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Participatory Evaluation and Demonstration of Sweet Lupin Technologies at Wolmera District, West Shewa Zone of Oromia, Ethiopia

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Abstract
The study was conducted at Wolmera district, western Oromia region, Ethiopia. A total of 12 women farmers were selected purposively to implement the activity. Sweet lupin demonstration was conducted to evaluate and crate awareness on sweet lupun technologies, food recipes and to analyze the macro and micronutrient composition of the varieties. The mean grain yield result of this variety was 2300 kg ha^{-1} with a minimum of 1900 and a maximum of 2800 kg ha^{-1}, respectively. Sensory evaluation test was made on sweet lupin recipes made in combination with wheat flour, field pea flour and alone using hedonic scaling method. A total of 112 participants out of which 62 were male and 50 were female were involved to taste the food recipe made from sweet lupin. The result of sensory evaluation indicated that the incorporation of 25% of sweet lupin flour (SLF) to the biscuit is more accepted by the panelists than 50% SLF substitution to the biscuit. The acceptability of bread containing 25% SLF was excellent. For Pulse stew 50% SL substitution level for 50% FP flour and 100% SLF alone has no any difference in acceptance among the panelists. The result also revealed that a very good acceptability of 100% SL Roasted and Boiled can also be prepared from sweet lupin. The lab analysis result of macro- and micronutrient composition content of sweet lupin grain as compared to field pea grain showed that mean protein and fat contents of sweet lupin were 31.6% and 8.3%, respectively, while the grain protein and fat contents field pea were 22.32% and 3.6% respectively. Sweet lupin grain has also the highest mineral contents of zinc, iron and calcium whereas, but field pea has higher contents of potassium and sodium. The demonstration of new varieties of sweet lupin with low alkaloid and high protein content has resulted in a renewed interest in utilization of lupin as source of protein for human and livestock nutrition.
Keywords: sweet lupin, protein content, Field pea flour**,** Wheat flour
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Introduction

Lupin is one of the potential multipurpose crops to be utilized as a homegrown cheap protein source in the developing world because of its low agronomic requirement. Even though bitter white lupin is a traditional old crop in Ethiopia, sweet lupins are new for the country. Bitter lupin seeds are consumed in Ethiopia as snack by roasting followed by soaking in running water for 4-9 days to remove the alkaloids which are responsible for the bitter taste (Solomon, 2007), and washing it twice (Yeheyis et al.,2012). But sweet lupin can be consumed without roasting and soaking in water. Lupins are known for their high protein value in human food and livestock feed. However, it has limitations associated with its alkaloid content (Wink, 1993, 2008). The major anti-nutritional factors in lupin are quinolizidine alkaloids, which are responsible for the bitter taste in lupin, and human and animal toxicity because they act as neurotoxins. Alkaloids are responsible for the bitter taste, lower palatability and toxicity in lupin seed and forage(Vilarino and Ravetta, 2007; Zulak *et al.*, 2006). In bitter cultivars, the alkaloid contents range between 0.5% and 6% and in sweet cultivars it is less than 0.02% (Wink, 2008). Therefore, unlike most legume grains, sweet lupins do not require heating or chemical treatment to denature the anti-nutritional factors so they can be eaten uncooked. Also, lectin activity is virtually non-existent in sweet lupin (Department of Agriculture and Food. Government of Western Australia, 2008).

Lupins are adapted to well drained light to medium textured soil and it is sensitive to soil pH, preferring acid to near neutral conditions (pH of 4.5 to 7.5) (Hughe, 1997; Jenson, 2006; Yeheyis et al., 2010). In Ethiopia according to Gebreselassie (2002) the soil type in most traditional lupin growing areas are Nit sol and Acrisol with soil pH ranging between 4 and 5 Engedaw (2012). In his study reported that the smallholder farmers in the North-Western part of Ethiopia grow the crop with minimal agronomic practices, that is they plant the crop using zero-tillage or plowing their land only once and they didn't use any type of fertilizer and weed management technique.

