

# Animal Source Foods (ASFs): Their Overall Nutritional Importance for Children Under-Five, and Cost-Protein Advantage in Low-income Countries with Particular Focus in Ethiopia: A Review

Tekeba E\*, Hiwote T, Mesele K, Alemayehu Z, Teodros B, Eyerusalem R, Carlos B, Solomon A, Gizachew Z, Tadesse A, Dereje B, Konjit N, Kamil D, Kindye G, Bezawit S

SNV (Netherlands Development Organization), Addis Ababa, Ethiopia

## ABSTRACT

Animal-source foods (ASFs) are nutritionally dense sources of energy, protein, and various essential macro and micronutrients that can help in alleviating malnutrition in general. They contribute a significant portion to the nutrient requirements of people to support normal development, physiological functioning, and overall good health. Undernutrition in some selected African countries indicated that it has debilitating impacts not only on the physical and cognitive capacity of the people but also on the national economies by reducing Gross Domestic Product (GDP) by as much as 16%. Milk (cow milk), meat (beef), and eggs (chicken egg) currently provide around 13% of the energy and 28% of the protein consumed globally; in developed countries, this rises to 20 and 48% for energy and protein, respectively. In Ethiopia, most of the daily nutrition requirements are met by cereal-based diets. These cereals are rich in energy content but limited with other essential nutrients including protein. On the other hand, the price of these nutritionally dense diets has been skyrocketing for the last three years in the Addis Ababa market. During this reference period, the price of milk on average increased by 100% (50-100ETB/litter), beef price increased by 33.3% (600-800ETB/kg), and the price of eggs increased by 43% (7-10ETB/egg). These continuous increases in the price of these products coupled with the poor purchasing power of most of the society resulted in a decline in purchasing of these products. The most affected social strata are the growing children and women under reproductive and lactating ages and the rural people. On the other hand, these escalating prices, limited access, and affordability resulted in poor decision-making in purchasing one livestock product over the other. Therefore, this review study is initiated to identify one livestock product over the other based on their relative cost of protein to children under five and other pertinent beneficiaries as benchmarking. The study focused on the nutritional requirements of under-five children for normal biological and physical functions. However, the result can be applied to all individuals consuming ASFs for similar purposes. Current average price data was taken from Addis Ababa's

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### \*Corresponding Author

#### Tekeba Eshetie

SNV (Netherlands Development Organization), PO box-40675, Roosevelt St. On the way from AU to Mexico Square, Addis Ababa, Ethiopia, Tel: +251987208580;

**E-mails:** teshetie@snv.org; tekebanega@gmail.com

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selected market sites for evaluation and analysis made using simple descriptive statistics. The result of this review study indicated that, based on their protein economics, eggs are relatively cheaper than meat and milk (in value-for-money terms). If we assume a child eats exclusively eggs rather than meat to meet their daily protein requirements, there is a 143% cost-protein advantage. If a child consumes meat instead of milk to meet its daily protein requirements, the cost-protein advantage will be 51%. When one prefers eggs instead of milk, a child fed with eggs will be 243% more benefited in terms of protein cost ratio. In general, based on the cost-protein advantage and other added values like highly digestible protein, with 95% biological value, the consumption of eggs is more promising than the other two. However, the study has limitations in that, for a child to meet its daily nutrient requirement it needs a minimum dietary diversity not only one product like eggs. The review study also focused on protein being a major nutrient, not other nutrients. But the information will give a clue for consumers and decision-makers mainly on protein economics to invest more in the most economically feasible sector.

**Keywords:** Affordability, Animal Source Foods, Nutritionally Dense, Protein Economics.

## INTRODUCTION

Currently, livestock supply 13% of energy to the world's diet but consume one-half the world's production of grains [1,2]. However, livestock directly contribute to nutrition security in terms of milk, meat, eggs, and others. The animal-source foods, though expensive energy sources provide high-quality protein and micronutrients essential for normal development and good health [1]. However poor people tend to sell rather than consume the animal-source foods they produce. Animal-source foods (ASFs) are nutritionally dense sources of energy, protein, and various essential macro and micronutrients. They match particularly well with the nutrients needed by people to support normal development, physiological functioning, and overall good health [1]. Milk (cow), meat (beef), and eggs (chicken egg) currently provide around 13% of the energy and 28% of the protein consumed globally; in developed countries, this rises to 20 and 48% for energy and protein, respectively [2].

Undernutrition in some selected African countries indicated that it has debilitating impacts not only on the physical and cognitive capacity of the people but also on the national economies by reducing Gross Domestic Product (GDP) by as much as 16% [3]. The most affected social strata are the growing children and women under reproductive and lactating ages. The people in, Asia and Africa including Ethiopia are the most affected by these challenges. As a result of this and knowledge gaps, the rural farmers are

the ones who are suffering most from undernutrition. The analysis of Demographic and Health Survey (DHS) data shows that people living in rural areas are between 1.3 and 3.3 times more likely to be stunted than their urban peers due to nutrition deficiency [3]. Among ASFs, chicken eggs are considered the best choice due to their affordability, limited taboos, accessibility, and limited requirements for refrigerators. The affordability of a diet depends on its cost and on the income a household has at its disposal [3].

In several high and middle-income economies, the prices of nutritious foods are high, and increasing. However, less is known about these prices in low-income countries. Using unique food price data from 116 markets in Ethiopia, it is found that real prices of all nutritionally rich food groups increased significantly (between 21 and 74 percent) from 2005 to 2018 [4]. This is in contrast to staple crops (grains, roots, and tubers), whose price increased only slightly (6 percent) [4].

In Ethiopia, several food items are commonly available, but access and affordability are issues. The lower quantile of society is struggling to afford these nutritious foods to meet even 50% of the dietary requirements for protein (from animal sources), calcium, and iron for their children [3]. As a result of limited access to and affordability of these nutritionally dense diets, stunting, wasting and overall undernutrition are serious problems for children in Ethiopia [3].

When we compare the cost of nutrients with calories, in most cases, nutrient costs are more than calories. In Ethiopia, a diet providing essential macro and micro-nutrients (ASFs) would cost almost four times more than a diet meeting calorie needs only. A diet meeting nutrient needs is most expensive for adolescent girls and pregnant and lactating women [4]. These groups are therefore most at risk of inadequate nutrient intake. Special analysis for Addis Ababa reveals that the cost of a nutritious diet has been increasing since the beginning of 2020 [4].

In Ethiopia, livestock products' consumption patterns and contribution to household nutrition consumption are very limited. A considerable difference exists between urban and rural areas and the consumption of livestock products rises significantly with income [5]. These escalating prices coupled with limited access and affordability resulted in poor decision-making to purchase one livestock product over the other regarding their protein economics and other added advantages. In Ethiopia, the price of common livestock products is known per kilo gram/litter/piece but not based on their nutritional contents and added values. Therefore, this review study is initiated to recommend one livestock product instead of another based on the relative

cost of protein (value for money) to meet the daily protein requirement of children under five as benchmarking and to give a clue to organizations engaged in nutrition-sensitive initiatives, decision-makers, and research institutes to plan on which sector to focus strategically.

