Turkish Journal of Agriculture - Food Science and Technology, 10(6): 1165-1173, 2022
DOI: https://doi.org/10.24925/turjaf.v10i6.1165-1173.4998

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X | www.agrifoodscience.com | Turkish Science and Technology Publishing (TURSTEP)

Opportunities and Challenges for Market Oriented Lupin (*Lupinus spp.*) Production in Ethiopia

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ARTICLE INFO

Research Article

Received : 23/12/2021
Accepted : 20/06/2022

Keywords:
Feed Industry
Feed Shortage
Lupin Grain
Market Segment
Pulse Crops

ABSTRACT

Over recent years, the demand for livestock products in Ethiopia is increasing; most of this demand is coming from urban centers, especially from Addis Ababa, as the buyers are demanding better quality and more hygienic produce. This has fueled interest in better quality animal feed, mainly from larger-scale commercial livestock producers. With this background, there has been interest in stimulating plant-based protein production that can be incorporated into livestock feed. Small quantities of lupins are grown (less than 20,000 ton per year) in the North Western part of Ethiopia for human consumption. These lupins are bitter due to their alkaloid concentration and are unsuitable for livestock feed. If non-bitter (sweet) varieties are grown, then they could be a source of protein for animals as is the case in some countries, such as Australia. The Ethiopian market for livestock feed was surveyed and segmented to evaluate the opportunities for lupins. The survey revealed that the livestock sector in Ethiopia is suffering from feed shortage both in terms of quality and quantity. Lupin, as a potential protein source feed has an opportunity to be incorporated into the livestock feed industry. Currently it is estimated that if sweet lupins were available, the short-term demand from commercial livestock producers and feed processors market segment is 20,000 t/year. In the medium-term, it is expected that as the national poultry production expands, there will be an increased demand from the large feed mill factories to around 35,000 to 40,000 t/year grain for high quality protein such as lupin. It is recommended that the already started sweet lupin promotion in the country has to be done at scale. In addition, production of sweet lupin in Ethiopia should be focused on the commercial farming sector and the marketing should be through the large-scale processors or direct to large-scale livestock producers.

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Introduction

Ethiopia has the largest livestock population in Africa with an estimated 70 million cattle, 95 million sheep and goats, and 57 million chicken (ECSA, 2021). Crop production in the country relies heavily on animal power. Livestock and livestock products also play significant role in nutrition, income generation, food security at the household level and in national domestic products and foreign currency earnings.

Though the country has huge livestock resource, productivity is disproportionately low. Shortage of good quality feeds (especially those high in protein), absence of commercial level fodder resources development, limitations in acquiring adequate supply of concentrate feedstuff of desirable quality and quantity and unavailability of drugs and limited veterinary services have hampered the development of the livestock industry in the country. With the current change in government policies, liberalization and encouragement of the private sector to participate in the development of almost all aspects of the national economy, there should be opportunities for growth and improvement of the livestock sector.

To solve the feed shortage problem it is very important to utilize the available huge roughage feed through strategic supplementation with concentrate feeds. Currently the price for commercial feed in Ethiopia is increasing and in areas where the price is relatively good, access to get it is a serious problem. This is primarily associated with the limited oil crop production and the

subsequent shortage of oil meal by-products as protein source feed input in the production of commercial concentrate feeds in the country. Lupins have a number of positive attributes that could make them a very sensible crop for Ethiopian farmers. They are Legumes that fix atmospheric nitrogen and leave a legacy for the following crop reducing the fertilizer that needs to be applied in the following season (Yeheyis et al. 2010). They are suited to a wide variety of soil types and climates, including land that is very acidic and of limited use for other crops. They are more resilient to drought than many other protein crops such as soybean and are expected to survive dry spells during the rainy season. They are relatively free of diseases, easy to grow, the pods do not shatter and they require no specialized harvesting of planting equipment. The main benefits to be gained from sweet lupin production for livestock will be the improvement in animal nutrition. It is the only crop that can replace soya as a primary protein source for all classes and species of agricultural livestock. In Australia, it is the primary source of protein for its sheep, beef and dairy industries. In Chile, much of the feed for their salmon industry is based on lupins. Sweet lupin has very high protein content with a very good amino acid profile which makes it an ideal protein supplement in livestock feed (Yeheyis et al., 2012a).