The potential of a given feed to support a target livestock production type and level can be predicted by determining the chemical composition of that feed (van Soest, 1994). In addition to the beneficiary nutrient fractions, knowing the amount of the alkaloid content of lupins is very important because the chemical composition of crops can be affected by the growing environmental conditions such as soil type, temperature and water availability. An experiment conducted by the proponents of this study on sweet lupins in Ethiopia showed that sweet annual lupins are adaptive and productive in the traditional lupin growing areas of the country (Yeheyis et al.,2012). The same authors reported a forage dry matter (DM) yield of up to 4.5 t/ha from sweet white lupin (*Lupinus albus* L.) and seed yield of up to 5.4 t/ha from sweet blue lupin (*Lupinus angustifolius* L.). However, their nutritional value under Ethiopian conditions was not known. Hence, in addition to studying about the adaptability of sweet lupins, information about the crude protein, fatty acid and micronutrient contents is essential. Thus, this study was conducted with the following objectives:

- To demonstrate and evaluate improved sweet lupin technologies/varieties to farmers, extension agents, experts and other stakeholders in the study area.
- To create awareness about the new crop technology to the community.
- To analyze macro and micronutrient composition and demonstrate food products made from sweet lupin in combination with wheat flour, field pea flour and alone
- To exchange experience among farmers and other stakeholders and to get feedbacks about this crops.

Materials and Methods

Description of the study area

The study was conducted at Welmera district of Addis Ababa Zuria Special zone of Oromia, Regional State in Ethiopia. Welmera district is one of the eight administrative units of the Addis Ababa Zuria Special zone of Oromia Regional State. Geographically, the district is located between 8°50'-9°15'N latitude and 38°25'-38°45'E longitude and has area coverage of 66,247 ha WoRLA (Welmera Woreda Office of Rural Land Administration) (2016). Most of its areas are high lands (Dega) and mid highlands (Weynadega) with an altitude ranging from 2060 to 3380 m above sea level. Majority of the soil is reddish-brown clay type similar to some other highland areas of Ethiopia Asefa, S. (2012). The district is sub-divided in to 23 rural kebele (Kebele is the lowest administrative unit under Ethiopian condition) administrations and one town, excluding the capital town of the district. The area is characterized by mixed crop-livestock farming systems like other central highlands of Ethiopia where both crop and livestock production play a central role in the lives of the farming community.

Farmer selection and sample size:

The target district Wolmera was selected purposively for the implementation of the experiments because of its potential in sweet lupin production. Among the 23 rural kebeles found in the district one potential sweet lupin growing kebele's *Robegebeya* was purposively selected. Twelve Volunteer women farmers who are willing to participate in the demonstration were randomly selected with the consultation of district Bureau of agriculture and kebele development agents (DAs).

Materials

One improved sweet lupin variety called Wolella was used to implement this activity**.** Non-replicated design with single plot was employed. The plot size was 10m x 10 m, with7 cm spacing between plants and 30 cm between rows. Sowing was done by hand into a well prepared seed bed and the seed rate was 80 kg/ha. Fertilizer was applied at the rate of 121 kg/ha NPS at the time of planting.

Weeding was done manually by hand at seedling and before the flowering stages. Varietal performance evaluations and observation at field level was undertaken by the participation of host farmers, neighboring farmers, DAs and researchers. Awareness creation about the performance of new crop technology was made for the host and neighboring farmers under field condition. Sweet lupin as a legume crop which is used for food and feed was discussed during field evaluation and visit.

Nutrient content

The macro and micro nutrient content composition of sweet lupin was analyzed using a standard method. Macro nutrient- Protein content (nitrogen %) was determined by Kjeldahl method as stated in the AACC (200) Method 46-11 and fat content was determined by Nuclear magnetic resonance spectrophotometric (MMR). The micronutrient content of mineral elements in sweet lupin food recipe was determined by Atomic Absorption Spectrometer AOAC, (1990) [16] methods

Sensory Evaluation

Sensory evaluation test of food products made from sweet lupin in combination with different ratio of wheat flour, field pea flour and sweet lupin alone was made by Holetta nutrition lab. Farmers (Women farmers and male farmers) agricultural experts, development agents and research staffs were practically participated in the sensory evaluation of different food products prepared from sweet lupin. In total 191 panelists (97 female and 94 male) were participated in the sensory evaluation process to recommend the products based on their test preference. The sensory evaluation test was made using hedonic scaling method (i.e. 5= like very much, 4= like moderately, 3= neither like nor dislike, 2= dislike moderately, 1= dislike very much). The treatment combination (substitution) levels were:

