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Fundamental Factors Reducing Feed Quality, Efficiency, and Carrying-Over Impacts: A Review

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ABSTRACT

The aim of this paper was to systematically reviewing the selected feed factors. A worldwide food demand, including animal-derived food is highly predictable to increase at 60% by 2050, particularly in developing countries. By 2030, an annual meat consumption is also estimated to grow from 25.5 to 37 kg per person. In some parts of the world; however, such a growing demand isn't currently matching with a comparable growth in the local production. For example, by 2050, around 40% of an animal-sourced food could be imported by African countries. Although such insufficiency of an animal-sourced food is generally due to that of the farm-animals' low productivity, this is specifically believed to be because of the poor quality and inadequacy of the feeds. Both anti-nutritional factors (ANFs) and mycotoxins are the main factors that can contribute to the low quality and less efficiency of the feeds. Although some have beneficial effects, at their low concentrations, anti-nutrients are generally accountable for the harmful effects on the nutrient absorption. For example, up to 50, 23 and 10% of proteins and amino acid digestibility, in non-ruminant animals are reduced by the presence of trypsin inhibitors (TI), tannins and phytates, respectively. Feeds that are toxic for the mono-gastric animals may not be toxic to the ruminants. Soaking/roasting followed by pressure cooking is one of the best treating mechanisms to reduce those of the harmful effects of ANFs. Supplementation of the feeds with typical microbial enzymes, particularly when they are in a combined state enables also to reduce the negative effects of ANFs. A quarter of the world's crops are being contaminated by the molds and fungi, and hence aflatoxin is an inevitable contaminant. Consequently, when animals eat these contaminated feeds, with aflatoxins the milk, eggs and meat could have the safety concerns to the human consumers. Due to that of some weak regulatory standards, the South-East Asian and sub-Saharan Africa (SSA) countries remain at a high risk of aflatoxin contaminations. In addition to that of the carrying-over impacts of aflatoxins, ANFs and mycotoxins are the main factors that are reducing the feed quality and efficiency, in animal production.

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Introduction

As compared to other parts of the world, agricultural productivity, in developing countries, particularly in Sub-Saharan Africa (SSA) remains low and it is even falling behind (Fuglie and Rada, 2013). Although both insufficient production and the low-productivity are its current characteristics, livestock production contributes around 33-35% of agricultural GDP in SSA (Ehui et al., 2002). Panel (2020) added also that livestock has a great contribution to the Africa's GDP, which ranges between 30 and 80%, across countries.

Livestock's low-productivity is mainly contributed by the poor quality and inadequate quantity of the feeds (FAO, 2019). Some factors that are greatly contributing to the poor feed quality are also due to the presence of factors, such as anti-nutritional factors (ANFs), mycotoxins and alfatoxins (D'Mello, 2006). Anti-nutritional factors and mycotoxins are always occurring in all major feed materials, such as processed/mixed feeds, cereals, protein concentrates and forages.

On the other hand, Thomas and Rangnekar (2004) suggested that over the next 20 years, there will be a massive increase, in the demands for foods of animal origin in developing countries. Rojas-Downing et al. (2017*)* added also that a worldwide demand for the livestock products is being projected to double by 2050. Therefore, the aim of this paper is to systematically review, analyze, summarize, and then to publicize the relevant information on the impairing effects of the fundamental factors of the feeds, and carrying-over impacts on the stakeholders /beneficiaries

Animal-Derived Products and the Consumers' Demand

Although a worldwide food demand is expected to grow at 60% by 2050, this rise will have projected to be even greater in SSA (Van-Ittersum et al., 2016). Protein and amino acid requirement (on average) in human nutrition is estimated to be around 105 mg nitrogen/ kg body weight per day (Who, 2007). Komarek et al. (2021) added also that the world's average protein demand might be increased by 14% per head, with a total of 38% (between 2020 and 2050). However, world's determination to meet the nutritional needs of the poorest population is being ignored (Enahoro et al., 2018). Livestock production has increased in developing countries; but animal-sourced protein consumption is almost limited and is continually decreasing (Schönfeldt and Hall, 2012). Income growth has always hastened the dietary transition towards to a higher consumption of meat, fruits and vegetables (FAO, 2017).

