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Research Article

Review on the Role Soybean on Animal Feed and Human Nutrition in Ethiopia

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Abstract: Soybean is the global miracle legume crop in the world regarding improving human nutrition and ration formulation in the animal feed industries. The crop has an excellent nutrient composition with balanced amino acid profile. Soybean has an indispensible role in the journey of nutrition security. This review is focusing on the role soybean and its products to formulate animal feeds and human nutrition. This paper compiled with a critical review of different published journals, books, and reports which are in line with the animal feeds and human nutrition. Although Ethiopia is the leading country in Africa in livestock population, the performance of the livestock sub-sector is still below the existing potential and the country is not benefited as well from this sector. The biggest challenge here is that shortage of feed both in quantity and quality. Soybean is the primary alternative legume crop to formulate animal feeds due to its high-quality protein and good nutrient composition in the appropriate proportion. Soybean meal has commonly used in the feed industries due to its high crude protein and oil in the need of animal diets. Soybean has a paramount role to improve human nutrition. Soy foods are the cheap source of proteins particularly for the poor sections of the community and substitutes animal source proteins. Soy-based foods contain all eight essential amino acids in the need of human diets. The large proportion of Ethiopian population is Orthodox Christian followers and cannot eat animal source proteins during fasting for about 200-250 days and consumption of soy foods highly recommended to reduce the problem of protein malnutrition during these days. It can serve as an excellent bridge for vitamin "A" absorption. Many epidemiological studies suggested that consumption of soy-based foods significantly reduce the risk of heart diseases, breast and prostate cancer, hypertension; regulate the glucose levels of diabetes, cardiovascular and other human diseases. Different important minerals and vitamins also can obtain through consumption soy-based foods. The demand of soybean and its byproducts increasing rapidly overtime due to its great contribution regarding reduce protein malnutrition.

Keywords: Animal Feeds, Human Nutrition, Soybean, Soy Foods

1. Introduction

Soybean (Glycine max) is one of the most essential crops in the world [1]. It is the global miracle crop due to its richness in nutrient composition to formulate animal feed and human diets. The crop is a good source of protein for human diets and as a biofuel feedstock besides serve as an oil seed crop and livestock feeding [2]. Its oil becomes one of the most important vegetable oil worldwide in the food and animal feed components [3]. According to the findings of this study, soybean seed contains 91.18%, 38.88% and 20.0% dry matter, crude protein and oil respectively. However, the nutrient composition of soybean seeds varies among varieties and findings of different scholars.

The demands of soybean increasing rapidly due to increasing demand of global meat and fuel consumption [4]. The results of this study revealed that large-scale and small-scale farmers account 80% and 20% of world soybean production respectively. Brazil, United States and Argentina are leading soybean exporters with the respective market value of USD 26.1billion, USD 22.8 billion and USD 3 billion. China, Mexico and Netherlands are leading importers and imported market value of USD 38.1 billion, USD 1.7 billion and USD 1.6 billion respectively.

Malnutrition is the major global health problem particularly for developing countries including Ethiopia [5]. Ethiopia is one of the highest countries regarding child malnutrition rate in the world besides food insecurity. This finding revealed that food insecurity is the determinant factor for malnutrition [6]. Around 33 million Ethiopian people suffer from chronic food insecurity and undernourishment [7]. According to the results of this study, 25% of the people needs urgent assistant due to such severe problems and nutritious foods like soy based foods can solve the problems. Besides to human nutrition problems, feeds both in terms quality and quantity were the major bottlenecks in Ethiopia and that is why the productivity of the livestock sub-sector is very low [8]. Feed is a key pillar in the journey of improving the productivity of livestock production to increase the contribution of this sub-sector in the overall economic growth. A total of 81 enterprises were involved under the Ethiopian commercial feed sub-sector and privately owned feed processing plants and farmers' union were the dominant enterprises. But still now, feed quality and safety are the big questions even in the commercial feed sector due to high price of ingredients and compound feeds [9]. The finding also suggests that maintaining feed at the desired level of nutritional and quality standards of ingredients also a challenge for the commercial feed processors. To improve the productivity of livestock under smallholder farmers' condition, quality feed is the main determinant factor [10]. This indicates that a soybean ingredient has been incorporated in the processes of ration formulation to ensure the feed quality. The nutritional value of soybean varies across varieties and improved varieties have better nutrient composition as compared to the local varieties [11]. Soybean contains minerals which are essential for the health of humans and reduce the risk of many diseases besides protein and fat source in the food and animal feed industries [12].

