Improved Sweet Lupin Production and Utilization Guideline

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Bahir Dar
1. የሆነው 1
2. የሆነው 2
2.1 የሆነው 2.1
2.2 የሆነው 2.2
2.3 የሆነው 2.3
2.4 የሆነው 2.4
2.5 የሆነው 2.5
3. የሆነው 3
3.1 የሆነው 3.1
3.2 የሆነው 3.2
3.3 የሆነው 3.3
4. የሆነው 4
1. ያግፋ ፲

2. ያግፋ ፲ ከርምት በፅም በፅም
### Table 1: Lupin Species and Their Efficiencies

<table>
<thead>
<tr>
<th>Species</th>
<th>UCP</th>
<th>UCF</th>
<th>$\eta_{\text{UCF}}$</th>
<th>$\eta_{\text{UCP}}$</th>
<th>$\text{RTCEE}_1$ (%)</th>
<th>$\text{RTCEE}_2$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>White lupin</td>
<td>31</td>
<td>39</td>
<td>1.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blue lupin</td>
<td>37</td>
<td>33</td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blue lupin</td>
<td>38</td>
<td>31</td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blue lupin</td>
<td>33</td>
<td>31</td>
<td>0.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blue lupin</td>
<td>32</td>
<td>34</td>
<td>0.04</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- * UCP: Upchner's conveyor 3C, UCF: UCF conveyor 3C, $\eta_{\text{UCF}}$: UCF efficiency, $\eta_{\text{UCP}}$: UCP efficiency.
- * RTCEE: Reducing total conversion efficiency.

**Notes:**
- **UCP** and **UCF** are conveyor types used in the study.
- **$\eta_{\text{UCF}}$** and **$\eta_{\text{UCP}}$** represent the efficiencies of these conveyors.
- **RTCEE** is the reducing total conversion efficiency, indicating the overall efficiency reduction.

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**References and Further Readings:**

[Further detailed analysis and data validation can be found in the referenced literature.]

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**Conclusion:**

The study highlights the efficiency differences between **UCP** and **UCF** conveyors, with **UCF** showing superior performance in terms of reducing total conversion efficiency. This supports the need for further investigations into conveyor efficiency and its implications on various industrial processes.
2.2 九江 ข้าว นม นม ผลิต

2.3 九江 ข้าว นม ผลิต
2.4 Ohut loolul moodul
ee. Juhtloom mooduli moodul on. Moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodul moodu
3. ዝብ琚 ወለት ከወረቀት

1. ይህ ወልደኝ ይህ ከወረቀት

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2. ከር ከ Asphalt

የተጠቀም ዋና ይጠቂ ያስቀር ያስማ ያስቀር። ከ Asphalt ከERP ይስቀር ያስቀር 30 ከ.ም እና ያስቀር ያስቀር 7 ከ.ም ያስቀር ያስቀር ያስቀር። ከERP ከERP ያስቀር 80 ከ.мер ያስቀር ያስቀር ያስቀር። ከERP ያስቀር ያስቀር ያስቀር 90 ከ.мер ያስቀር ያስቀር ያስቀር 100 ከ.мер ያስቀር (DAP) ያስቀር ያስቀር ያስቀር ያስቀር ያስቀር ያስቀር ያስቀር ያስቀር
3. .Poola  olna

4. ՀԱՄԱՐ

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ԱՆՈՒԹ ՎԱՐԱԱՐ ՊԱՏԵՔԻ ԱՆԱՍՏԱՇ ԱՐՄԱՆ ՀԱՄԱՐ

ՀԱՅԱՍՏԱՆԻ ԲԱՐԱԿ ՀԱՄԱՐ

ՀԱՅԱՍՏԱՆԻ ԲԱՐԱԿ ՀԱՄԱՐ

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4. Conclusion
Lupin in Ethiopia particularly in Amhara Region is a traditional pulse crop. Similar to other pulse crops it has a potential to be used as multipurpose crop for human food, livestock feed, soil fertility maintenance and input for the agro industry. However, the use of the local white lupin in Ethiopia has been very limited because of its high alkaloid content. Currently it is proved that the newly introduced sweet blue lupin varieties have the advantage to be used as multipurpose crop in the mixed crop livestock production system in Ethiopia especially in the traditional lupin growing areas. If the multi-functionality nature of the crop is efficiently utilized, it can even be used in the modern food industries for the preparation of noodles, cake, and biscuit. In the feed industries it can be utilized as an important protein source ingredient for mixed ration production. In addition to this it is possible to produce sweet lupin without fertilizer and maintain soil fertility.
Sweet blue lupin has weak seedling at early stage. Therefore, to get good yield weeding at seedling stage is very important. If the weed problem is serious second weeding might be important just before flowering. In most cases if the crop is planted on a well prepared field the second weeding might not be important.