Relatively small amounts of white lupin (*Lupinus albus* L.) are grown (about 20,000 ha) in Ethiopia; it is a traditional multipurpose crop found mainly in the North-western part of the country. The crop is known as a very easy crop to grow with a relatively high yield and minimal agronomic practice. It grows from the warm mid-altitude areas of South Gondar up to the cool and humid high-altitude areas of West Gojjam. The ability of the crop to be grown in acidic soils is one of the major important features of the crop in the traditional lupin growing area of Ethiopia (Yeheyis et al. 2010). However, this traditional pulse crop has low food value and unpalatable to livestock due to its high alkaloid content (Yeheyis et al., 2011a; Yeheyis et al., 2012a). To improve the overall value of the crop sweet lupin species with very low alkaloid content which are suitable for both human food and livestock feed were introduced and the adaptability of varieties was evaluated in Ethiopia (Yeheyis et al., 2012b; Alemu et al., 2018; Riga et al., 2021 and Tarekegn, 2016). In addition, for wider dissemination and utilization of these varieties two sweet blue lupin (*Lupinus angustifolius* L.) varieties namely Sanabor and Vitabor have been officially registered for wider use in Ethiopia (Yeheyis and Mekonnen, 2022). Since the introduction of these new sweet lupins to Ethiopia in 2009 a series of on-farm demonstration and promotion has been made by different institutions. Promotion of the adaptability, productivity, feeding and food value of sweet lupins has been done by Mekonnen et al. (2015); Yeheyis et al. (2015) Haile et al. (2017), Yeheyis et al. (2012c) and Assefa (2021). Though lupin is a very important input for livestock feed industry globally, the varieties introduced in Ethiopia are not utilized by the feed industry and are still in the hands of smallholder farmers being cultivated in small plots. Hence, this research work aimed at showing the different market segments for lupins in Ethiopia, estimating the size of market opportunity, projects likely selling prices and develops a market strategy for expanding the crop.

Methodology

The data for this research work was collected from various sources in 2018. Different livestock business owners, feed processsors, individual smallholder farmers, different association chairs were interviewed and secondary data sources were used. As our target is to promote and introduce sweet lupin to both small holder and commercial livestock farmers, the study has targeted both category of farmers. Hence, during data collection about eighteen commercial livestock producers were interviewed as key informants in the central Ethiopia and traditional lupin growing areas. In Ethiopia it is estimated that there are about eighty-one commercial feed processers who are engaged in compound livestock feed processing business (Bediye et al. (2018), Among these forty-nine enterprises are found in and around Addis Ababa (Bediye et al. (2018). From these and in the northwestern part of the country where lupin is traditionally cultivated twenty-three were included for the key informant interview and discussion. In addition to this the Ethiopian national feed producers association chair, Ethiopian poultry producers association chair were interviewed. The key informant interview was conducted using checklists for the interview. Cost of production for lupin under smallholder farmers' condition was calculated based on the information obtained from lupin producing smallholder farmers and researchers. For this data collection a total of twenty-six smallholder farmers and five researchers were interviewed. In addition to this, field visits to commercial livestock farms and feed processing plants around Addis Ababa and smallholder farmers' lupin fields in five traditional lupin growing administrative zones of North-western Ethiopia were made. Finally conclusions and recommendations were made through an in-depth respective sector analysis of the collected data.

Result and Discussion

The Ethiopian Livestock Sector

Total meat production is more than 600,000 t/year carcass weight equivalent (cwe), more than half is beef followed by sheep and goats (Figure 1. Gira, 2016). Livestock, like all agricultural production, is overwhelmingly in the hands of small-scale farmers; large-scale commercially focused production, whilst increasingly important, is still very under-developed. In fact, in the rural areas, the main aim of livestock production by smallholder farmers is for traction and immediate cash income source. Therefore, given the low levels of consumption in rural areas, the limited market-orientation and poor institutional support, productivity remains low. This situation is more exacerbated by drought and diseases. Given the lack of focus on commercial livestock production, it is difficult to promote improved feed to small-farmers, especially if it is more costly than alternative sources.

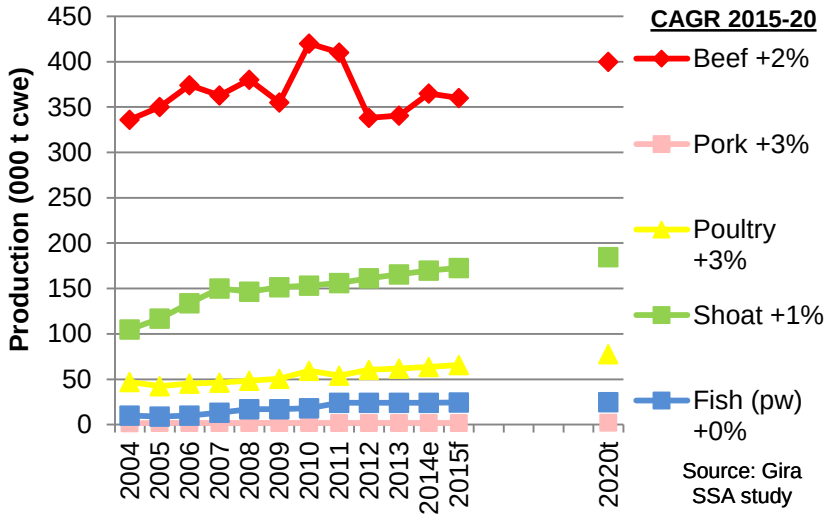

Figure 1. Meat production in Ethiopia by species, 2004 to 2015 ('000 t, cwe)
Source:- Gira (2016), CAGR=Compound Annual Growth Rate, cwe= carcass weight equivalent, data for 2016-2019 was not available but there was data for 2020

The major growth driver for meat arises from the increasing demand from urban centres; this driver will tend to favour peri-urban production with their cheap logistics for accessing the main towns. For instance, there has been a significant increase in milk production just north of Addis Ababa and a cluster of poultry production is becoming established in and around Debre Zeit, which has good road links to the capital city (ECSA, 2021; ECSA, 2020). But in the short to medium-term, commercially focussed operations will represent a small portion of the industry.