Ethiopia has huge potential for soybean production [13]. Although Ethiopia started soybean research and production in the early 1950s, the production status and area coverage is below its potential [14]. Findings of this study indicated that lack of awareness for local farmers regarding utilization, absence of attractive market for the produce, improper approach of popularizing the crop, limited use of improved varieties and week linkage of producer-processor-exporter – consumer contributed for the low level of soybean production. Soybean contains essential fatty acids in the needs of human diets and significantly reduced cholesterol levels. Its macronutrient composition is different from other legumes [15]. Soybean protein can reduce cholesterol level and also its isoflavone has a positive implication for the improvement of bone health [16]. Soy protein has significant effect on the reduction of cholesterol. Different countries approved that 25g/day soy protein intake successfully reduced cholesterol level [17]. Overall, comprehensive review conducted focusing on soybean and its byproducts to improve animal feeds and human nutrition and can help readers to increase their knowledge regarding human nutrition and ration formulation.

2. Methodology

This paper was compiled by conducting a critical review of different published journals, books, proceedings and reports. The researcher critically reviewed focusing on the role of soybean for animal feed formulation and human nutrition. Both qualitative and empirical evidences well reviewed to strengthen the information regarding the nutritional aspects of soybean for livestock feed formulation and human diets. Different literatures reviewed and valuable information noted accordingly till the paper has been completed.

3. Review of Related Literatures

3.1. Biochemical Composition of Different Soybean Genotypes

The nutrient content of soybean varies among different genotypes. Average dry matter, nitrogen, sulfur, crude protein, free amino acids, methionine, cysteine, starch, total soluble sugars, sucrose and reducing sugars content of soybean seeds in eight different genotypes was 92.1%, 6.6%, 0.18%, 41.4%, 0.55%, 0.20%, 37.1%, 5.6%, 6.7%, 9.7% and 0.27% respectively [18]. Similarly, the respective average trypsin inhibitor, phytic acid, total phenols, Flavonols and orthp-dihydroxy content of soybean (mg g^{-1}) was 70.6, 3.80, 1.20, 0.25 and 0.20. This study used SL 688, SL 525, SL 783, SL 768, SL 799, SL 794, SL 831 and SL 869 soybean genotypes. Findings of this study reveal that significant difference observed regarding sulfur, free amino acids, methionine and reducing sugars content among genotypes. Overall findings of this study showed that soybean is nutritionally richen and contains many nutrients in different proportions that is why soybean is highly recommended to be included in the diets of humans and animals.

Table 1. *Nutrient composition of different soybean genotypes.*

Parameters	Average contents of 8 genotypes
Dry Matter (%)	92.10
Nitrogen content (%)	6.60
Sulfur content (%)	0.18
Crude protein (%)	41.40
Free amino acids (%)	0.55
Methionine (%)	0.20
Cysteine (mg%)	37.10
Starch (%)	5.60
Total soluble sugars (%)	6.70
Sucrose (%)	9.10
Reducing sugars (%)	0.27
Trypsin Inhibitor activity (mg g^{-1})	70.6
Phytic acid (mg g^{-1})	3.80
Total phenols (mg g^{-1})	1.20
Flavonols (mg g^{-1})	0.25
Ortho-dihydroxy (mg g^{-1})	0.20

3.2. Role of Soybean in Livestock Feeding Industries

Poor animal nutrition and management practices are the major constraints in the livestock production system [19]. This study indicates that most of the farmers still depend on pasture lands, crop residues and raw agro-industry byproducts to feed

their livestock. Use of compound feeds is very low due to its high cost and dispersal of compound feed processing companies since most of them located around Addis Ababa. Soybean is the source of high quality vegetable protein in the animal feed industry worldwide [20]. Its meal is widely used for animal feeding in the world due to its high protein content and essential amino acids in good proportion [21]. Soybean meal is the first and best preferred protein source in the feed processing industries particularly for the poultry sector in the world [22].