#### **Specific objectives:**

- To make information available on the relative cost of protein from common ASFs to consumers in Ethiopia to support them in the decision-making process during purchasing.
- To give some start-up information for those organizations, policymakers, and projects engaged in human nutrition where to focus and capitalize.

#### **LOCAL AND GLOBAL EXPERIENCES ON THE ROLE OF ASFs IN HUMAN NUTRITION**

Undernutrition is a significant public health concern. Globally, out of 676 million children under five [1], 155 million are stunted and 52 million are wasted [2,3]. Worldwide, almost three million children die before the age of 5 years and 45% of those deaths are attributed to malnutrition [4]. Africa is home to about 59 million stunted and 14 million wasted children in the world [4]. Regionally, countries located in East Africa share 4.1 % of wasting and 24 % of stunting. Ethiopians consume one-tenth as much meat as people in developed countries [6].

One in five children worldwide experiences stunted growth and underdevelopment due to undernutrition [7]. ASFs offer the opportunity to address this problem and make significant progress towards achieving the World Health Assembly nutrition targets. Eggs and milk are among nature's first foods, providing holistic packages of nutrients and bioactive factors to support healthy growth. Dietary patterns in the evolutionary history of hominids point out the importance of ASFs for increased brain size and function [7].

Stunting is a major public health concern in developing countries like Ethiopia, which is caused by chronic and recurrent malnutrition that leads to growth failure both physical, psychological, and cognitive [7]. According to the World Health Organization (WHO), stunting is defined as length/height per age being less than -2 Standard Deviations (SD) [7]. Although childhood stunting is reduced in the past two to three decades, it is still a major public health problem globally, which resulted in poor cognitive and educational performance, low adult wages, low productivity, and an increased risk of nutrition-related chronic diseases in adulthood life [7,8].

ASFs are micronutrient and protein-rich, with the proteins they contain being good quality and highly digestible and

the micronutrients including iron, zinc, and vitamins A and B12 that are often lacking in the diets of the nutritionally vulnerable. The bioavailability (i.e. how much of a nutrient can be absorbed and used by the body) of these nutrients is also higher in ASF than in many plant-derived foods. For all these reasons, consumption of even small amounts of milk, meat, and eggs can contribute substantially to ensuring adequate nutrition. This all marks ASFs as being potentially efficient for improving the quality of diets for the nutritionally vulnerable, especially during periods of high nutritional demand such as pregnancy, lactation, early infancy and childhood, and adolescence [8].

Overcoming deficiencies in diet quantity and quality are major nutritional challenges globally, particularly in developing countries. Diet quantity is concerned with the availability and consumption of total food energy (kcal) and diet quality with the ability of the diet to supply protein of high biological value and adequate supplies of micronutrients to meet biological requirements under a wide range of physiologic and environmental conditions. For human nutrition, the micronutrients of major concern in the growth, development, and health of children are iron, zinc, iodine, calcium, and vitamins B12 and A, and folate. ASFs contain quality nutrients important for growth, development, immunity, and behavioral outcomes [6]. The overall national prevalence of stunting in Ethiopia varies from 47.9% in 2000 to 35.9% in 2019, which indicates a 25% reduction in the past twenty years. The reduction in the prevalence of stunting is due to the implementation and expansion of a community health extension program by the Ethiopian government since 2004, which aimed to promote disease prevention and control including screening, treatment, and counseling for malnutrition [9].

Livestock already are making significant contributions to Ethiopia's national economic growth. The sector now makes up 40% of the country's Agricultural Gross Domestic Product and 27% of its national GDP [10]. Therefore, increasing ASFs, especially chicken production (broilers and layers) rather than increasing the numbers of cattle, sheep, and goats could provide the additional benefits of increasing investment in and employment of women and youth while lowering the greenhouse gas emissions generated by the country's livestock sector [10].

The low ASF consumption in Low and Middle-Income Countries (LMICs) is attributed to several factors, including low animal productivity, unaffordability, cultural norms, and religious beliefs [11]. Usually, ASF is costlier per calorie in LMICs compared to grains and staple foods, which creates a significant economic barrier to ASF consumption. Low-income households consume lower amounts of eggs

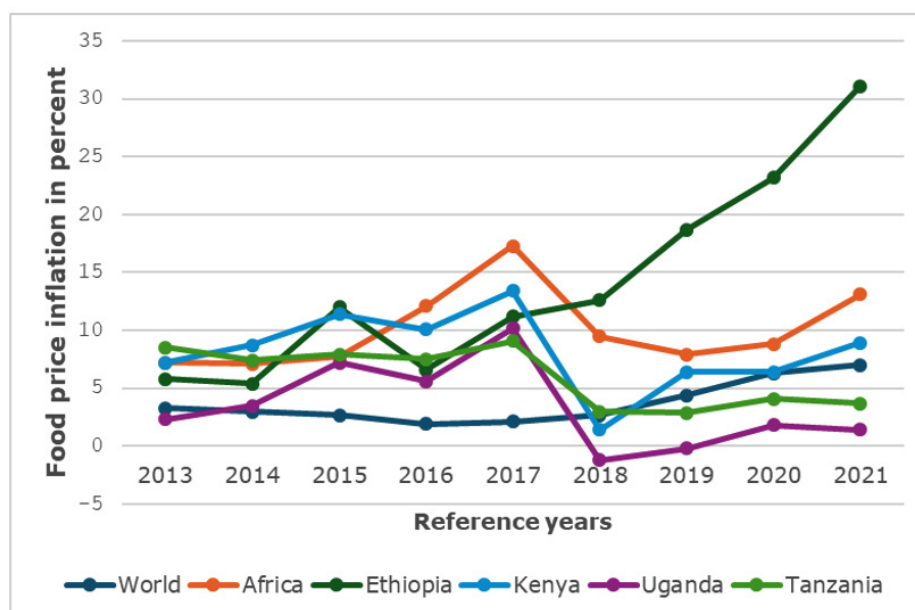
compared to higher-income countries. A study in Ethiopia found low egg consumption in infants and young children which is associated with low economic status, wealth, and occupation [11].

Increasing evidence shows that consumption of ASF has important beneficial nutritional impacts. However, only a minority of consumers in developing countries eat such foods, and poorer households especially forego ASF consumption seemingly as prices are perceived to be prohibitively high. Using a large national retail price dataset for Ethiopia that spans the last ten years, indicated that the prices of ASF, over time changed significantly as compared to these prices with other food products, such as staple cereals [12]. First, there is price seasonality mostly driven by changes in demand due to religious festivities and fasting periods in the country. Second, there are significant spatial patterns with higher prices in cities and commercial livestock areas. Third, ASFs are relatively expensive. Average prices of ASF per calorie and kg are about ten times as high as for staple cereals, an important consideration in these settings and especially so for the poorer part of the population [12].

Moreover, the real prices of ASF have been increasing rapidly in the last decade, on the order of 33, 36, and 32 percent for beef, milk, and eggs, respectively [12]. Such ASF price increases are strongly related to increases in livestock prices [12]. These estimates imply that the price increases seen in the last decade in the country would have led to decreases in per capita consumption of beef and dairy products of almost 25 percent when one compares the end to the beginning of the decade [12].