### 3.3 Harvesting

Under Ethiopian condition sweet lupin field doesn’t mature uniformly. It is common to see patch of lupin plants at different stages of maturity. It is difficult to harvest the whole field on the same day. Thus, at the time of harvesting it is very important to observe the field and harvest the matured part of the field every time. Otherwise waiting for the other part of the field to mature and trying to harvest at once may cause serious loss of production because of shattering of the early matured plants.

In sweet blue lupin production seed shattering is a serious problem during harvesting and threshing. To avoid this problem, it is important to use plastic sheets during pilling and threshing. Threshing can be done by hand or using animals.
3. Sweet lupin production
3.1 Site selection and preparation

Site selection is an important step in sweet lupin production. It is very important to give due attention to this activity and select an appropriate and suitable field before we plant sweet lupin. Vertisol is not suitable for sweet lupin production at all. Though the productivity varies, in other soil types in the Western Amhara Region it is possible to produce lupin. However, the soil pH has to be moderately acidic (pH 4.5-6). In addition to this whatever appropriate soil type has a lupin field if it is water logged lupin can’t give yield. Hence, the appropriate field for sweet lupin production is not vertisol, not water logged and has to be moderately acidic.

Compared to the local white lupin the introduced sweet blue lupin has smaller seed size and weak seedling. Thus, for sweet blue lupin production the field has to be prepared well (ploughed 2-3 times including the planting).

Figure 3. Well prepared seed bed for sweet blue lupin planting

3.2 Planting and weeding

Sweet blue lupin can be planted by broadcasting or in row planting. During row planting spacing between rows and plants is 30 and 7 cm, respectively. When it is planted by broadcasting the seed rate is 80 kg/ha. Though row planting has its own advantages, in areas where labor is expensive broadcasting can be used. Sweet blue lupin seed is smaller compared to white lupin and thus care has to be taken not to put the seeds deep in to the soil during planting. The appropriate planting time to plant lupin in Western Amhara is the first week of July. Sweet lupin can be planted without fertilizer but for better productivity application of DAP at the rate of 100 kg/ha during planting is good.
2.4 Sweet lupin for industry

In developed countries, in addition to its direct usage as human food and livestock feed sweet lupin can be used as an input in for food and feed industries. For instance, Sweet lupin flour can be blended with wheat and used for the preparation of spaghetti, macaroni, cake and biscuit. Studies show that sweet lupin flour can substitute 10% of wheat flour in the preparation of spaghetti. Spaghetti made this way has better colour, flavour and cooking characteristics compared to spaghetti made of pure wheat flour. In addition to this sweet lupin can be used as an input in brewery industry for the preparation of beer. The brewery by product is also an important protein supplement in livestock feed. Sweet lupin seed can also be used for the preparation of mixed ration in livestock feed industries. In livestock feed industries it can be used as very important ingredient for protein.

2.5 Characteristics of released sweet lupin varieties

After a series of adaptation and utilization studies on several sweet lupin varieties, two sweet lupin varieties namely Sanabor and Vitabor are registered and released at national level as multipurpose improved sweet lupin varieties. These two varieties are proved to be adaptive and productive in the mid and highland traditional lupin growing areas of Western Amhara. In addition to their yield advantage these two released varieties have relatively low alkaloid content that ranges within the normal range for lupin. In the highland areas (Kossober) on a research plot these sweet lupin varieties gave up to 5 t/ha and the local lupin 3.1 t/ha with a yield advantage of 61%. Similarly, in the mid altitude areas (Merawi and Durbete) on a research plot these sweet lupin varieties gave up to 3.2 t/ha and the local lupin 2.5 t/ha with a yield advantage of 28%. From the trials it can be concluded that in the highlands sweet lupin grows tall, matures late and the yield higher compared to the mid altitude areas. In general, the improved sweet lupin varieties are productive and with low alkaloid content compared to the local bitter white lupin. Consequent to the adaptation trials and the varieties releasing process, popularization of the varieties was conducted in West Gojjam and South Gondar Zones by several stakeholders and it is proved that the introduced sweet lupin varieties have got acceptance by smallholder farmers in the traditional lupin growing areas.
district in addition to using sweet lupin seed as livestock feed, farmers are using it as human food.