Soybean molasses is the by-product of soybean protein concentrate obtained from defatted soybeans through alcohol extraction. It can be used as a pelleting aid during feed production in the animal feed industries. Soybean molasses is the cheapest feed ingredients and easily available for farmers besides to its high nutritional value. Soybean molasses significantly improve the quality of animal feeds formulated due to its high nutritive and functional value [23]. The diets of major farmed animal species (poultry, pigs, cattle and aquatic) contain soybean [20]. This finding reveals poultry and pigs are the prioritized animals regarding providing high quality protein in their diets. The average daily body weight gain and hot carcass of black head ogaden sheep significantly increased as soybean supplementation in the feed increased [24]. Anti-nutritional factors such as trypsin inhibitor, phytate, oligosaccharides among others, which limit its utilization, are found in soybean. The nutritional value of soybean meal can be improved by altering its native composition by using bacteria or fungi through microbial fermentation [25]. The findings of this study confirmed that fermented soybean meal increases the acceptability of soybean meal (SBM) by degrading anti-nutrients besides to increase free amino acid, small-sized peptides, CP content and bioavailability of nutrients.

Soybean is one of the major ingredients in formulating poultry diets [26]. Although soybean meal remains the most important and preferred protein feed source for poultry production, its supply and quality level fluctuates and become expensive due to processing and transportation costs [27]. Findings of this study also revealed that appropriate heat treatment can be applied to alleviate some anti-nutritional factors from soybean meal. Soybean meal fitted the requirements of feed quality regarding appropriate ration formulation in the animal feed industries [28].

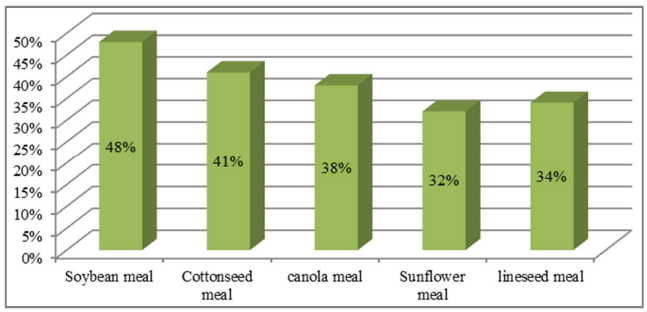
The compound feeds can be prepared by incorporating the ingredients in the acceptable ranges. As depicted in Table 2, the CP content of soybean meal is the highest among other crop ingredients in the compound feed. The respective CP content of soybean meal (toasted) and soybean meal (FF) was 39.34% and 37.46% followed by cottonseed (31.38%) and sunflower seed cake (28.64%). The maximum CP content observed from fish meal (Mwanza) 49.23% [29]. The CP content of maize bran, maize grain, wheat bran, wheat pollard, rice polishing and lentil was 14.58%, 11.17%, 18.81%, 17.46%, 14.87% and 19.21% respectively. The result implies that the protein content of crops is lower than soybean and that is why soybean is the main and preferred ingredient in ration formulation. Because protein content is the primary concern in the process of formulating animal feeds.

Table 2. *Mean nutrient composition of ingredients in the animal feeds in Tanzania.*

Feed type	DM (%)	Fat (%)	Ash (%)	CP (%)
Cottonseed Cake	91.15	5.54	7.97	31.38
Sunflower seed Cake	91.98	10.94	7.83	28.64
Fish meal (Mwanza)	90.14	5.13	14.21	49.23
Fish meal (sea)	88.36	1.72	19.47	39.45
Soybean meal (toasted)	91.17	6.15	9.82	39.34
Soybean meal (FF)	91.11	15.58	9.86	37.46
Maize bran	90.22	6.11	7.94	14.58
Maize grain	88.95	3.5	4.53	11.17
Wheat bran	90.31	1.85	9.42	18.81
Wheat pollard	90.15	1.97	8.55	17.46
Rice polishing	90.26	5.01	14.87	14.87
Lentil bran	90.72	2.09	19.21	19.21

DM=Dry matter, CP=Crude protein
Source: [29]

