Nutritive quality of Finnish grown grain legumes

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Introduction

About 56% of Finnish arable land is devoted to cereal production (Ekroos, 2010), but less than 1% to grain legumes (Stoddard et al. 2009). Consequently, Finland has a major dependence on soybean imports, mostly from the Americas, for different feed and food uses (Stoddard et al. 2009; Ekroos 2010). Legume cultivation in Finland needs to be promoted, because legumes can be a sustainable source of food and feed, and can also help to reduce the environmental impacts of Finnish agriculture through their ability to biologically fix nitrogen.

In order to overcome the Finnish dependence on expensive fertilizers and imported vegetable protein (e.g. soybean meal), Finland should not only increase the current legume cultivation, but also include regionally novel such as lupins and lentils. It is a challenge to grow grain legumes in northern latitudes due to the short growing season and long daylength (Stoddard et al. 2009); but, it has been done successfully in other short-season areas such as western Canada, so there is a very good probability of achieving the same in Finland.

Grain legumes have excellent nutritional quality that makes them a staple ingredient for feeding ruminants, pigs and poultry. Legumes are known for their high protein content, and although they are low in the sulphur-containing amino acids and tryptophan, they have a high content of lysine; thus they are an ideal supplement to cereal-based diets and food products (Duranti & Cius 1997).

Legumes have many beneficial effects in human diet. For example, lupin food products help to prevent type II diabetes, cardiovascular problems and obesity (Duranti, 1997; Sipsas, 2008). Similarly, faba bean can help reduce plasma LDL-cholesterol levels (Crépon et al. 2010). In addition to their high protein content, lupins have other functional ingredients such as carotenoids and 'lupeol' a small fraction of their oil, which is considered to have a positive role in epidermal tissue reconstitution and restraining the growth of melanoma cells (Sipsas, 2008).

Taking into consideration the need for legumes in Finnish agriculture and food systems, blue lupin and faba bean cultivars were screened to identify the most suitable ones for Finland as part of the project "MoniPalko" funded by the Finnish Ministry of Agriculture and Forestry. The aim of the present research is to select early cultivars with high yield and high nutritive value.

Materials and methods

Four cultivars of each of narrow-leafed lupin (*Lupinus angustifolius* L.), and faba bean (*Vicia faba* L.) were sown on 7 May. Blue lupin cvs Haags Blaue, Boruta, Boregine and Sanabor were obtained from Saatzucht Steinach, Germany. Faba bean cvs Kontu, Aurora, Mélodie and Jõgeva were obtained from Boreal, Naturcom, Agri-Obtentions (France) and Jõgeva Plant Breeding Institute (Estonia), respectively. Appropriate rhizobium inoculants were obtained from Elomestari and were applied to the seeds before planting. The experiment was laid out in a randomized complete block trial with four replicates at Viikki and was sown in early May; flowering and maturity dates were recorded. A subplot of 1 m^2 was manually collected from each plot to determine yield components and for quality analysis. Growing degree days were calculated from data recorded at Viikki, using 5°C as the base temperature.

Seeds were milled to pass a 0.5mm sieve using a Retsch Centrifugal Mill ZM200. The resulting flour was used to determine several quality parameters. Moisture and ash content were determined following standard methods. Starch content was determined using the Megazyme total starch kit (K-STSA 04/2009). Total C and N were analyzed by the Dumas combustion method in a Vario Max CN analyzer. Content of other elements (Al, B, Ca, Cl, Cu, Fe, K, Mg, Mn, Na, P, S, Si and Zn) was determined on dried, ground, microwave-digested samples in an inductively coupled plasma emission spectrometer (ICP).

Results and Discussion

Maturity dates ranged from 15 August to 30 September, with 15-30 August being considered acceptable for most purposes. Blue lupins yielded 3.3 – 4.8 t/ha. Faba beans yielded 6.0-7.0 t/ha, about 40% more than the national average yield for this crop. None of the exotic cultivars was earlier than the local cultivar Kontu, which needed 1055 growing degree days to reach maturity (Table 1); on the other hand, the earliest blue lupin cultivar was Haags Blaue, which needed only 981 growing degree days, so this cultivar is very promising for Finland growing conditions (Table 2).

Table 1. Faba bean flowering and maturity dates, growing degree days (GDD) and yields.

Cultivar	Flowering date (10%)	Maturity date (90%)	GDD from sowing to maturity (base 5°)	Yield (t/ha)	Total dry matter (t/ha)
Kontu	22 June	22 Aug.	1055	6.29	10.4
Jõgeva	19 June	25 Aug.	1082	6.04	10.2
Aurora	29 June	5 Sept.	1208	7.33	12.8
Mélodie	30 June	14 Sept.	1271	6.30	10.9
SE			23	0.35	0.4

Table 2. Blue lupin flowering and maturity dates, growing degree days (GDD) and yields.

Cultivar	Flowering date (10%)	Maturity date (90%)	GDD from sowing to maturity (base 5°)	Yield (t/ha)	Total dry matter (t/ha)
Haags Blaue	23 June	14 Aug.	982	3.28	7.7
Boruta	28 June	27 Aug.	1107	3.94	9.4
Boregine	26 June	13 Sept.	1284	4.08	10.0
Sanabor	27 June	23 Sept.	1364	4.82	10.8
SE			39	0.23	0.4

The moisture content of the faba bean flour was 6-7% with significant differences among cultivars (Table 3), while that of the blue lupin flour was about 6% with no significant differences among cultivars (Table 4). There were significant differences in ash content among cultivars of each species and the underlying differences in mineral composition are still under evaluation.

Table 3. Faba bean proximate analysis (dry weight basis).

Cultivar	Moisture content (%)	Ash content (%) (dry basis)	Protein content (%)	Starch content (%)
Kontu	7.1	3.211	34.29	36.06
Jõgeva	6.8	3.198	34.22	36.04
Aurora	6.9	3.073	35.22	36.66
Mélodie	7.1	3.122	31.86	36.03
SE	0.04	0.020	0.34	0.27

As expected, there was a marked difference in starch content between blue lupin and faba bean, the former having virtually no starch while the later had around 36% (Tables 3 and 4). Furthermore there were no significant differences among cultivars. The present value of blue lupin starch content is in agreement with literature reports of less than 1% (White et al. 2002), but the faba bean starch content was lower than the 40% reported in some previous studies (Crépon et al. 2010). The low starch content found in lupins is very beneficial, as it contributes to their remarkably low Glycemic Index (Sipsas, 2008).

Table 4. Blue lupin proximate analysis (dry weight basis)

Cultivar	Moisture content (%)	Ash content (%)	Protein content (%)	Starch content (%)
Haags Blaue	6.1	3.676	30.98	0.6292
Boruta	6.2	3.469	32.38	0.6582
Boregine	6.6	3.700	29.35	0.6823
Sanabor	6.2	3.852	36.15	0.6601
SE	0.08	0.045	0.68	0.0081

Interestingly, significant differences in protein content among cultivars were found in both species. Furthermore, protein content was not correlated with either maturity date or yield. Average protein content of blue lupin was 32%, while for faba bean it was 34%, thus both can be used as excellent protein sources.

Analyses of the oil, dietary fibre and soluble sugar contents of both species are still in progress.

Conclusions

There is potential and sufficient farmer interest to establish grain legume crops in the Nordic-Baltic region through screening imported germplasm for adaptation. There are many potential uses of legume seeds as functional ingredients, thus further research is needed to design legume-supplemented food products. In addition, it is very important to publicize their health benefits, to assure consumer acceptance.

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