The fastest increase rates of protein demand, per person were 49 and 55% in South Asia and SSA, respectively (Komarek et al., 2021). In principle, a growing demand for meat, milk and egg will also drive the growth of livestock production (FAO, 2017). Demand for animal-derived products, in SSA is growing progressively. However, this trend of an increasing demand isn't currently being matched by a similar growth in local production (Herrero et al., 2014).

Between 1999 and 2030, a yearly meat consumption, in developing countries is expected to grow from 25.5 to 37 kg per head, compared with a raise from 88 to 100 kg in developed countries (Bruinsma, 2017).

By 2050, around 40% of the protein foods that are derived from livestock and poultry will be projected to be imported by African countries (Enahoro et al., 2018). In Africa, the rate of consuming the foods that are derived from livestock and poultry, is generally skyrocketing (Prica-Cimarra et al., 2014). Dairy and poultry production have been offering the highest potential for the benefits of the livelihoods and they are also the key food nutrient suppliers to the poor people (Enahoro et al., 2018).

A sustained and substantial shifting of human diets towards to livestock-derived foods is already happening (Komarek et al., 2021). A demand for foods of animal origin may grow over the years, and this is due to the changing of the key drivers, including those of the growth of human population, income, and consumer preferences (Komarek et al., 2021).

Common Factors Reducing Feed Quality and Efficiency

There is concern that animal source-food production is an inefficient and more extravagant than production that of crop-sourced foods. The feed competence symbolizes the collective efficiency, with which animals utilize the dietary nutrients for maintenance, lean gain and lipid accretion (Patience et al., 2015). Feed-efficiency is a complex entity by its nature, because it is affected by much more than the composition of the diets (Patience et al., 2015). The same author reported that utilization of energy, in the diet is a fundamental driver of the feed-efficiency. Either under-consumption or overconsumption of an animal-derived food can create a threat on animal-health-care system.

A High Concentration of Selected Factors in Feeds and their Effects

Plant species, season and their interactions can generally influence the concentration of anti-nutrients and minerals in both forage-grasses and legume-plant products (Onyeonagu et al., 2013. Grass seeds usually contain a more amounts of starch, and a less total phenol concentration than the seeds from forbs (Rios et al., 2012). Forages and the root-brassica crops contain a non-protein amino acid in the form of S-methyl cysteine sulfoxide (Rios et al., 2012).

Feeding the feed with a dietary phytate level of greater than 0.319% reduced the feed intake, body weight gains and feed efficiency of the chickens (Walk and Rao, 2002). It is always lethal to the animals when the concentrations of cyanogenic glycosides and phytates have both 50-60 mg/kg of the feeds. It is also lethal to the farmed-animals when the concentration of both oxalate and TI found to be 2.5 g per a kg of their feeds (Inuwa et al., 2011). These concentrations look higher compared to the amounts that can be possibly and practically be found in the food/ feed substances (Inuwa et al., 2011). Akaninyene et al. (2011) evaluated the concentration of some ANFs, in leaves of puberula plant, such as phytic-acids (18.220 $\pm$0.030 mg/kg), hydrocyanide (0.002 $\pm$ 0.000 mg/kg) and oxalate (1.861 $\pm$ 0.002 mg/kg) and then these ANFs are found to be at their low levels. Balina et al. (2018) added also that the lethal dose values of alfatoxins ranges from 0.5 to 10 mg/kg of the feed.

Although Hell and Mutegi (2011) reported that decreasing and decontamination of aflatoxin is regularly attained by applying physical, chemical and microbiological treatments, other scholars (Cassel, 2001; Khan et al., 2021) reported that due to its colorlessness, odorless and tastelessness, it is very difficult to detect the aflatoxin, and it isn't usually treated by the heat, cold or light. Once an aflatoxin is produced, it is stable. Leave-alone a high concentration, low concentration of aflatoxins is dangerous for both human and the livestock (Mahato et al., 2014). Money-making products like the peanut-butter, cooking-oil and cosmetics were also reported to be contaminated by aflatoxins (Mahato et al., 2014).

To be safe or not to exceeding the Food and Drug Administration level of 0.5 ppb in milk, do not exceed a 20-ppb aflatoxin level per a kg of the feed in the rations of the lactating cows (Cassel, 2001). Treating the roughages, with a white-rot fungus also showed a higher digestibility for the ruminants (Mahesh and Moheni, 2013).