High protein content is the primary concern in the process of ration formulation in the animal feed industries. Different meals have different proportion of protein contents. As the results depicted in Figure 1, soybean meal has a crude protein content of 48% which is the highest as compared to other meals followed by cottonseed meal (41%). Canola meal contains 38% of crude protein and it is good next to soybean meal and cotton seed meal. Linseed meal and sunflower meal have the crude protein content of 34% and 32% respectively. The results indicated in Figure 1 showed that soybean meal is the primary source of protein to formulate animal feeds with an excellent nutrient composition. Findings of this study suggest that soybean and its byproducts highly demanded in the feed processing industries to produce high quality animal feeds with appropriate nutrient composition in the need of animal diets.



Source: [30]

Figure 1. *Crude protein contents in different meals.*

Addition of soybean molasses in the total mixed ration (TMR) increased milk yield by 4.94% at ($p<0.05$) and more yield 4% FCM by 5.03% as compared to rations without soybean molasses [31]. This implies that inclusion of soybean molasses in to the total mixed ration significantly increases the amount of milk produce per day at ($p<0.05$). As the results depicted in Table 3, the level of milk fat concentration increased by 0.56% due to addition of soybean molasses in to TMR. However, there is no statistical evidence for the

existence of significant difference regarding milk fat concentration and milk fat yield due to inclusion and exclusion of soybean molasses in the TMR. The study results showed that milk fat yield increased by 5.68% due to inclusion of soybean molasses in the TMR which is statistically significant at ($p<0.1$). Milk protein concentration increased by 3.92% while adding soybean molasses in to the TMR at ($p<0.01$). This indicates that addition of soybean in to the TMR highly increases the protein concentration of milk. Findings of this study also indicated that milk protein yield increased by 8.64% when soybean molasses added to the total mixed ration at ($p<0.01$). This shows that significant difference observed regarding milk protein yield due to soybean molasses in TMR of lactating cows. Replacing dietary corn meal and wheat bran by soybean molasses adsorbents in the diet of dietary lactating cows significantly increased the level of milk fat and protein contents at ($p<0.01$). Soybean-hulls and wheat bran have a positive effect on the improvement of milk quality with good nutrient composition [32]. Overall findings of this study suggest that soybean molasses has an indispensible role to increase the level of milk yield with good nutrient composition.

Table 3. *Milk yield and chemical composition of lactating cows nutrition due to soybean molasses.*

Parameter	Diet with soybean molasses	Diet without soybean molasses	p-value
Milk yield (kg per day)	25.68±4.09	24.47±4.17	0.036
4% FCM yield (kg per day)	24.20±4.01	23.04±4.22	0.044
Milk fat concentration (%)	3.62±0.37	3.60±0.35	0.811
Milk fat yield (kg per day)	0.93±0.17	0.88±0.18	0.063
Milk protein concentration (%)	3.45±0.38	3.32±0.30	0.006
Milk protein yield (kg per day)	0.88±0.17	0.81±0.16	0.002
Milk fat: protein ratio	1.06	1.07	

Source: [31]
FCM: 4% of fat -corrected milk calculated as (0.4 x kg milk) + (15 x kg milk fat)

3.3. Soybean and Human Nutrition

Legumes are important crops for human nutrition and the cheap source of proteins for the poor sections of the society than animal source proteins [33]. Soybean is the global oil crops and staple crops with an excellent protein content and nutrient composition for human diets and has significant health and medical benefits [34]. Vegetarians' are commonly consuming soy foods regarding improving their nutritional value due to high protein content and versatility of soybean [35]. Soy-based foods recommended for consumption to ensure the health of humans. Soybean is a rich source of protein for millions of individuals with affordable price. Its protein and amino acid content is comparable to beef [36].