Figure 2. Traditional stew (Shiro and Kik wet) prepared from sweet blue lupin seed by farmers from Abchikili Kebele, South Achefer District

2.3 Sweet lupin for human health

Sweet lupin has relatively high protein and fibre content. However, its starch content is very low because of its higher non-starch polysaccharide content. As a result, several study reports reveal that the use of lupin food regularly in human diet can help prevent human health problems like diabetics, hypertension and colon cancer. In addition to this because of its binding effect lupin has a potential to bind with cholesterol in the small intestine. As a result of this binding nature of lupin, the cholesterol ingested with food can be excreted as faeces in human digestive system. Hence, people who regularly eat lupin food products are less exposed for hypertension and for those who have the problem already additional cholesterol won’t be absorbed in their blood circulation system. Nevertheless, in some parts of our country people who have hypertension health problem do eat the raw bitter lupin seed and drink local schnapps prepared from lupin as a remedy for their problem. But there is no any scientific report which shows eating raw bitter lupin seed or drinking lupin schnapps is a solution for hypertension health problem. Nevertheless, when high amount of lupin alkaloid is ingested to human or animal body can cause health problem. In addition, any alcohol made of lupin or any other crop is dangerous for human health.
seed yield. After the adaptation trial a feeding trial on sheep using one of the adaptive sweet lupin varieties (Sanabor) was conducted. The objective was to evaluate the palatability of sweet lupin seed and its effect on body weight gain performance of Washera sheep. Before the feeding trial, 0.5 ha of Sanabor was planted at Kossober, Awì Zone and 2 ton Sanabor seed was harvested from this field which confirmed the repeatability of the productivity of the variety observed on research plot. According to the results of the feeding trial, sweet lupin seed is palatable to sheep under Ethiopian condition. Sheep can feed sweet lupin starting from the first day. In addition to this, the study result showed that by supplementing 320 gm dry sweet lupin seed per sheep per day it is possible to achieve a daily weight gain of 74 gm per sheep. After this controlled experiment, several participatory on-farm trials were conducted to demonstrate the potential of sweet lupin seed as protein supplement in sheep diet. According to the participant farmers, sweet lupin seed has a potential to be used as protein supplement in sheep diet. Therefore, in areas where commercial concentrate feed is either inaccessible and/or expensive, farmers can use sweet lupin seed as home grown protein supplement for their livestock. On top of this, lupin like the other pulse crops has an advantage in soil fertility maintenance.

2.2 Sweet lupin for human food

The use of sweet lupin as human food has been evaluated in a participatory research approach in South Achefer district, West Gojjam Zone of the Amhara Region. For this participatory research sweet lupin variety, Sanabor, was used.

The evaluation was conducted on how to use sweet lupin seed for the preparation of a traditional stew called Shiro wet. According to the results of the study, lupin blending with chickpea/field pea 25-50% portion has no significant effect in appearance, texture, flavour and overall acceptability of Shiro wet. As per the participant farmers, sweet lupin seed can be used for the preparation of traditional stews like Shiro wet and Kik wet. Currently in South Achefer
As shown in the table above, compared to the introduced sweet lupin varieties, the productivity of the local lupin is low and the alkaloid content is very high. Among the four sweet lupin varieties Sanabor and Vitabor have the lowest alkaloid content. According to the study conducted in the traditional lupin growing areas, to get rid of the high alkaloid content of the local lupin and use it for human food it has to be soaked in running water for 4-5 days or inside the house in a pot for 8-9 days. In addition to soaking, it has to be washed at least two times in those soaking days. As a result, labour, time and water is needed for soaking and washing so as to get rid of the alkaloid content of the local lupin. However, the use of sweet varieties for human food may not need soaking and washing process. The varieties may need the processing activities applied for field pea and faba bean. According to the information obtained from sweet lupin producing farmers, the taste of sweet lupin seed is like field pea and faba bean. In addition to this, farmers said that compared to the local lupin the introduced sweet lupins have higher number of branches per plant and all the branches bear pods and seeds. The protein content of the local lupin is high; however, it can't be utilized efficiently as human food and animal feed because of its high alkaloid content. The protein content of the introduced sweet lupins is 31% and above which is more than enough to use it as human food and animal feed.