Exploring the exact reasons for the increases in livestock and ASF prices should be fertile ground for further research. Several hypotheses can be forwarded. First, the adoption of modern practices is low. For example, yield levels of livestock are low because of the low adoption of artificial insemination, lack of improved breeds, and bad feeding practices [6]. Second, cropland cultivation has expanded rapidly in Ethiopia. The increasing land pressure might have led to less land being available for grazing and subsequently to the adoption of more expensive purchased feeds. These higher production costs are then reflected in higher livestock and ASF prices [6]. Third, better road and information infrastructure as well as closer links with rewarding export markets might have contributed to general price rises in the livestock sector [12]. One of the main reasons for undernutrition in Ethiopia is the unavailability of cheap animal protein sources. Currently, only 12 percent of the country's protein intake comes from ASFs [13].

The relative inflation of food consumer prices (percent) for some African countries is compiled and presented in Figure 1. The trends indicated that the food price trend for Ethiopia is maximum as compared to its peers. These all indicated that, in Ethiopia, there is a very huge gap between supply and demand for livestock products. For example, between 2017-2021, the food price inflation increased by 178% in Ethiopia whereas in Uganda food inflation reduced by 86%.



**Figure 1.** Comparative food consumer prices inflation in percent.



Source: Calculated by the authors from [14].

On top of this, FAOSTAT indicated that consumption of protein from ASF is the least for Ethiopia as compared to Tanzania, Kenya, Africa, and the world average between 2000-2019 as data presented in Figure 2. The average animal protein consumption between 2000 and 2019 indicated that only an 11% increase was observed in Ethiopia, whereas the African average increased by 30%. So, in the Ethiopian case, there needs to be more effort in the production and supply of ASFs.

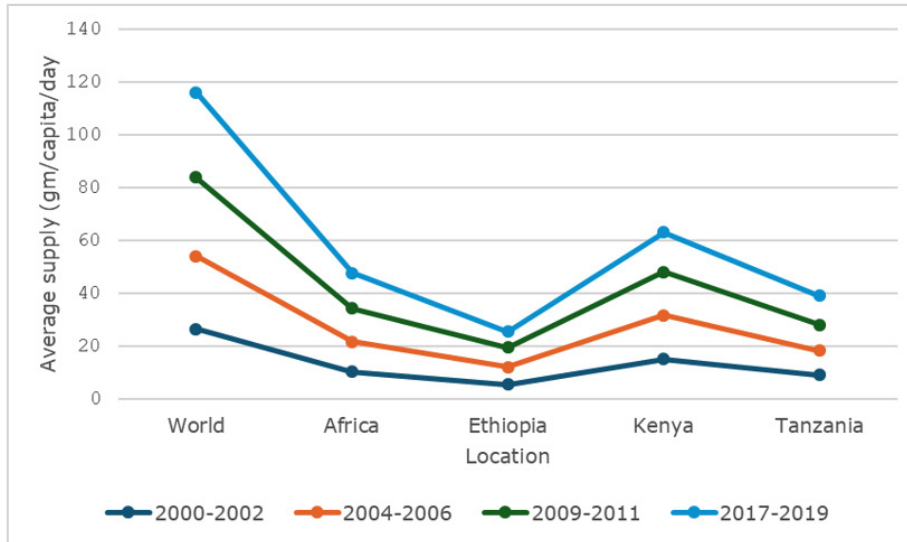


Figure 2. The average supply of protein from animal origin.

Source: Calculated by the authors from [14]

FAOSTAT, 2022 further indicated that, except in Kenya, there is a strong negative correlation between stunting in children and protein consumption from ASFs. The values in Figure 3 indicated that, as the level of protein consumed from ASF is low, the stunting of children is significantly higher like the case in Ethiopia (negatively correlated).

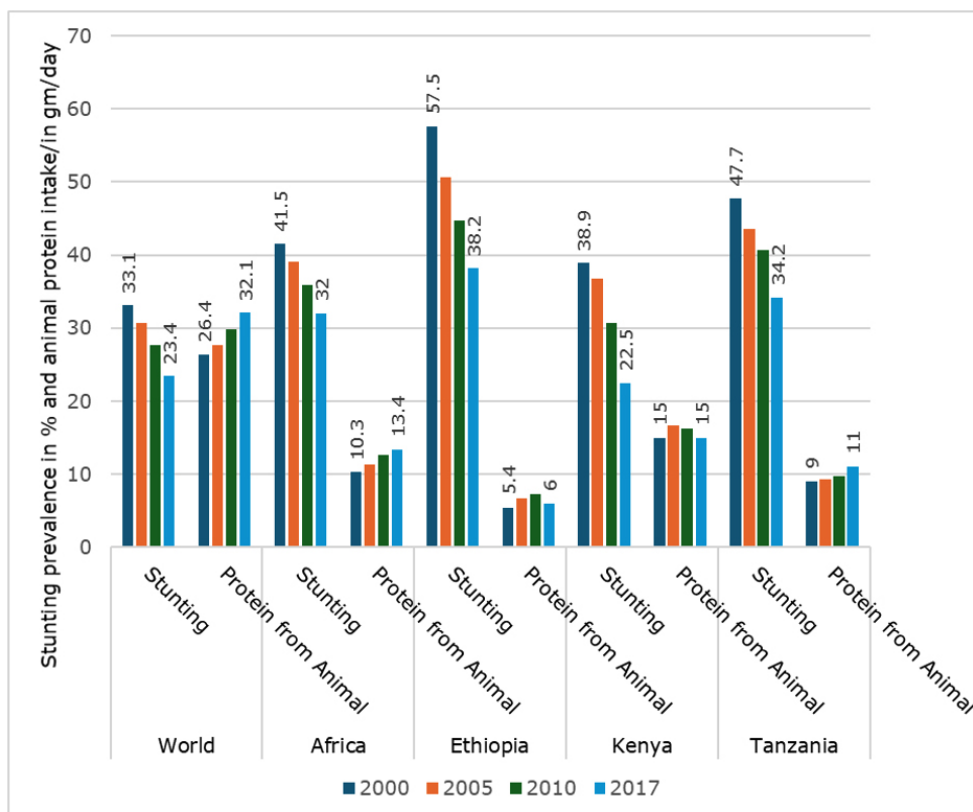
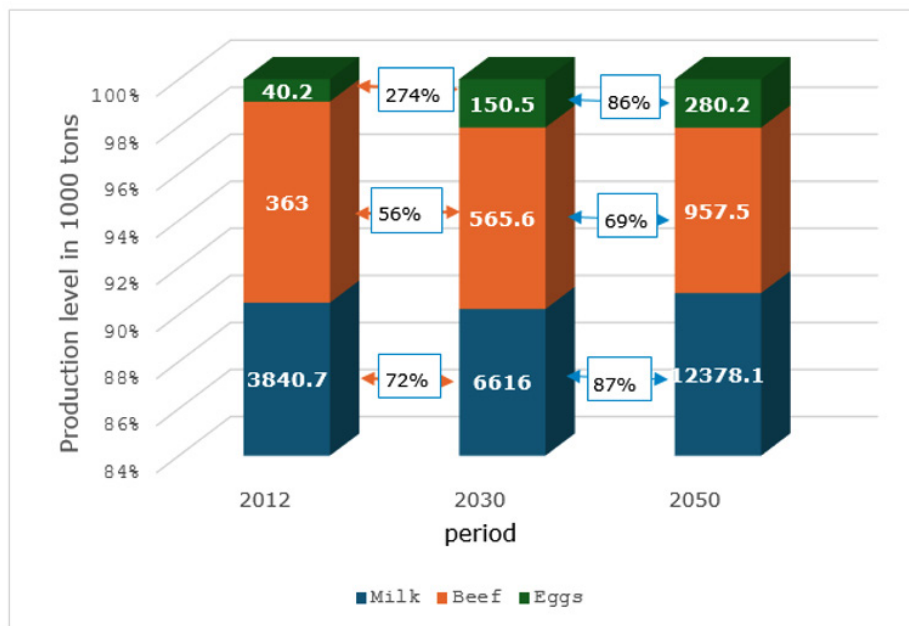