Protein malnutrition and energy continues as a global problem especially for Sub-Saharan Africa. Unable to afford animal source proteins is the main reason for protein malnutrition. Consumption of soy-based foods alleviate nutrition insecurity particularly protein malnutrition besides minerals and vitamins due to its high and quality protein within an affordable price [37]. Findings of this study confirmed that underweight and wasting problem of the children reduced by 47.27% and 44.23% respectively for those who consumed soybean fortified porridge. The finding indicates that underweight and stunted growth of children significantly reduced at ($p<0.05$) due to consumption soybean fortified porridge. It has an indispensible role for human diets due to its high protein content, vitamins, minerals and insoluble fiber [38]. Findings of this study revealed chronic kidney disease, malignancy, osteoporosis & menopause, hypotensive action, hypercholesterolemia & cardiovascular maladies, circulatory strain & endothelial capacity, insulin emission & vitality digestion, diabetes and platelet accumulation can impact through consumption of soybeans. Consumption of soy-based foods can reduce the risk of coronary heart diseases, breast and prostate cancer and others [15]. Many epidemiological studies suggested that about 50% of breast cancer is related to dietary factors and increasing soy foods consumption significantly reduce breast cancer [39]. The risk of breast cancer can reasonably be reduced through more soy intake. A 10mg/day increment of isoflavone intake to women results a 3% reduction of the risk of breast cancer [40]. It is an attractive crop regarding alleviating protein malnutrition and an excellent bridge for vitamin 'A' absorption [8].

Agro processing industries that are engaging in human and animal feed production are the major end-users of soybean in Ethiopia [41]. Findings of this study reveal the respective dry bean protein and oil content is about 40-42% and 20-22% and the highest among other legume crops. It contains all eight essential amino acids for human health with good proportion. Soybean has 18-20% oil and 38-46% protein contents. On average, soybean contains 38% crude protein with rich and balanced amino acid profile [42]. Some scholars also confirmed that soybean contains 37-38% crude protein and 20% fat [43]. Its protein content is 2.5 times the protein content of wheat and four times the protein content maize [13].

Although Ethiopia has the potential for soybean production, utilization of soybean and its byproducts is so limited besides production constraints. Now a days, soybean being consumed in the form of Nifero and Kolo and in processed forms like soy milk, soya oil, soy blended flour and tasty soya due to some awareness on its health benefits by the people. Consumers get the processed byproducts of soybean from processors, whole-sellers, retailers, hotels and restaurants [44]. Byproduct demands of soybean particularly soybean oil become increasing and this would be a good opportunity for processors and producers.

The nutritional profile of soy milk is higher than milk

implying that the nutrient composition of soy milk is better for humans. Addition of soy milk up to 50% can increase the protein content and decrease carbohydrate content and used to replace milk in the process of cake production [45]. The protein and fats found in the cow milk can be obtained from soymilk. Soymilk is free of lactose and cholesterol and it is a healthy beverage and popular alternative for dairy milk for those who are lactose-intolerant [46].

Ethiopia has numerous food taboos like many African countries and some of the food types cannot be consumed during the fasting days. The large portion of the population is Orthodox Christian followers and has to respect the fasting days. Orthodox Christian religion followers cannot eat animal source proteins for about 200-250 fasting days/year and they can face protein malnutrition [47]. Food insecurity and malnutrition are chronic problems for Ethiopian people particularly the rural settings. Majority of the Ethiopian people cannot afford animal source proteins. Nearly 32 million people are fasting animal source proteins for about 200 days per year and it causes high protein deficiencies during these days and consumption of soy foods can significantly reduce such problems. The problem becomes sever for those vulnerable groups (children, pregnant and lactating) mothers. The respective of 15% and 40% more protein is needed for pregnant and lactating woman than the general woman in the population that is why soy based foods recommended for those vulnerable groups. People facing different widespread diseases due to nutrient deficiencies and the average daily energy intake are estimated at 16 to 20% which is below the minimum accepted level [41]. As the results of this study, 44% Ethiopian children whose age under five are stunted and 21% were severely stunted. The prevalence of stunting growth increases with age and the highest prevalence of chronic malnutrition problem observed at the age of 24-35 months.

As depicted in Table 4, the highest (40.20%) underweight problem observed from Afar region followed by Tigray (35.10%). The least (6.40%) problem was observed from Addis Ababa which is relatively good as compared to others. Soybean and its derivatives play an indispensible role regarding mitigating such malnutrition problems.