Over the past decade, sheep and goat production registered the strongest growth rate, followed by poultry meat. However, the growth in beef production was much stronger up to 2010 but then fell sharply in 2012 and has remained rather flat since. Pork production is and will remain marginal for cultural reasons. Future Compound Annual Growth Rates (CAGR) could be strongest in beef, but that would merely mean a return to those peak levels of 2010/11. Sheep and goat production should continue to grow but at a lower rate, while poultry meat output will maintain a 3% CAGR.

All the indicators suggest that livestock productivity will increase and this will lead to an increasing demand for feed. Traditionally, increases in animal population have traditionally been based on small-scale production where purchased inputs are minimal. However, in the future it is expected that there will be increased commercial production, admittedly from the current low level.

The Ethiopian Livestock Feed Industry

Currently, the main sources of animal feed are the natural pasture and crop residues. In fact, the use of purchased feeds and other inputs by smallholder farmers is very limited or non-existent (Tolera, 2008). The few more commercially focussed operators tend to use agro-industrial by-products such as flourmill by-products, oil seed cakes, brewery spent grains and molasses.

Grain production accounts for nearly 80% of the cultivated land, but yields are very low. It is claimed that poor yields are due to the country's rugged topography, small landholdings, limited mechanisation as well as insufficient supplies of fertilizer and a shortage of improved seed. Most grain produced is for human consumption and only a small portion goes to the livestock sector (presently less than 10% of maize production, and much less for other grains). However, in the future, it is expected that more maize and soybean will be grown for animal feed, probably by the more commercially focused livestock farmers who will grow their own feed, or contract it out to other commercial farmers.

The commercial livestock feed industry consists of 32 privately owned companies and 25 owned by unions. Most of the union owned factories are supported by the USAID (United States Agency for International Development) financed by the FEED (Feed Enhancement for Ethiopian Development) project. The largest privately owned feed mill (Alema Koudis Feeds) produces about 5,000t/month of livestock feed whilst the fourth biggest (Kality Animal Food Enterprise) only produces about 480t/month. The majority of the union-owned mills each have a capacity of 176t/month, but are only operating at about 30% efficiency. It was calculated that the Alema Koudis factory uses about 15,000t/year of oil seed cake, mainly soya), whilst Kality Animal Food Enterprise uses about 1,200t/year of cake (about 360t/year of soya and the rest is mainly noug cake). It was reported that all the union-owned mills use about 3,600t/year of oil seed cake, the vast majority being the cheaper cakes such as noug. In addition to the formal manufacturers of animal feed, many livestock farmers buy the ingredients and mix their own animal feed.

Ethiopia's Production of Oilseed and Pulse Crops

Ethiopia has about 12.57 million ha of cultivated land; about 10.22 million ha are planted with cereals, 1.55 million ha with pulse crops, 0.80 million ha with oil seed crops and the balance to horticultural and other cash crops (ECSA, 2017). Even though beans and peas can be used as an animal feed, in Ethiopia they are almost entirely used for human consumption (Table 1). Lupin (Gibto) is grown on almost 20,000ha and production is 27,400t, so compared to the other pulse crops grown in Ethiopia, it is a very minor. It is interesting to compare gibto to soya, which is grown on almost double the area and achieves considerably higher yields. In many other countries, lupin crops reportedly give higher yields than soya; but most of Ethiopia's soya crop is grown by larger more commercial farmers who probably use better technologies and therefore get better yields.

Table 1. Area & production of pulse crops in Ethiopia, 2016/17 Meher season (Jun. to Nov.)

Crop	Area (ha)	Total production (t)	Yield (t/ha)
Faba beans	427,697	878,011	2.05
Chickpeas	225,608	444,146	1.97
Field peas	212,531	348,145	1.64
Red haricot	211,292	357,942	1.69
Grass peas	151,269	297,097	1.97
Lentils	113,685	166,274	1.46
White haricot	78,910	125,980	1.6
Mung beans	37,774	42,916	1.14
Soybeans	36,636	81,237	2.22
Gibto (Lupin)	19,907	27,407	1.38
Total pulses	1,549,912	2,814,633	

Source:- ECSA (2017)

Table 2. Area & production of oil seeds in Ethiopia, 2016/17 Meher season (Jun. to Nov.)