Treatment

Biscuit: 25% SLF + 75 WF; 50% SLf and 50% Wf

Kukis: 25% SLF+75%WF; 50%SLF+50%WF

Snak: 25% SLF+75%WF; 50%SLF+50%WF

Anbasha: 25% SLF+75%WF; 50%SLF+50%WF)

Bread: 25% SLF + 75 WF; 50% SLF + 50%

Pulse stew: 50% SLF and 50% FPF, 100% SLF;

Fried (Kolo): 100% SL; and Boil and roasted *(Nifro)* lupin: 100% SL.

Data collection and analysis:

Quantitative and qualitative data was collected using appropriate data collection methods such as field observation and measurement, agronomic data, Perception of farmers towards the technology and grain yield and sensory evaluation data. The collected data was analyzed using SPSS software package (descriptive statistics). The analysis of variance (ANOVA) was performed to examine the macro and micro nutrient composition significance level of parameters measured. Least Significance Difference (LSD) test was used for mean comparison.

Results and Discussion

Grain yield and sensory evaluation of sweet lupin

The result of mean grain yield in both years in Table 1 below showed that the grain yield of sweet lupin ranged from 1900 kg ha^{-1} to 2800 kg ha^{-1} with a mean of 2300 kg ha^{-1}. Previous studies conducted in Amhara region also showed that the grain yield potential of sweet lupin could range from 2200 kg ha^{-1} to 4800 kg ha^{-1} depending on the area (Yeheyis et al.,2012) [2].

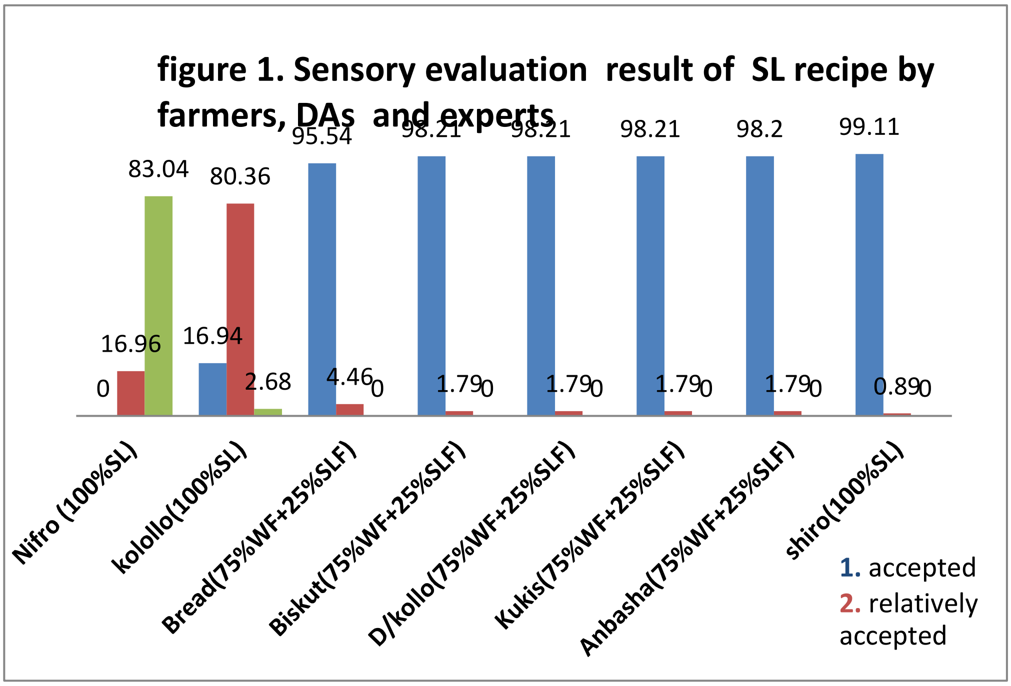
In 2016/17 season there was a problem of hail damage at vegetative stage and frost damage at grain filling stage of the crop. This problem causes the reduction of grain yield data on the tested sites. However, the mean grain yield data 2300 kg ha^{-1} recorded from sweet lupin which was better in production as compared to faba bean and field pea yield in the area during the same season.