Table 4. *Proportion of underweight children in Ethiopia.*

S/N	Region	Proportion of underweight children (%)
1	Amhara	33.40
2	Oromia	26.00
3	SNNP	28.30
4	Tigray	35.10
5	Somali	33.50
6	Harari	21.50
7	Gambela	20.70
8	Benishangul Gumuz	31.90
9	Afar	40.20
10	Dire Dawa	27.60
11	Addis Ababa	6.40

Source: [41]

According to the study conducted in [5] at Bure town, the overall under nutrition of the children below five years was 35.50% among 342 total studied participants. The results of this study also confirmed that 24.90% of the children below five years faced stunted growth due to poor nutrition. Similarly, 14.30% of the children were exposed to underweight problem implying that foods with appropriate nutrient composition significantly reduced such problems. And also 11.10% of the children were wasted because of nutrition insecurity. Stunted growth (low height for age), waste (low weight for height) and underweight (low weight for age) problems commonly observed in Rwanda. According to the study results found in Ruhong district of Rwanda, off the total (294) studied children below five years, 37.8% of children were faced to stunted growth due to malnutrition problem. Similarly, 8.5% and 3.1% of the children were exposed to underweight and waste problems respectively. The problems of underweight, stunted growth and waste were also the main concerns in East Badawacho district of South Ethiopia [6]. This finding suggests that 26.3% of the children under-five were faced underweight among 508 total studied children. Similarly, 45.6% and 14.6% of the children were stunted and waste respectively. The problem of underweight significantly reduced through consumption of soy based foods like soy milk and soy flour [37]. The mean weight gain of the children was 0.9 (±0.5) kg for those who fed soybean products within three months of intervention. Findings of this study suggest that significant difference observed regarding weight gain between children who took and not took soybean products at ($p<0.05$). The overall findings in the two locations indicate that children are highly vulnerable for malnutrition and need nutritionally richen foods like soy-based foods to reduce such problems.

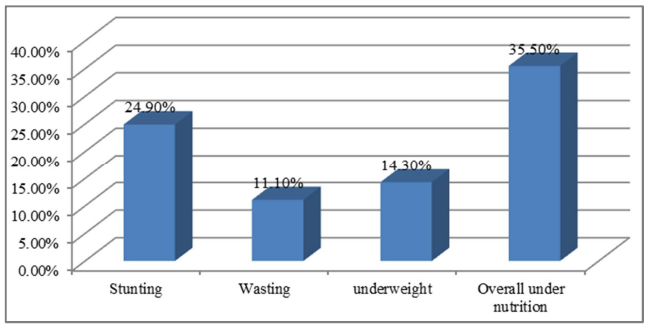


Figure 2. *Magnitude of under nutrition for children below five years ago (Bure town).*

4. Conclusion and Recommendations

The global soybean production volume is increasing over time due to its increasing demand in the food and feed industries. Soybean is sometimes called a miracle legume crop due to its high nutrient composition and balanced amino acid profile. Feed with good nutrient composition is the major component in livestock production. Soybean meal is the best source of animal protein and contains amino acid compositions in the needs of animal diets. Soybean seeds and its by-products are the best and preferred ingredient in the feed

processing industries due to its high-quality protein and good nutrient composition in the requirements of animal diets. Additions of soybean molasses in to dairy cows ration successfully increased milk yield and milk protein. Soybean is also an interesting and attractive crop in the diets of humans for its significant contribution to improve their nutrition. Soy-foods contain all essential amino acids that are very important in the diets of humans to lead a healthy life. Many scientific studies proved consumption of soy foods reduces the risk of certain cancers, hypertension, regulate glucose levels in diabetes, cardiovascular and other human diseases. Soy foods are the major source of protein and oil for the poor sections of the society since they cannot able to get animal source proteins. Vulnerable groups can get the protein and oil as well as fats by consuming soy foods that are comparable to animal source proteins since soy foods is cheap and affordable for these target groups. Soybean is a multipurpose crop and a preferred ingredient for feed and food processing plants to produce a quality and nutritious foods to realize the health of humans and animals.

Soybean processing plants concentrated in Addis Ababa and they are so far from production potential corridors. Processing plants recommended to be established accordingly couple with ensuring infrastructural facilities based on the potentials of the producing areas. Consumption of soy-based foods and feeds has to be promoted by concerned bodies to ensure the feed quality and nutrition security.

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