Figure 3. Stunting prevalence and protein intake from ASF/day/capita correlations.

Source: Calculated by the authors from [14].

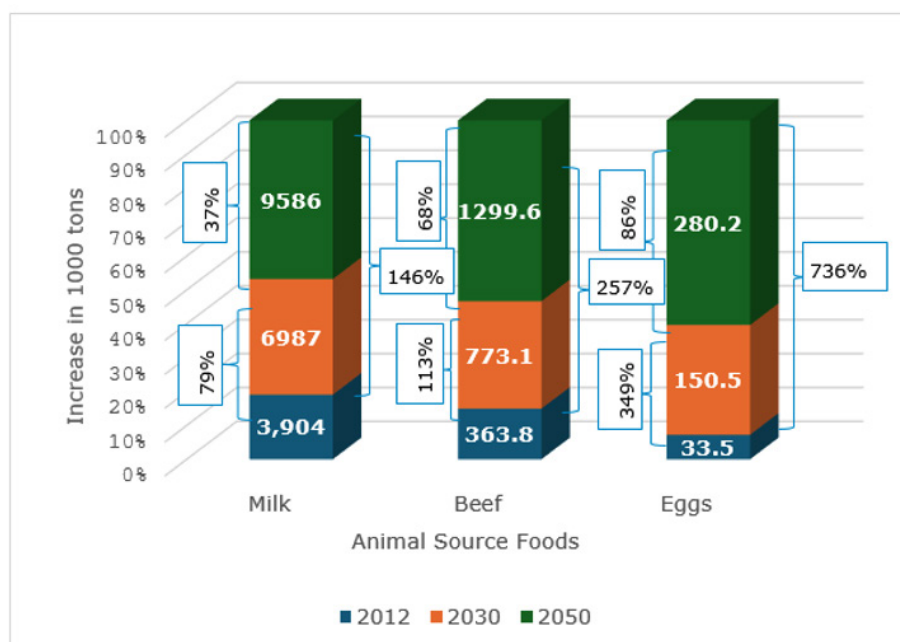
In Ethiopia, only nearly half of children aged 6–23 months consume any type of ASF. The findings of [15] imply that ASF consumption can be increased through integrated actions that involve community and religious leaders and programs focused on empowering households' capability of owning other socioeconomic entities including assets and livestock [15].

The actual level and projections of ASF production and consumption trends between 2012-2050 in Ethiopia are summarized and presented in Figures 4 and 5 to show the level of efforts made to improve ASF supply and the gaps. The FAOSTAT projection further indicated that between 2012 and 2050, egg production will increase by 597%, meat will increase only by 164%, and milk by 222%. Similarly, the level of ASF consumption in the same reference period indicated that egg consumption will increase by 736%, meat by 257%, and milk by 146%. All the production and consumption statistics indicated that the production and consumption of eggs are better than meat and milk production and consumption.



**Figure 4.** Ethiopia's current and projected production of animal-source foods in 1,000 tons.

Source: Calculated by the authors from [16].



**Figure 5.** Current and projected consumption of ASFs in Ethiopia between 2012-2050.

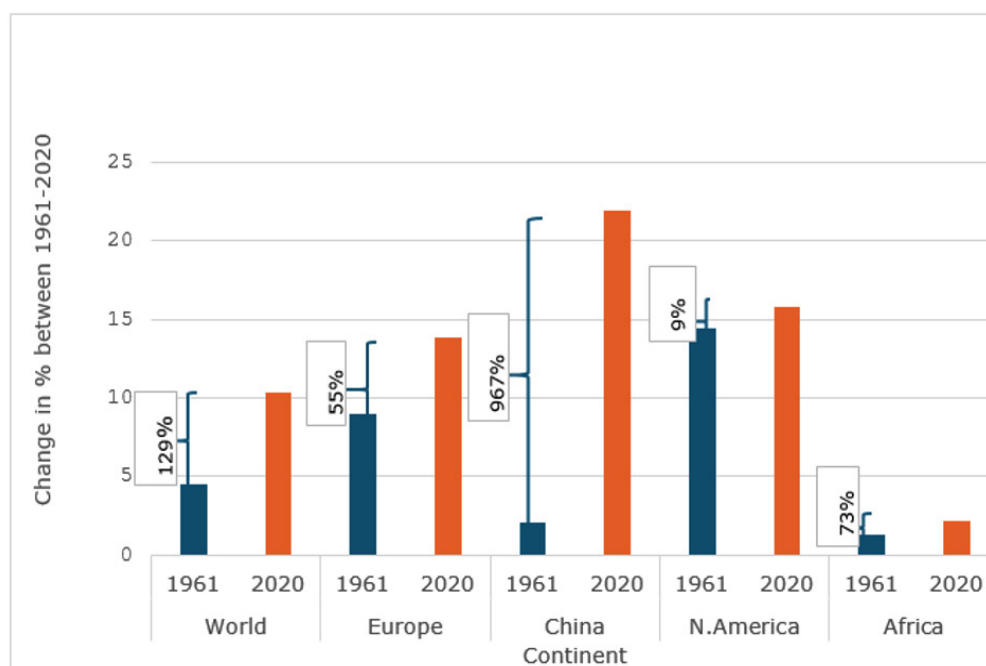
Source: Calculated by the authors from [16].

In Ethiopia, micronutrient deficiencies are common, leading to poor growth and development among young children and undernutrition among other vulnerable populations, such as pregnant and lactating women: 37% of children under five are stunted and 21% of them are underweight [16]. This is largely due to inadequate diets: only 11% of Ethiopian children aged 6-23 months were fed a diet meeting minimum diversity and meal frequency standards. The per capita annual consumption of dairy products in Ethiopia is just 11% of the recommended levels by the World Health Organization (WHO) (22 liters versus 205 liters). For most low-income households, dairy products are unaffordable due to limited disposable incomes [17].