Table 1. Mean grain yield of sweet lupin varieties in 2016/17 and 2017/18 season at Wolmera district

Variety	Grain yield kg ha^{-1}		
	Minimum	Maximum	Average
Wolella	1900	2800	2300

Sensory Evaluation

Sensory evaluation result of incorporating sweet lupin flour (SLF) into wheat flour (WF), field pea flour (FPF) to make Biscuit, kukis, snaks, bread, stew roasted lupin and boiled lupin for the acceptability of the product was shown (figure 1). The results of sensory evaluation indicated that the incorporation of 25% of SLF to the biscuit was more accepted by the panelists than 50% SLF substitution for the biscuit. The acceptability of the bread baked from 25% SLF blended with 75% wheat flour was rated excellent by the panelists. In contrast**,** for stew, the mixture of 50% SLF with 50% FP flour and 100% SLF alone had no any difference in acceptance among the panelists. The result in figure 1 showed that boiled and roasted sweet lupin grain was not accepted by the evaluators as a food recipe. The evaluation of sweet lupin under field and lab condition by women farmers and researchers has been presented in Figures 1.



Nutritional quality

Legumes provide a range of essential nutrients including protein, low glycaemic index carbohydrates, dietary fiber, minerals and vitamins. Legumes are uniquely rich in both protein (17%-20% dry weight in pea and beans, 38%-40% in soybean and lupins) and dietary fiber (5%-37% dry weight) FAO, 2014. On the other hand the protein content of cereals varies from 7%-13% respectively. Specifically sweet lupins have one of the highest combinations of both protein (38% dry weight in lupin splits) and fiber (30% dry weight + 5% inulin in lupin splits) of all the pulses and of all plant foods. Lupin also contains low amount of carbohydrate (6-10% compared to other legumes (35-50%) and grains (65%) FSANZ, 2015. Sweet lupin has high protein content, approximately 38% of its weight in lupin splits. Lupin is a good source of arginine (3.6 g/100 g) but contains lower levels of sulphur-containing amino acids such as cysteine (0.4g/100 g) (Antigone and Regina, 2016).

The analysis of macro- and micronutrient composition of sweet lupin and field pea were given in Tables 2 and 3. Based on a comparison of sweet lupin seed nutrient composition with that of field pea, sweet lupin seed has a potential as human food and livestock feed. For example, sweet lupin had higher protein content than field pea grain. According to the analysis result, the protein content of sweet lupin varied from 30% - 35% with a mean of 31.6%, while field pea seed has a protein content of 22.32% (Table 2). Sweet lupin seed also had a fat content of 8.3% compared to a fat content of 3.6% for field pea. Sweet lupin food recipe of flour for stew, boiled and roasted sweet lupin had protein contents of 34.65, 30.22, and 30.12%, respectively, and fat contents of 7.75, 8.35, and 3.6%, respectively.

The results of the micronutrient composition also indicated that sweet lupin grain had the highest mineral contents of 8.0, 21.0, 69.0 mg/100g for zinc, iron and calcium, respectively, whereas, field pea had the highest contents of potassium (224 mg/100g) and sodium (20 mg/100g) (Table 3).

Health benefit

Recently the effect of consuming sweet lupin on cardio-metabolic parameters have been explored and reviewed in both human and animal studies (Arnoldi etal, 2015). Pharmaceutical and nutraceutical companies regard some lupin components as strategic molecules for prevention and possibly even therapy of various pathological states including the metabolic syndrome (a collective name for a simultaneous occurrence of abdominal obesity, increased triglyceride level, decreased HDL cholesterol concentration, hypertension, and hyper glycaemia (fasting), which is typical of rich countries and is included in the so-called civilization diseases (Duranti 2006). Further evidence from long-term human studies in those with metabolic syndrome such as the obese, insulin resistant/type 2 diabetic, hypercholesterolaemic and hypertensive is now required to substantiate the metabolic benefits of lupin consumption (Hodgson et al. 2015).