Crop	Area (ha)	Total production (t)	Yield (t/ha)
Sesame	337,927	267,867	0.79
Noug	281,206	302,432	1.08
Linseed	80,354	87,912	1.09
Groundnuts	74,861	129,636	1.73
Rapeseed	23,666	43,402	1.83
Sunflower	6,738	7,954	1.18
Total oilseeds	804,752	839,202	

Source:- ECSA (2017)

Table 3. Potential production of oilseed cake from 2016/17 Meher season (Jun. to Nov.)

Crop	Seed production (t)*	% cake	Total cake (t)
Noug	302,432	60%	181,459
Groundnuts	129,636	60%	77,782
Linseed	87,912	60%	52,747
Rapeseed	43,402	60%	26,041
Sunflower	7,954	60%	4,772
Total cake			342,801

*Source:- ECSA (2017)

Ethiopia's oil seed production is dominated by sesame followed by noug (Niger seed), linseed and groundnuts (Table 2). The sesame is mainly grown for export and very little is processed in Ethiopia, while the other crops are grown for their oil. The oil is extracted from the seed and the resulting cake is often used as an animal feed; as it contains protein and some residual oil. Crude protein levels of noug cake are quoted as 23 to 30% (plus about 8% oil), sunflower and rapeseed have 34% and 36% protein with 14 and 13% oil respectively. However, the quality of the protein for animal feed in these oil seed cakes varies enormously, a fact that is reflected in the cakes selling prices.

In Ethiopia, the by-product from processing noug seed is about 60 to 75% cake; this does depend on the oil content of the seed and the efficiency of the factory. If the lowest figure is assumed and all the noug seed grown is processed, the total tonnage of noug cake produced would be 181,000t in 2016/17 (Table 3). If the same assumptions are made for the other oil seed crops, it can be argued that the total amount of oil seed cake produced in Ethiopia is about 343,000t (Table 3). This does assume that all the oil seed grown is processed, but some is exported and some will not be processed. The Ethiopian Animal Feed Industry Association (EAFIA) quotes that in 2010, the total annual production of oilseed cake was 141,132t with 56,400t coming from noug. Either the estimate of 343,000t is too high or the production of oilseed cake has rapidly increased. In reality, it is probable that the truth is somewhere in the middle – and the amount of oilseed cake produced is currently around 200,000 to 250,000t/year. Efforts were made to get more accurate data from the Ethiopian Pulse and Oil Seed Processors and Exporters Association, but without success.

In addition to oilseed cake there are other sources of protein for animal feed; the main one being soybean, which is also processed to remove oil and the remainder is sold as a high quality animal feed. In the 2016/17 Meher season, soya was planted on almost 37,000ha and total production was 81,000t (Table 1). However, another publication estimated that total production was 150,000t in 2014 (Sopov and Sertse, 2015). The difference in production is unlikely to be a decline in production; it is more likely to be that the data collected by Ethiopia's Central Statistical Agency possibly does not take into account all the production by larger commercial farmers. It is estimated that about half Ethiopia's soya production comes from the commercial farmers (Sopov and Sertse, 2015). Sopov and Sertse (2015) noted that the Ethiopian soya yields are low at 2.1t/ha; but with better agronomy, they should be about 4t/ha. Data on Ethiopia's imports and exports of soybeans are also confusing; Sopov and Sertse (2015) reported that there were small quantities exported (3,300t in 2014) whilst FAO data shows that exports increased from 500t in

2009 to 42,000t in 2013. Whichever data are more accurate, it does seem to suggest that Ethiopia is an exporter of unprocessed soybean, which could mean that there is insufficient processing capacity in the country. Alternatively, the combination of cheap palm oil and lack of demand for the high protein cake makes exporting the beans more attractive than processing in Ethiopia.

The data on Ethiopian soybean production and processing might be very confusing, but it is important to understand because it represents the main competition for lupins as animal feed. It could be estimated that total amount of soya processed in Ethiopia is between 80,000t (ie the Central Statistical Agency figure) and 110,000t (ie using the Sopov and Sertse (2015) estimate less the FAO exports) per year. After processing to remove the oil, about 80% remains as the soya meal; therefore it is calculated that there is about 60,000 to 90,000t of soya meal produced per year. It is reported that no by-products of soybean processing are exported (Hailu and Kelemu, 2014), so it all must be consumed within Ethiopia. If the total by-products from the soya processing are between 60,000 to 90,000t/year; the largest livestock feed manufacturer, Alema Koudis Feed, uses about 15,000t/year; other buyers take much less. Therefore, it is likely that around 20,000t/year is used in the commercial production of animal feed and it is assumed that the rest is purchased direct by larger commercial farmers for making their own animal feed.