On average, 67 calories/person/day are obtained from livestock products in Ethiopia: or only 2.9 percent of total calorie intake [5]. There is, however, considerable variation between rural and urban areas. In urban areas, the average daily per capita calorie intake from livestock products is about 96 calories, which is 42 percent higher than the rural average of just 61 calories. Richer households tend to have higher consumption of livestock products which is 3.5 times more meat and two times more dairy products than the poorest quintile. Consequently, the amount of calories obtained from livestock products rises with income. Individuals in the poorest quintile get only 35 calories per day, whereas those in the richest quintile get about 107 calories [5].

Overall ASF consumption was determined by livestock ownership, household annual income, and maternal education. In summary, consumption of ASF was dependent on socio-economic status and women empowerment as it was measured by household food security, livestock ownership, household income, and maternal educational status [18]. Women's empowerment through education and income-generation activities may also positively impact the nutrition of children in the country [18]. Affordability is a major barrier to improving healthy diets in Ethiopia. Meeting daily recommendations for starchy staples and oils/fats is the cheapest, and ASFs command the highest cost share of the recommended food groups, followed by fruits and vegetables [19].

In general, eggs, meat, and milk consumption trends (kg/person/year) and percentage changes between 1961-2020 for the world, and selected continents indicated that egg consumption increased to the maximum for China by 967% followed by a world average 129%. For Africa during the reference period, it was only a 73% increase as opposed to the serious stunting and undernutrition challenges. According to the same source, like egg consumption, meat consumption in China increased by 1,447%; on the contrary, for Africa, it is only a 24% increase. On the other hand, the average milk consumption percentage of the world decreased by 6 percent between 1961 and 2020. The same negative trends were observed for N. America and Africa. In China like eggs and meat, milk consumption increased on average by 957% in the reference period. The details of each ASF consumption are summarized and presented in Figures 6, 7, and 8, respectively.



**Figure 6.** Eggs consumption trends (kg/person/year) and % changes between 1961-2020.

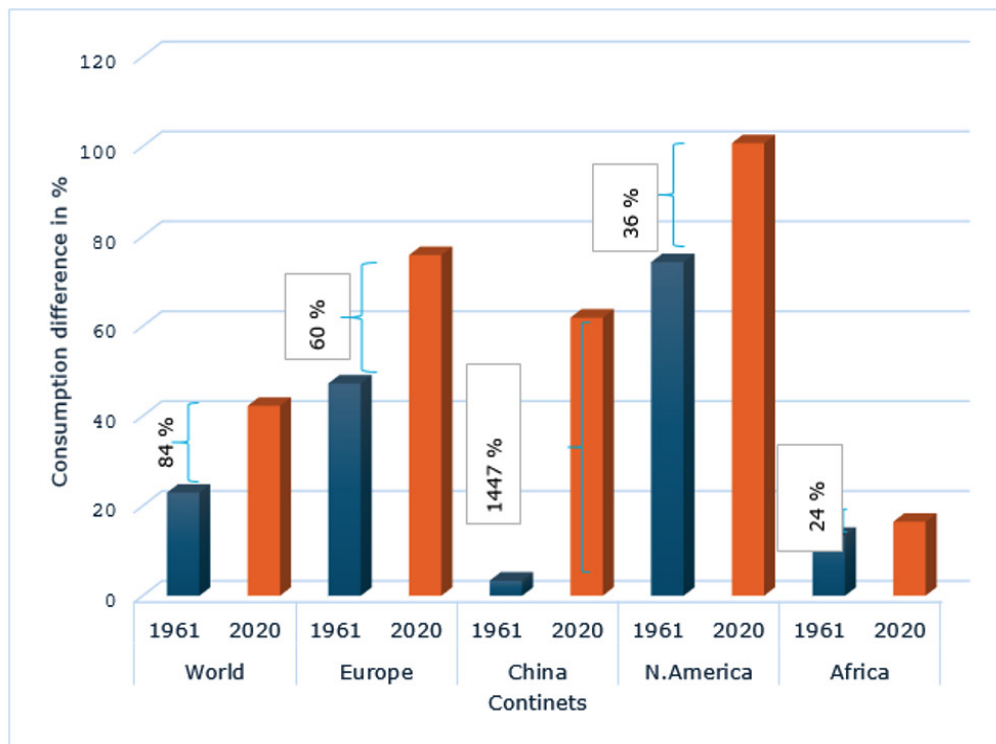


Figure 7. Meat consumption trends (kg/person/year) and % changes between 1961-2020.

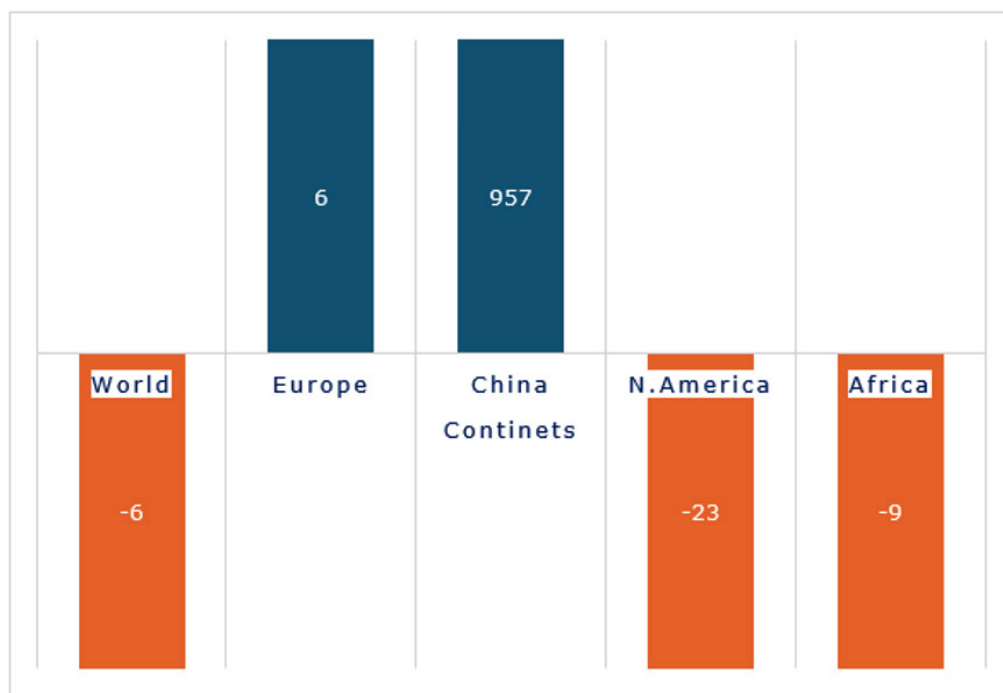


Figure 8. Milk consumption trends (kg/person/year) and % changes between 1961-2020.



Source: Calculated by the Authors from [20].

Many children in the complementary feeding period—the period when infants and young children are 6–23 months old and breast milk alone is no longer sufficient to meet their needs—do not consume enough iron, vitamin A, calcium, zinc, and animal-source protein, and these shortfalls hinder their growth and development. Unaffordability is an important barrier, among others, to the consumption of foods rich in these important nutrients. Although ASFs tend to be relatively nutrient-rich, they are much less affordable than plant-source foods based on cost per kilocalorie [21].

