed less oil then conventional mayonnaise to thicken during the blending process. Color of the Andean lupin mayonnaise was rich yellow compared with the conventional prepared mayonaiise

(Figure 7, left). Stability of the Andean lupin Mayonnaise was demonstrated by creating mayonnaise figures with an icing bag where the mayonaise application remained stable for several hours at room temperature. (Figure 7, right).

Figure 7: Color of conventional oil and Andean lupin based oil mayonnaise (left) and stability of Andean lupin mayonnaise when applied with an icing bag after 4 hours at room temperature.

The high amount of unsaturated fatty acids and the high antioxidant content of the Andean lupin oil makes it an interesting ingredient for healthy food products. Further research in the LIBBIO project will result in more prototype food applications with Andean lupin oils such as margarines and other sauces.

4.4.2 **Lipstick**

Andean lupin oil is rich in tocopherols. Different forms of tocopherols have different anti-oxidant effectiveness. γ-Tocopherol provides different antioxidant activities in food and in-vitro studies and showed higher activity in trapping lipophilic electrophiles and reactive nitrogen and oxygen species and has complementary effects to α-tocopherol (Wagner et al 2004). γ-Tocopherol has its major anti-oxidant effects in lipid phases of applications and has therefore potent effects on free radical scavenging in skin care applications especially lipsticks.

Figure 8: Lipsticks prepared from conventional and Andean lupin oil as an ingredient.

Different series of lipsticks were developed and compared with commercially available lipsticks regarding sensory and optical characteristics. Standard questionnaires were used for consumer panel evaluation. First results (Figure 9) show that lupin-based lipsticks are appreciated by consumers regarding spreadability, smoothness, lip moisturization and not-messiness. Color transfer can be improved and hardness can be reduced. LIBBIO project will continue to optimize lupin-based lipstick recipes with respect to consumer preferences.

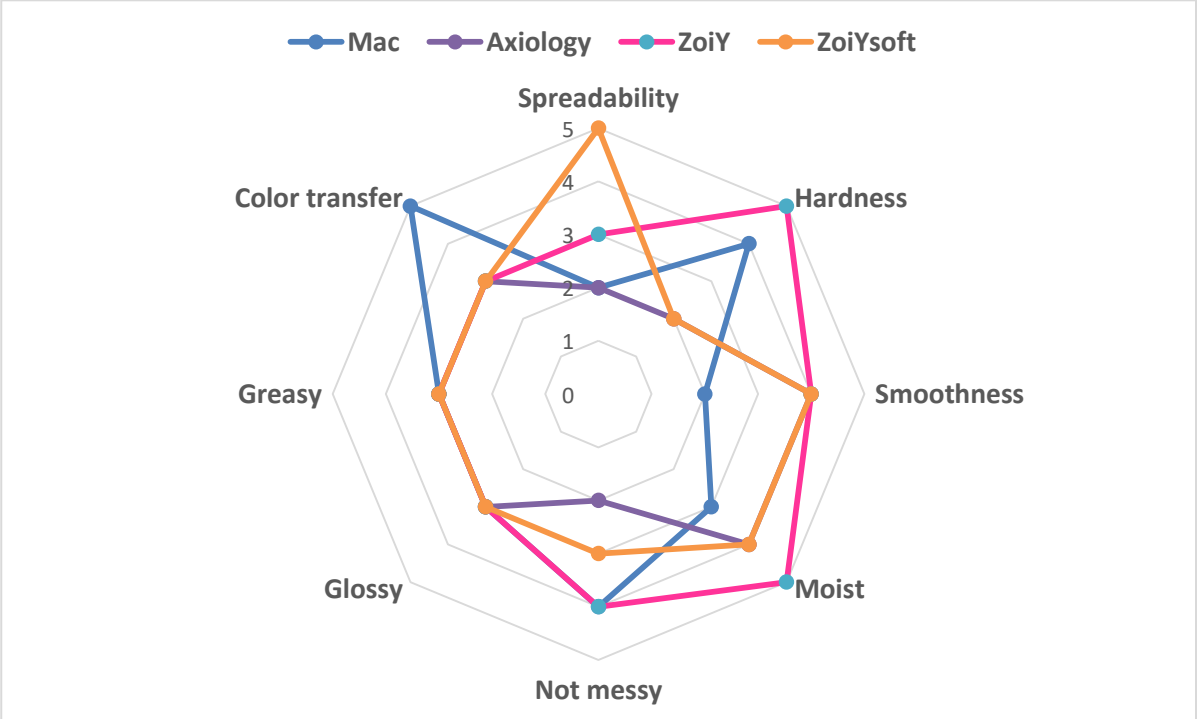

Figure 9: Results of sensory tests of lipsticks prepared from conventional (Mac, Axiology) and Andean lupin oil (ZoiY, ZoiYsoft) as an ingredient.


Lupin oil is rich in tocopherols and other components like phytosterols, lecithin (phosphatidylcholines) and more. Further research in the LIBBIO project will elucidate the potential applications of Andean lupin oil in skin care applications.

5 Conclusions and further work

First results regarding Andean lupin oil are promising with respect to fatty acid composition and minor components in the oil with different functionality. The fatty acid composition of the Andean lupin oil has a quite high amount of saturated fatty acids which enables a good stability of this oil with respect to oxidation. Oxidation stability is also enhanced by the quite high natural content of the antioxidant γ-tocopherol compared to other edible crop oils. On the other hand, such an oil with the relatively high content in poly-unsaturated fatty acids of nearly 40 °C can be considered as very healthy.

The high amounts of γ-tocopherols not only contribute to higher oil stability, but have also positive effects on lipid metabolism in the human body. γ-Tocopherol is especially active as anti-oxidant in the lipid phase of food and cosmetic systems This makes Andean lupin oil especially suited for advanced anti-oxidant applications in these systems. Especially food products like mayonnaise and margarines and cosmetic products like lipsticks, lip gloss and skin care creams might benefit from this high γ-tocopherol content.

Other interesting minor components of the oil will be researched in future such as phytosterols and lecithin fractions.

Food and non-food applications can be developed with Andean lupin oil resulting in high quality consumer products. Prototype examples are mayonnaise for healthy food and lipsticks for glamourous cosmetic applications. The LIBBIO project will develop more prototype applications for demonstrating the versatility of the Andean lupin oil.

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