Some price data for livestock feed ingredients were collected (Table 4); and these data were confirmed during interviews with ingredient buyers during the mission. These show that soybean is the most expensive at ETB12,000 (USD444/t), whilst other protein sources are discounted, a reflection of their lower nutritional benefits. The price of all the ingredients have increased over the last five years, but given the rate of inflation in Ethiopia increased by 11.1% over this time (IMF, 2016), the rate of increase is not that dramatic; apart from rapeseed cake.

The main reason for growing oilseed crops in Ethiopia is to produce vegetable oil after processing. The cake that is sold for livestock feed is simply a by-product. Data for 2011 to 2013 shows that Ethiopia imports on average 287,000t/year of palm oil worth USD365 mn (Table 5). It is therefore important to understand the Ethiopian oilseed sector because if there is an attempt to promote more production of locally grown oilseeds to substitute some of the imports, this will obviously increase the amount of oilseed cake available for livestock feed.

Supply and Demand in the Ethiopia Livestock Feed Market

The above analysis shows that Ethiopia has a very large livestock population, but most animals are owned by small-scale producers who are reluctant to invest in inputs. This is very true when it comes to buying high quality and high priced feed. However, it is reported that there is an increasing demand from the better retailers for higher quality meat and livestock products from urban customers. But this will be mainly supplied by the commercial producers who will need good quality feed.

There are already a significant number of different sources of animal feed available. It is estimated that between 200,000 and 250,000t/year of oilseed cake is available and between 60,000 to 90,000t/year of soya meal. There are a range of by-products that could also contribute protein to the diets of Ethiopia's livestock. Compared to the total livestock population, this amount of protein is very small. To put it into perspective, the world production of soybean is 276 mn t/year of soya, Sub-Saharan Africa (SSA) uses about 1.4 mn t/year (i e, 0.6% of the world's soya). Ethiopia may have one of the largest livestock populations in the world, but it is one of the smaller buyers of protein for livestock feed.

Currently, Ethiopian livestock producers have a wide range of protein sources for their animals. These are available at a wide range of prices; which reflects their effectiveness as a feed. The assumption is that lupins will be a high quality feed and compete in the segments that use soya. It is estimated that currently there is about 60,000 to 90,000t/year of soya cake compared to in the order of 200,000 to 250,000t/year of by-products from oil seed processing (mainly noug cake). The great advantage of the oil seeds as opposed to soya is that they are much cheaper (Table 4); it is recognised that they are cheaper because they are less effective as a feed, but many Ethiopian farmers simply buy on price.

Table 4. Major livestock feed ingredients prices, 2010/11 & 2015/16 ETB/t

Ingredient	2010/11	2015/16	CAGR (%)
Maize	4,000	5,100	5.5
Wheat bran	2,800	4,170	9.8
Wheat middlings	3,000	4,200	8.0
Noug cake	3,000	4,800	12.0
Rapeseed cake	1,300	2,900	24.6
Soybean meal	7,500	12,000	12.0
Cottonseed cake	4,550	5,000	1.6

Source:- Bediye et al.(2018)

Table 5. Imports of palm oil into Ethiopia, 2011 to 2013

Year	Quantity (Tonnes)	Value (USD thousands)	Unit price (USD/t)
2011	231,458	330,735	1,429
2012	283,369	372,725	1,315
2013	346,450	391,448	1,130
Average	287,092	364,969	1,271

Source:- TrendEconomy (2021)

Creating Competitive Advantage for Lupins in Ethiopia

If lupins have a future as a livestock feed in Ethiopia, it will be necessary to outcompete other sources of protein. Given that the protein characteristics of soya and lupins are very similar, it will have to compete soya on price. The advantage that lupins have over oilseed cake is that they have better quality of amino acids that give much better growth rates and productivity, which should appeal to the more commercially minded farmers.

In many countries, lupins out yield soya beans and often have very similar growing costs. According to Ayalew et al. (2018) the total operational cost to grow soybean in Ethiopia (ETB 3945.44 per/ha) is much higher than our cost of production finding for lupin in this study (ETB 2800 per/ha). Therefore, lupins are cheaper to produce than soya. However, national average yields in Ethiopia show that soya yields better than lupin (Table 2); but this may reflect farming systems. Therefore, it is essential that proper field trials comparing both crops are made and the costs of production are calculated. If lupins can be produced significantly cheaper than soya cake, then it will give it a major competitive advantage.

Given that the most important aspects of creating competitive advantage for lupins is to be cheaper than soya and as good as Soya in terms of quality source of protein, it is important to understand its costs of production and the price that farmers would expect. During the research for this project, a team spent time with farmers collecting data. They estimated that farmers growing the traditional bitter white lupins achieved a yield of 1.2 t/ha and sold the crop ETB 9,100/t (USD337/t). It was claimed that the total labour cost was ETB 2,800/ha, but other costs were not recorded, but if the data are accurate, it would imply that the farmers get a very healthy margin. It is recognised that more work is required to obtain a more accurate costs and gross margin. However, lupins are going to gain market share at the expense of soya, they will have to be cheaper; perhaps by at least 10 to 20%. In other words, lupins should have a factory gate price of between ETB 9,600 to 10,800/t. Given that the costs of aggregation and transport from the farm to factory (or commercial livestock farm) will be significant, lupin growers may well have to receive a lower price. It would be hoped that if farmers used more inputs and with better management they could achieve much higher yields than 1.2t/ha, then they would still generate acceptable margins at prices less than ETB 9,100/t.