More recent studies by different Scholars have also shown that legumes included in an energy controlled diet resulted in significant reductions in weight compared to diets without legumes (McCrory, 2010). Li et al in his studies of Dietary pulses, satiety and food intake: a systematic review and meta-analysis of acute feeding trials observed that healthy people felt 30% fuller after eating about 160 gram legumes compared with an energy matched control meal. Having the benefit of consuming lupin for health, it has a short-time effect on satiety (appetite suppression) and on the energy intake. Lee et al. 2006 reported that bread enriched with lupin seed meal may decrease appetite for a short time and, compared to white bread, the plasmatic response of ghrelin changed considerably, which was in accordance with the observed short-time effect on satiety and energy. Archer et al. 2004 study also showed that incorporation of lupin seed fiber in processed foods resulted in the feeling of satiety for a period of up to 4.5 h after eating and in approximately 15% lower energy intake during the tested day.

Farmers' opinion about the technology

The feedbacks collected during the field evaluation from the participants about the demonstrated technology were positive. During the demonstration of sweet lupin varieties, farmers provide constructive feedback for further research on sweet lupin varieties. Farmers appreciated the technologies based on its important merits such as acid soil tolerance, its serves as a rotation crop for soil fertility maintenance, preparation of different food recipes, and its use as feed for animals. Farmers also observed that sweet lupin has been found to be relatively better in frost tolerance than faba bean and field pea. From the sensory evaluation test, it is possible to conclude that sweet lupin seed can be used for both traditional stew preparation and as a protein supplement in the diets of cereal dominated areas.

Conclusion and recommendation

This demonstration study has shown that sweet lupin technology appear better suited to small holder farmers in areas that are affected by soil acidity and production of faba bean and field pea was constrained by diseases and insect pests. Sweet lupin a legume crop with the highest natural combined source of protein and dietary fiber and lowest levels of anti-nutritional factors, making the protein and its nutrients more bioavailable and due to low level of antnutritional factors they do not require heat or chemical treatment. Consumption of sweet lupin is a usual and beneficial part of the human diet and contributes to health. It has been demonstrated to have a favorable impact on blood lipids, blood pressure, insulin sensitivity and the gut micro biome.

Farmers showed an interest and demand were created by the farmers on the demonstrated area to use sweet lupin. To enhance sweet lupin technologies, specific training should be provided on crop production and management, food preparation and health benefit for farmers, agricultural experts and development agents. Therefore, in order to disseminate sweet lupin technology to a wide area, further demonstration and popularization is paramount importance.

Table 2. Protein and fat composition of sweet lupin (*Wolela Variety*) recipe compared to field pea variety (*Bursa*)

Recipes and grain	Protein content	Fat content
1.*Shero*	34.65 ± 0.00[a]	7.75 ± 0.07[b]
2.*Nefro*(cooked food)	30.22 ± 0.035[c]	8.35 ± 0.07[a]
3.*Kolo*(Roasted Food)	30.12 ± 0.17[c]	8.5 ± 0.14[a]
4.Sweet Lupin grain	31.65 ± 0.00[b]	8.3 ± 0.00[a]
5.Bursa (Field pea variety)	22.32 ± 0.00[d]	3.6 ± 0.00[c]

Table 3. Micronutrient (Zn, Fe, Ca, K and Na (mg/100g) composition of sweet lupine (*Wolela variety*) recipe compared to field pea variety (*Bursa*).

Recipes and grain	Zinc (mg/100g)	Iron (mg/100g)	Calcium (mg/100g)	Potassium (mg/100g)	Sodium (mg/100g)
1.*Shero*	9.5 ± 0.002[ab]	3.5 ± 0.005[c]	27 ± 0.0014[e]	82 ± 0.75[b]	2.5±0.0021[b]
2.*Nefro*	12.0 ± 0.0014[a]	21 ± 0.012[b]	94 ± 0.0014[a]	18 ± 0.002[b]	1.4 ± 0.007[a]
3.*Kolo*	9.0 ± 0.0014[ab]	20 ± 0.006[b]	78 ± 0.0035[b]	29 ±0.00[b]	2.5±0.00071[b]
4.Sweet Lupine grain	8± 0.00[bc]	21 ± 0.00[b]	69 ± 0.00[c]	29 ± 0.00[b]	1± 0.00[b]
5.Field pea (Bursa)	5 ± 0.00c	5.2 ± 0.00[a]	34 ± 0.00[d]	224 ±0.00[a]	20±0.00[a]

Source Biadge, 2018

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