When developing countries fall behind in their physical growth and become stunted relative to their healthier peers, they tend to fall behind in a lot of other things too: their health, cognitive development, schooling, and eventually, their productivity and income as adults [22]. ASFs fit that bill, being rich in high-quality protein, essential fatty acids, and multiple micronutrients, as well as more mysterious growth-promoters, like the insulin-like growth factor found in cow's milk [22]. Inadequate protein and energy intake may be a predictor of childhood linear growth failure in rural Ethiopia. Nutrition programs that emphasize food security, recommend child-feeding practices, and increase the nutrient density of complementary foods, including the density of high-quality protein and energy, may improve a child's linear growth, especially in areas characterized by high inflammation [7]. Further, the calculated requirements for protein and essential amino acid intake for children should account for inflammation, energy deficiency, and intestinal parasites in Ethiopia [23]. Food from animal sources is deemed part of a healthy diet and can go a long way toward achieving FAO's standards, such as reducing wasting among children under five years of age, low birth weight, anaemia in women of reproductive age, and obesity, and non-communicable diseases in adults [24]. High food prices and low wages or incomes can interact to make healthy diets unaffordable for many, presenting a serious constraint to improved diet quality. Moreover, while healthy diets can become more expensive in nominal terms, whether they become more expensive for the poor depends on whether the poor's income rises more, less, or equally to CoHD costs [19].

The affordability of a diet depends on its cost and on the income a household has at its disposal. Modelling using Cost of the Diet (CotD) software and household food consumption data estimated that while 93% of households would be able to afford an energy-sufficient diet, only a quarter (26%) would be able to afford the foods required to provide a nutritious diet for all household members [26]. A diet

meeting nutrient needs is most expensive for adolescent girls and pregnant and lactating women. Special analysis for Addis Ababa reveals that the cost of a nutritious diet has been increasing since the beginning of 2020. In May 2020, beef was estimated to cost 880 Ethiopian birr (ETB), up from 790 ETB in February, an increase of 11% [25]. The lowest-cost of ASFs, fresh milk, costs almost twice as much as the two plant-source foods with the highest energy density and costs 15 times as much as maize flour, a commonly consumed and low-cost but nutrient-poor staple. Even the nutritious plant-source foods, pulses, and groundnuts, cost 7–8 times more than maize flour per kilocalorie [25].

The chemical composition of ASFs (meat (beef), milk (cow), and eggs (chicken) indicated that there are 22.5 grams of protein in 100 grams of meat, 3.4 grams in milk, and 12.6 grams in egg [26] on dry matter bases. When we see their energy content in Kilo Joule, meat has 542 KJ per 100 grams, milk 265 KJ of energy, and eggs 547 KJ per 100 grams [26].

Healthy young infants need about 3 times more energy per kg body weight than adults, primarily due to the added metabolic requirements for growth. Premature infants who grow at rates like normal intrauterine growth have even greater metabolic needs. Further growth spurts occur during the preschool age and puberty, respectively [27].

#### RELATIVE COST OF PROTEIN OF MAJOR ASFs IN ETHIOPIA

According to [28] the daily protein requirement of children under five is 19 grams/day/child. To meet this requirement, a child can get it from different sources including ASFs. But these days the price of ASFs is skyrocketing in Ethiopia. So, selecting relatively cheap ASF among meat, milk, and eggs is important to get value for money. Therefore, Table 1 data indicates the relative costs of nutrients and their nutrient content among major ASFs which are summarized and presented for the Ethiopian case.

Based on the analysis of Table 1, the relative cost-protein ratio of meat, milk, and eggs in Addis Ababa, Ethiopia market indicated that when meat is used exclusively instead of eggs to meet their daily protein requirement (19 grams), the price will increase by 123%. But if meat is used instead of milk for the same purpose, the cost-protein advantage will be increased by 51% meaning consumption of meat is better than milk. If eggs are used instead of milk for the daily protein requirement of under-five children, the cost-protein advantage will be 243%. Therefore, based on their cost-protein advantage, the results of the three comparisons indicated that the consumption of eggs is by far better than meat and milk. Meat comes in the second position and milk in the last raw.

**Table 1.** Protein-cost estimates of common ASFs in Addis Ababa, Ethiopia

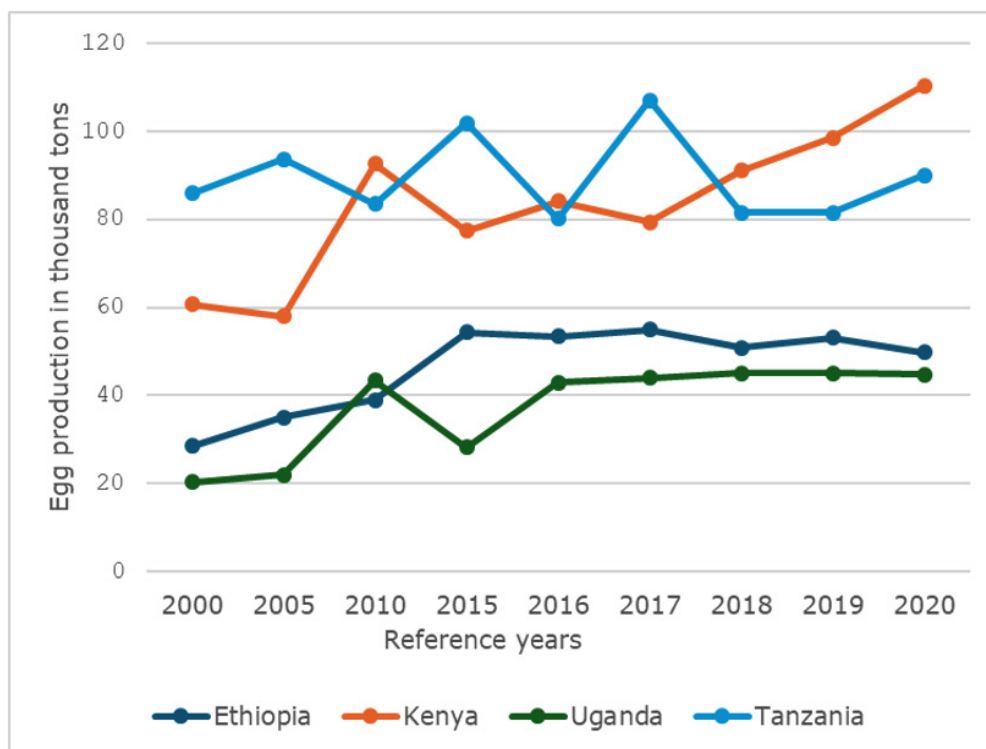
No	Description	Common Livestock Products			Source/remark
		Meat	Eggs	Milk	
1	DM content (%)	25	25	13	[29-31]
2	Protein content in grams/100 gm DM	22.5	12.6	3.5	[26]
3	Fresh weight of the products in gm to give the above-mentioned protein	400	400	769	Calculated by the authors
4	Cost of the fresh weight of products to give the above-mentioned protein (ETB)**	320	80	769	Calculated by the authors
5	Average cost of the product per KG as of September 2024 (ETB)	800	200*	100	*20 eggs each 50 gram with 50 gm
6	Fresh weight of the products to give 19 gm of protein	337	603	4175	Calculated by the authors
7	Cost of the fresh products to give 19gm of protein (ETB)	270	121	417	Calculated by the authors