The market

Market Segments

The previous section has demonstrated that there could be an interesting opportunity for marketing lupins for animal feed in Ethiopia. However, more research is needed to confirm the exact scale of the opportunity. It is necessary to establish trials to compare yields, calculate production costs and prove that the inclusion of lupins in livestock feed improves productivity and growth rates.

The main driver for the lupin market will be the demand from the livestock farmers who are prepared to pay for improved feed for their animals. The market opportunity can be segmented by the different supply chains that link lupin producers with livestock farmers. There are a number of chains that could link growers of lupins with livestock owners. The first could be the livestock feed factories who could buy lupins either directly from farmers or through market intermediaries (who would aggregate and organise transport). The second group could be larger livestock farming companies that make their own feed. These companies buy grains, protein and supplements and mix the rations for their animals. Some of these farmers (poultry, dairy and beef farmers) might produce some of their own feed ingredients, and therefore could be interested in growing lupins. The third group could be small holder farmers who are currently reluctant to spend money on buying in commercial feeds. However, if lupin is promoted well it can be used as home grown protein supplement for smallholder farmers. The characteristics of each of these segments and sub-segments are described, then attempts are made to quantify the scale of the opportunity and possible obstacles for the adoption of lupins are considered.

Livestock feed factories

In 2016, the world's production of livestock feed was over 1 billion tonnes; an increase of 3.7% over the previous year. Interestingly, the number of mills decreased by 7.0% showing that internationally the industry is consolidating (Alltech, 2016). African production of feed per capita lags well behind the rest of the world, and despite its large livestock population; Ethiopia is not even in the top five African countries in manufacturing animal feed. This suggests that there could be considerable potential for an increase in animal feed manufacture in Ethiopia, although it is almost certainly being constrained by the lack of commercial focus to livestock production.

The Ethiopian Animal Feed Industry Association (EAFIA) notes that the commercial livestock feed industry consists of 32 privately owned companies and 28 owned by unions. However, most are small and tend to use cheap sources of protein such as noug cake. However, the few larger ones might be interested in using lupin.

Larger and better feed manufacturers

During the survey work we found out that there are four feed mills that might be interested in using lupins. Two of the four were visited; Alema Koudis Feeds, the largest privately owned feed mill in the country and the fourth biggest Kality Animal Feed Enterprise. One of the shareholders of Alema Koudis is a Dutch animal feed company that plays an important role in controlling the quality of the feed. This company has plans to double the capacity of the factory to 10,000t/month. The smaller factory manufactures about 480t/month with **no** plans to increase in the short-term. Between the two companies visited and perhaps the other two that are reputed to use soya, the current total market opportunity for lupins in this segment is probably no more than 20,000t/year. However, with the proposed increase in capacity at Alema Koudis factory coupled with the expansion in the national poultry production that is predicted; this could mean that this market segment could increase to around 35,000 to 40,000t/year of high quality protein over the next few years. Therefore, currently it is estimated that the maximum opportunity for lupin sales in this market segment is currently about 20,000t/year.

This segment currently uses soya as its protein source and lupin will only replace it if it is either cheaper or has a better protein content or profile. Both mills visited

expressed interest in working with any development actor to investigate the use of lupin. It is therefore important that there is continued dialogue with them and they are provided information on likely costs and further information about the benefits of using lupin. When there are sufficient quantities of sweet lupin available, the Alema Koudis factory would be ideal to do small-scale trials as they could involve their Dutch partners in the feed analysis.

Smaller feed manufacturers

The smaller feed segment is made up of mills owned both privately and by Unions. The EAFIA reported that these privately owned mills produce cheap livestock feed using the cheaper sources of protein. It is not likely that these mills will change their business strategy in the short to medium-term and most certainly not until it can be proved that using lupin and producing a more expensive feed can actually be more profitable. It is therefore recommended that this segment is only targeted after the larger privately owned mills have successfully adopted lupins into their range of feeds.

The Union owned factories are supported and financed by the FEED project. Most of these small mills are operating well below capacity and use noug cake. The FEED project estimates that the 25 mills buy approximately 3,500t/year of oil seed cake; therefore this is the total market opportunity for lupin. Given that they are supported by a USDA project, there is a potential entry point for promoting the use of lupin to the mill managers.