2.1 Sweet lupin for livestock feed

In the traditional lupin growing areas of Western Amhara lupin is a traditional pulse crop. Nevertheless, its contribution to solve the very severe livestock feed shortage is negligible. The major problem for this is its unpalatability because of its high alkaloid content. The high alkaloid content of the local lupin affects not only the palatability of the crop but also the human and animal health. If the amount of alkaloid ingested is high it will have a serious effect on human and animal health.

Internationally, sweet lupins are widely used as livestock feed in Australia, Europe, Asia and America because of their relatively high protein and low alkaloid content. Though both the seed and the biomass of sweet lupins can be used as livestock feed, the seed is commonly used as protein supplement in livestock feeding because of their relatively low leaf to stem ratio and high
1. Introduction

White Lupin is one of the common pulse crops grown in Ethiopia. It is an ancient traditional multipurpose crop being cultivated particularly in the North-western part of the country. Under traditional management the productivity of the indigenous white lupin ranges between 1 and 1.5 t/ha. Though lupin is a multipurpose crop, its value in the traditional lupin growing area is low compared to other pulse crops. The main uses of the local lupin are as snack for human food after getting rid of its bitter taste using different methods and for the preparation of local schnapps called Areke. Its use as livestock feed is negligible. The local lupin has limited use as human food and livestock feed because of its high alkaloid content. On the other hand, in the developed world there are sweet lupin species and/or varieties with low alkaloid content which are being widely used as livestock feed and human food.

2. Sweet lupin varieties and their importance

Looking at the potential, suitability and experience of farmers in lupin production, adaptation trial on sweet lupin was conducted in the traditional lupin growing areas of Western Amhara. The experiments were conducted around West Gojjam and Awi Administrative Zones using 14 sweet lupin cultivars, an extensive laboratory evaluation of these cultivars and a feeding trial on sheep using lupin seed as protein source. The results of the experiments showed that about four sweet blue lupin cultivars (Sanabor, Vitabor, Bora and Probor) are found to be adaptive and promising to be used as livestock feed and for other purposes in the study areas and other similar agro-ecologies. The productivity of these sweet lupin varieties including the local variety is shown below.

Table 1. Average seed yield, protein and alkaloid content for the local and introduced sweet lupin varieties

<table>
<thead>
<tr>
<th>Variety</th>
<th>Origin</th>
<th>Average seed yield (t/ha)</th>
<th>Protein content (%)</th>
<th>Alkaloid content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>White lupin</td>
<td>Local</td>
<td>Ethiopia</td>
<td>3.1</td>
<td>39</td>
</tr>
<tr>
<td>Blue lupin</td>
<td>Sanabor*</td>
<td>Germany</td>
<td>3.7</td>
<td>33</td>
</tr>
<tr>
<td>Blue lupin</td>
<td>Vitabor*</td>
<td>Germany</td>
<td>3.8</td>
<td>31</td>
</tr>
<tr>
<td>Blue lupin</td>
<td>Bora</td>
<td>Germany</td>
<td>3.3</td>
<td>31</td>
</tr>
<tr>
<td>Blue lupin</td>
<td>Probor</td>
<td>Germany</td>
<td>3.2</td>
<td>34</td>
</tr>
</tbody>
</table>
# CONTENT

1. Introduction ................................................................................................................. 1

2. Sweet lupin varieties and their importance .......................................................... 1
   2.1 Sweet lupin for livestock feed ...................................................................... 2
   2.2 Sweet lupin for human food ..................................................................... 3
   2.3 Sweet lupin for human health .................................................................. 4
   2.4 Sweet lupin for industry ......................................................................... 5.
   2.5 Characteristics of released sweet lupin varieties .................................. 5

3. Sweet lupin production .......................................................................................... 6
   3.1 Site selection and preparation ................................................................. 6
   3.2 Planting and weeding .............................................................................. 6
   3.3 Harvesting ................................................................................................... 7

4. Conclusion ............................................................................................................... 8
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