\*\* = Ethiopian Birr

#### EGG CONSUMPTION AND ITS NUTRITIONAL BENEFITS

Increasing egg consumption has the potential to meet nutritional needs, promote growth, and improve cognitive function, physical activity, and general health of infants and young children [32]. However, caregivers rarely feed eggs to their children because of economic reasons, knowledge gap on the nutritional significance of eggs, and their cultural belief that the child is too young to eat eggs [32]. Caregivers' concerns about introducing eggs to younger children aged 6–12 months included fear of food allergies and difficulty in digestion. These views of caregivers suggest gaps in caregivers' knowledge about the appropriate age to initiate feeding eggs to infants and young children. Thus, promoting eggs among caregivers may potentially improve the feeding and consumption of eggs. Information from a campaign promoting eggs would be expected to enter caregivers' social networks and result in behavioural changes [32].

In general, slightly more than half of infants and young children aged 6–23 months in Ethiopia did not consume eggs [32]. Egg consumption was higher when caregivers and household heads had higher education, have economic resources, and when eggs are accessible in the local market. The influence of these determinants on egg consumption may operate through caregiver behaviour and child health [32]. Interventions are needed to overcome constraints related to education, economic resources, availability of eggs in households, and caregiver behaviour to promote egg consumption for infants and young children. Egg production trends in some East African countries between 2000-2020 [Figure 9] indicated that, during the reference period egg production increased by 74% in Ethiopia, 82% in Kenya, 119% in Uganda, and only 5% in Tanzania. These indicated that even though some progress is observed there is still a huge gap to address the nutrition deficiency in these East African countries [32].



**Figure 9.** Production of hen eggs (thousand tons) for selected East African countries between 2000-2020.

Source: [14].

According to the review study made by [33,34], among ASFs, chicken eggs are considered the best choice due to their affordability, limited taboos, accessibility, and limited requirements for refrigerators.

Eggs can be purchased relatively cheaply and in small numbers. Poultry meat and eggs are widely available, relatively inexpensive, and can be of central importance in helping to meet shortfalls in essential nutrients, particularly for impoverished people. The incidence of several common metabolic diseases associated with deficiencies of critical dietary minerals, vitamins, and amino acids can be minimized by the contribution of chicken eggs, which are rich in all essential nutrients. Consumption of one egg per day per child will not affect blood cholesterol and recent research also suggests that two eggs per day per adult will also not affect most of the population. In general, eggs are not detrimental to human health and for those in low-income countries, eggs are very important for good health and well-being, and their consumption should be encouraged [29]. Eggs are a nutritious food for children of all ages, including those under 5 years old. They are a good source of protein, choline, vitamins A, D, E, and K, and selenium. Eggs also contain healthy fats, which are important for brain development [33-35].

Chicken eggs are the most widely consumed type of egg, although the diets of many populations also include eggs from other poultry species, such as turkey, duck, quail, and goose. Egg in shell is the predominant product on the market, although there are others, including liquid eggs and egg powder. The literature on the nutrient composition of eggs often differentiates the nutrient content of the yolk from that of the white. These two constituents originate during different phases of egg production and serve separate functions in the development of the chick: the yolk is derived from hepatic tissue which is primarily nutritive, and the white is secreted in the oviduct and serves largely for defense [36].

The combination of amino acids and proteins in eggs is considered a gold standard against which other proteins are compared [36]. The concentration of proteins does not vary greatly across bird species, with slightly higher levels in turkey eggs (13.7 g/100 g) and goose eggs (13.9 g/100 g) than in chicken eggs (12.6 g/100g). A study made by [36] found a higher quantity of essential and total amino acids in the albumen of turkey eggs than in that of chicken, duck, goose, quail, and pigeon eggs, although a higher ratio of essential to total amino acids was found in duck and goose eggs than in chicken, turkey, quail, and pigeon eggs.

Egg is the most nearly balanced food of all the foods available to man. It contains all the essential nutrients that we need for growth, maintenance, lactation, and reproduction. The edible portion of the egg is made up of the yolk and the albumen. A hen's egg weighing 57g gives us about 51g of food materials made up of 18g yolk and 33g albumen. The nutrients include proteins, fats, vitamins, and minerals [37].

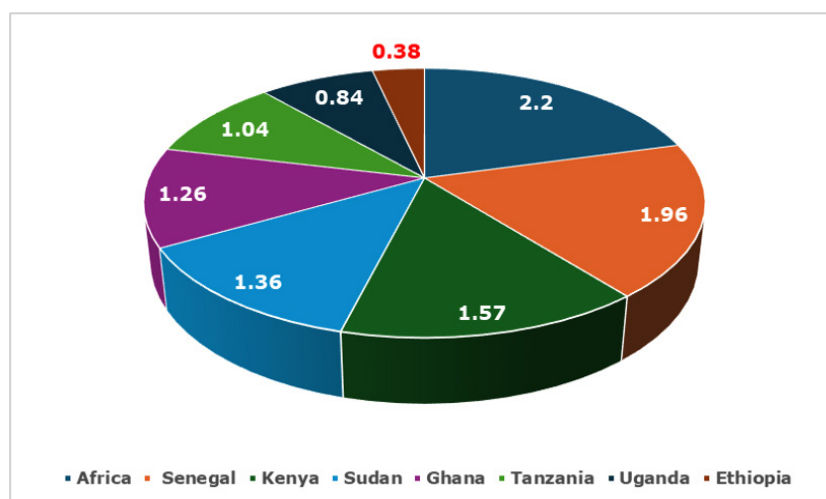
The nutritional contents of eggs indicated that yolk and albumen contain about 17.5 % and 11.0 % protein, respectively. An egg of 57g contains 6.7g protein (3.64g in albumen and 3.15g in yolk). It is a highly digestible quality protein. The biological value of egg protein is 95% as compared to 85% for milk and 70% for meat protein (Biological value is a measure of how much protein from food is absorbed and used by an organism's body). It is a complete protein because it contains all essential amino acids required to maintain the body and promote growth and reproduction [37]. Whereas, eggs are moderate from the standpoint of calories content. An egg of 57g supplies 90 calories of energy to our body [37].

When we see the vitamin contents of eggs, the egg contains all fat-soluble vitamin- ADEK and all members of the B-complex including vitamin B12 which are stored in the yolk. Egg yolk is a potential source of vitamin A which varies from 200 to 1000 I.U. Its component is present in pure form as well as in precursor i.e., as carotenoid pigments. The quantity of vitamin D depends on direct sunshine to the layers and vitamin D supplements in the poultry ration. An egg supplies 15% of vitamin D of the daily needs of an adult person [37]. On the other hand, eggs contain large amounts of minerals. It contains 116 mgm phosphorous of which 110 mgm is present in the yolk, iron-2 mgm mostly in the yolk, and calcium in the edible portion is about 2gm per egg. Others are Na, K, Mg, S, Cl, Zn, Cu, Mn, etc. are also present [37].