Commercial-scale farming operations

The commercial farming operations that make their own feed are very important for lupin-based feed manufacturing and demonstration. In addition, another crucial issue is that they can be guaranteed a regular supply of consistently good lupins. This will inevitably mean that it will need to be grown by larger-scale farmers who have the land area and other resources to grow and supply sufficient quantity of lupin to enable the livestock producer to make a commitment. The three market segments that offer the best opportunity for lupins are poultry, dairy and beef.

Poultry

The livestock subsector that is expected to expand most rapidly in Ethiopia is poultry and much of this increase will come from larger-commercial operations. Interviews with large poultry farmers, both egg and broiler producers, confirmed that they make their own feed and use soya as the protein source. If it could be replaced with lupin with no detriment to productivity and it reduced their input costs, they would be interested in trying it.

The poultry flock in Ethiopia is estimated at 48 million birds; about a third are egg-layers and the balance being kept for meat. Over 90% of the flock are backyard birds and are fed on waste and scrapes and therefore unlikely to be a market for specific poultry feed. There are about five or six businesses with more than 30,000 birds with the biggest three being Elfora, Alema and Genesis; these are regarded as large-scale companies in Ethiopia. These companies are fully integrated with their own feed mills, modern production and processing equipment and also produce their own day old chicks (DOC). It was estimated that the biggest, Elfora, sold about 500t meat in 2015. Given the company's expansion and increase in market demand for top-end poultry meat, this could now be 750t in 2020. Therefore, it could be projected that the total commercial poultry meat production is in the order of 2,500 to 3,500t/year (Gira, 2016). To approximately calculate the market opportunity for lupins; it is estimated that to produce one kg of poultry meat, 2kg of feed is needed which would contain 35% high protein supplement such as soya or lupin. Therefore, the requirement of feed would be about 6,000t/year and if all the broiler producers used only lupin as their protein supplement, this could be a market opportunity of around 2,100t/year.

Accurate data on commercial egg production is less readily available. As it is estimated that a third of the chickens in Ethiopia are raised for egg production, the same proportion could be used for the estimate of their feed consumption. Therefore, the demand from commercial egg producers would be about 3,000t of feed that would include about 1,050t of high-protein supplement. Therefore, the total market demand from the commercial broiler and egg producers would be about 3,150t/year. Obviously, it would be necessary for trials to be undertaken to prove that lupins can replace soya cake and that it would help the producers make more money. Without this information, it is impossible to accurately predict what could be the market share for lupins in this sector. But if there was a medium-term target of 30% market share and if the target yields of lupins are 3 t/ha (Yeheyis et al., 2012), this would be just over 300ha. Given that there are only about 5 or 6 main players in the segment and they make their own feed, it is a relatively easy market to access.

In addition to the larger more modern broiler farmers, there is a small-scale commercial poultry production system, which is common in the urban and peri-urban areas of the large cities (Addis Ababa particularly, but also Debre Zeyt, Bahir Dar and Adama areas). These farmers generally have flocks with 50 to 2,000 birds of mainly highly productive exotic birds. The birds are kept either indoors or outdoors usually with low bio-security levels. The DOCs are bought from one of the 14 hatcheries in the country and the farmers also buy in feed from the mills. Gira estimate that production from this group is about the same amount of poultry meat as the larger scale companies described above, ie around 3,300t meat/year. As there are many hundreds of these small-scale commercial poultry businesses, it will be difficult to target them directly. However, as they buy in feed, the best way to encourage the use of lupins in this segment will be through the feed manufacturers as described in above.

Dairy

About 20% of the cattle population in Ethiopia are primarily used for milk- which would mean about 11 million head (ECSA, 2017). Ethiopia's per capita consumption of milk is very low at about 19kg per person per year; the World Health Organisation (WHO) recommends 175kg. Interestingly, a significant part of the milk production, about a half, is turned into butter. Productivity is very low; average daily production is 1.69litre/day/cow with an average lactation of 180 days giving 305 litre per cow per year. According to Olga and Tessema (2010) an analysis of milking cows around the regional capitals and Addis Ababa in 2009/10 showed that out of 215,000 animals, 25,000 were exotic breeds of which 21,000 were in clusters near to Addis Ababa and Mekele. As with much of the livestock industry in Ethiopia, the lack of quality feed is claimed to be a major

cause of the low milk productivity. However, until there is a dramatic upturn in market demand that would lead to more commercially focused farms, the demand for improved feed will be slow. As with the poultry industry, the first dairies that should be targeted for using lupins in the rations are those that use exotic breeds; most of which are located around Addis Abba and Mekele.

Beef cattle

The majority of cattle are owned by small-farmers; it is claimed that 70% of farmers have cattle, sheep or goats. Most of the animals are raised in a subsistence fashion with very little market focus; the animals used for traction or for payment of dowries, which means there is very little outlay buying feed. However, there are some feedlots being developed to produce beef for selling in the main towns. The more traditional feedlots purchase animals that are two or three years old and fatten them using by-products from grain processing and oil seed cake. However, there are a few companies looking to have more modern feedlots, e.g. Luna, which combines a ranch, were the young animals are reared, and a mill for making their own feed. They hope to expand their operations significantly and eventually move into exports to the Middle East. Modern feedlots could become a buyer of lupins, especially as part of the finishing rations, if they can be demonstrated to be better than the feed currently being used. Some commercial growers are starting to grow alfalfa and dry it for use as cattle feed. It is appreciated that alfalfa has lower protein levels, but is much cheaper than lupins and is easily digested by the cattle, but the addition of lupins to cattle diets would still improve growth rates.

The introduction of lupins into diets for feedlot cattle is an opportunity, but work has to be done to prove that it is a cheaper option than the current feeds. Therefore, it is recommended that an animal nutritionist and economist evaluates the costs of current diets and compares it with a diet including lupin. When it can be demonstrated to be cheaper and when there are sufficient sweet lupins available, it would be relatively easy to organise a feed trial in a feedlot when there is sufficient sweet lupins produced in Ethiopia.

Small-scale farming operations

Obviously that vast majority of agricultural production is by small-farmers; it would be very positive if they could grow lupins to feed to their animals. However, it is very important that commercial farmers have proved that they grow well in Ethiopia and feeding to animals has definite advantages. It is also difficult to get the correct seed varieties and rhizobium to the rural areas at prices that subsistent farmers can afford. This market segment should only be investigated further once trials have taken place on the commercial farms in order to minimise the risk for small-farmers. When the advantages of using lupins in Ethiopian commercial farming systems have been proved, then perhaps Government extension officers could be used to educate the small-farmers. It should be recognised that it is only sensible to target this segment in the medium to longer-term.

Human consumption

Some bitter lupins are already used in the human diet; *gibto* is grown and consumed in limited areas, mainly in four administrative zones in Amhara region. There could be an opportunity to replace bitter lupins with sweet lupins, which would remove some of the drudgery and effort currently being expended to remove the alkaloids. But this would require trials to test whether the consumers would accept the new varieties.

There is a possibility that lupins could be used to improve the nutrition in some foods; especially for children and refugees. In many countries, there are feeding programmes for disadvantaged groups that provide maize meal fortified with soya meal. It could be possible to replace the soya with lupin; however, it would be necessary to undertake extensive research. It would also require a regular supply of good quality lupins. Another issue with this market is that the demand tends to be erratic and is therefore difficult to plan for.

Lupins can be used in more complicated human foods; they can be used to add structure, protein, fibre and micronutrients to gluten-free and other foods. Lupins can be broken down into various ingredients and used to improve and enhance certain foodstuffs. However, it must be recognised that these sorts of uses are still in their infancy in developing countries that have access to a consistent supply of lupins as a raw material, but once Ethiopia has developed an industry growing lupins consistently, it could start to be used for human foods, especially for feeding programmes. As with all the uses for lupins, it will be very reliant on being able to outcompete soya cake.

Conclusion and Recommendations

Conclusion

Ethiopia has a very large population of livestock and there is a considerable shortage of feed for optimum animal growth. However, most of the animals are raised by subsistence farmers who rarely purchase feed, but use natural pastures and/or allow the animals to graze and scavenge. Therefore, there is a very large shortage of good quality feed. Therefore, any new developments in the feed industry have to be focussed at the commercial producers who have identified market opportunities. Some market segments have been identified as having potential for buying lupins, but before they can be targeted, some further work is required. The interviews and analysis suggests that there are a number of interesting market segments that would be interested in using lupins for animal feed. Some of the market segments will be much easier to target than others. Therefore, the marketing strategy should focus on targeting the commercial feed processors and commercial livestock farmers.

Recommendations

Need to calculate costs of production:- Before being able to develop a proper marketing strategy, it is important to know how much it will cost to grow lupins and deliver them to the feed mills. It is assumed that if lupins were to be seriously grown for commercial animal feed, larger and more commercial farmers would be targeted. We believe it would be more effective to establish new agricultural technologies with the larger and more commercial farmers and, once the growing of lupins had been perfected and agronomic and marketing risks had been minimised, then it might be possible to introduce it to smallholder farmers.

Promote the potential of lupin as livestock feed:- According to the results of this study most commercial livestock farmers and commercial feed processors who are the potential of lupin are unaware of the potential and

advantages of lupin as livestock feed. Hence, there is a need to promote lupin production and its potential as livestock feed through feeding trial demonstrations in commercial farmers farms.

Understand the market competition for lupin:- When a new product is brought to market, it will take market share from the current suppliers and it is important to understand how they will react. It is assumed that the main competition for lupins will come from soya and other oil seed cakes.

Acknowledgments

The authors would like to acknowledge ELFF (Ethiopian Lupin for Food and Feed) project for the financial support to do the survey work. Our thanks also go to the commercial livestock farmers, feed processors, local extension workers and smallholder farmers in the study areas.

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