Eggs are almost pure protein of very high quality. They also provide virtually the entire Adequate Intake for young children of vitamin B12 and choline. The essential fatty acid content of eggs may be especially important in pregnancy. Eggs are a highly popular food in many countries and can be produced at affordable prices. Hence, they can be used to reduce rampant undernutrition in low- and Middle-Income Countries (LMICs) including Ethiopia [37]. Some main barriers to egg consumption in LMIC include unaffordability and unavailability, partly due to low poultry productivity, high poultry feed prices, and cultural beliefs, many of which disproportionately restrict egg consumption among children and pregnant women [38]. The evidence supports egg intake as a mechanism for meeting nutrient recommendations and a healthy diet in LMIC [38].

Both demand and supply-side policies can serve as strategic solutions to removing barriers to egg consumption in LMICs. Supply-side policies, including those targeting agriculture, trade, value chain policies, and investment, can help drive down the relative price of feed, poultry production, and ultimately eggs, thereby increasing egg affordability [38]. Further enabling policies that provide incentives, the requisite training, and affordable resources to farmers and value chain agents for increasing poultry production can increase egg availability. In addition, demand-side policies through nutritional counselling and media campaigns, including behavioural-change campaigns, social protection programs, the inclusion of eggs in school meals, etc. can remove the cultural barriers and taboos and significantly foster and facilitate egg consumption in LMICs [38].

As Figure [10] below indicates, Ethiopian farmers should produce eggs six or more times to reach the African average which is 479% higher than the Ethiopian average. On the other hand, the per capita chicken egg consumption of some selected African countries including Ethiopia is summarized and presented in Figure [10].



**Figure 10.** Percapita egg consumption in kg for some selected African countries.



Source: [39].

Eggs provide an exceptional protein source as well as fatty acids and a large range of vitamins, minerals, and bioactive compounds that could potentially improve birth outcomes, child nutrition, and brain development. Egg consumption is low among women of reproductive age and young children with the lowest intakes in the African Region, India, and among children 6 to 8 months of age in all regions. Feeding one egg per day for six months for 6-9-month-old children in Ecuador revealed, an increase in linear growth, reduced stunting by 47%, improved underweight by 74%, and an increase in biomarkers associated with cognitive development [34]. Eggs provide the most concentrated source of choline, which is essential for a myriad of processes critical for brain development. The unique egg matrix that includes macronutrients, micronutrients, and hormone and immune factors may act in concert to not only promote growth but also child development [34].

## CONCLUSION

The prevalence of stunting varied substantially at subnational and local levels over time. Spatial clustering of stunting indicated that low-income countries are the ones who suffer more from undernutrition and stunting than developed countries. Therefore, understanding physical and economic access to healthy diets is important to determine success in delivering sustainable and healthy diets to all and reducing stunting and undernutrition. The escalating food prices coupled with low wages or incomes can interact to make healthy diets unaffordable for many, presenting a serious constraint to improved diet quality. Moreover, while healthy diets can become more expensive in nominal terms, whether they become more expensive for the poor depends on whether the poor's income rises more, less, or equally to the increase in the costs of nutritious diets. The cost share of each food group within the total cost of a healthy diet provides important information for policymakers and the reader, highlighting areas for interventions to reduce food costs or increase their affordability and benefit most from nutritionally dense diets.

Affordability is a major barrier to improving healthy diets in Ethiopia. Meeting daily recommendations for starchy staples and oils/fats are relatively the cheapest, and animal-source foods command the highest cost share of the recommended food groups, followed by fruits and vegetables. Animal-source foods supply not only high-quality and readily digested protein and energy but are also a compact and efficient source of readily available micronutrients.

This review study indicated that in the last three years, the price of animal-source foods in Ethiopia is skyrocketing as compared to cereals-based diets. Those households with better income and located in urban areas are relatively better at accessing nutritious foods. The lower quantile of society and those people living in rural areas are the most affected social segments when it comes to securing their daily nutrient requirements in Ethiopia. The study further indicated that, in the last three years, the average price of major livestock products (meat, eggs, and milk) in Addis Ababa at some pocket market sites increased significantly. For example, beef prices increased by 33.3%, cow milk by 100%, and eggs by 43%. These escalating prices coupled with the limited purchasing power of most people reduced their consumption of nutritionally dense products. The limited information available on the cost-nutrient ratio affected consumers which ASF to select at a reasonable price (value for money).

The data taken from some pocket areas of Addis Ababa on the relative cost of proteins of ASFs indicated that eggs are relatively the cheapest protein sources as compared to meat and milk. Meat comes in the second position in terms of protein economics and milk takes the last position. In addition to the highest biological value of eggs, the mineral and vitamin contents of eggs are still better than the other two. If a child consumes exclusively eggs rather than meat to meet their daily protein requirements (19 grams), there is a 143% cost-protein advantage. If a child consumes meat instead of milk to meet their daily protein requirements, the cost-protein advantage of meat will be 51%. When we prefer eggs for our children instead of milk, a child fed with eggs will be 243% times more benefited in terms of protein cost ratio. The other added advantage of consuming eggs per day by under-five children and the rest of the lower quantiles of the population is that eggs are accessible by most families, affordable per unit size, and don't need cold chains for transportation and storage. Eggs are also free from adulteration and other quality disturbance misconduct. But based on the income of the households and affordability, consumption of eggs is the first choice from ASFs (meat, and milk) in the Ethiopian case. However, for a child to meet its daily nutrient requirement it needs a minimum dietary diversity not only one product like eggs. The review study also focused only on protein economics, not other nutrients. However, the information will give a clue for consumers and decision-makers on major nutrients (protein), and its economics to invest more in the most economically feasible sector.



## RECOMMENDATIONS

- The consumers can get better nutrients for the same price from eggs than meat and/or milk. So, parents or caregivers can feed their children one to two eggs/day/child for better physical as well as cognitive development.
- Those nutrition-sensitive projects engaged in nutrition-smart activities can use the information when they formulate policies and strategies.
- There should be a promotion on the importance of egg nutrition to bring behavioural changes among family members to stimulate better adoption of egg consumption.
- Nutrition policies and programs should focus on nutrition-sensitive agricultural extension, livelihood improvement, and women empowerment interventions integrated with egg nutrition education.
- Cooking demonstration of eggs and children's egg consumption to rural women is very important to share new and locally acceptable recipes.
- Prepare and disseminate educational materials on nutrition-sensitive messages including egg nutrition.
- Promotion using local media on nutritional importance and the economic advantage of eggs should be frequently done by the government, development partners, private associations, and civil societies.
- For calculating least-cost diets from ASFs, food group recommendations should be based on their nutrient contribution cost (value for money) instead of grams.

## CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest related to this study.

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