Effects of Anti-Nutritional Factors, on the Ruminant-Animal Production

Tannins are the secondary plant metabolites and are one of the most common ANFs in animal feeds. Tannins and saponins are known to inhibit the growth of that of some bacteria species and protozoa in the rumen, respectively and are the most common ANFs in the feeds of ruminant-animal (El-Shewy, 2018). Etuk et al. (2012) added also that the main effect of tannins is to reduce a voluntary feed intake. This is mainly due to reduction of the palatability, diminishing the digestibility of the feeds and creating toxicity in the rumen ecology.

Although a high concentration of tannins always reduces both a voluntary feed intakes and nutrient digestibility, its low concentrations may also improve digestions that due to its reduction effects on the protein degradation in the rumen (Frutos et al., 2004). Due to the presence of anti-nutritional substances, leaves, pods and edible twigs of shrubs and trees are not properly utilized by the animals (Kumar et al., 2017). Atiku et al. (2016) reported also that levels of ANFs become high at a dry-time, but those freshly browse-able plants contain, relatively low levels of ANFs, which makes these plants to be safely consumed by the ruminant animals. The ANF do not affect all ruminants equally. Although Bhat et al. (2013) reported that, so far there was no any a successful method in a total inactivation or removal of tannins that without losing the nutrients, Wang et al. (2022) suggested that addition of a lactic acid bacteria in ruminant-animals' feeds can improve the fermentation and thereby reduce the effects of ANFs, including tannins.

Feed ingredients, for the ruminant-animals are traditionally being collected from everywhere that could be contaminated by the mycotoxins, as compared to the non-ruminant animals, for example, feeds of swine or poultry have less probability to be contaminated (Gallo et al., 2015). Binders are usually used to minimize the negative effects of ANFs, and the diets may also be treated with the other decontaminating products. Animals may also be supplemented with antioxidants and the response found so far, in dairy cattle to some of these products, have been very encouraging (Whitlow and Hagler, 2010). Since rumen microbiota have the capability to degrade both ANFs and mycotoxins, ruminant-animals have more resistant to the adverse effects of these factors (Zain, 2011).

Effects of Anti-Nutritional Factors, on both Non-Ruminant and Aquaculture Production

Several feedstuffs that are usually used in preparing the diets for the mono-gastric animals contain ANFs. These compounds always interfere with the utilization of the dietary nutrients in a variety of ways (De-Lange et al., 2000). However, Hassan et al. (2020) reported that some ANFs have their own health benefits (when they are at low concentration), especially by preventing the zoonotic pathogens, such as salmonella. Feed additives that are required to replace coccidiostatic or anthelmintic activities (Wenk, 2003) are the probiotics, prebiotics, enzymes and highly available minerals that can motivate both the feed intake and hormonal secretions or to have antimicrobial effects.

The mycotoxins have always negative impacts on the health, productivity and economic-losses of both layer and broiler chicken productions (Ochieng et al., 2021). Due to the contamination of poultry feeds, with mycotoxins, their products, including eggs and meat have safety concerns to human consumers (Ochieng et al., 2021).

The presence of ANFs, in most of plant sourced ingredients, interfere with that of both the feed acceptance and animal performances. This is due to an impairing effect on the metabolism as well as digestibility by the ANFs (Kokou and Fountoulaki, 2018). The presence of ANFs, within the plant feedstuffs is one of the major factors that limit the use of feedstuffs that are being sourced from the plants, at a higher dietary inclusion level within the aqua-feeds (Tacon, 2002). Although scholars (Francis et al., 2001) stated that some ANFs, such as protease inhibitors, phytates, antigenic compounds, and alkaloids are unlikely to negatively affects the growth of fish, others (Kumar et al., 2012) reported that the major concerns about the presence of phytate in the aqua-feeds is its negative effects on the growth performance, nutrient and energy utilizations, and mineral uptakes.

The presence of ANFs, in untreated foodstuffs, usually results in a loss of appetite, reduced growth, and poor feed efficiency, especially when they are used at their high dietary concentrations (Tacon, 2002). Certain symptoms, such as nausea, bloating, headaches, rashes, nutritional deficiencies, e.t.c., are being expressed when large amounts of anti-nutrients are available in the animals' body. Many types of ANFs are available in feeds, such as phytates, oxalates, and lectins, which are the well-known anti-nutrients (Popova and Mihaylova, 2019). Although the presences of ANFs, in the raw soybean interfere with the growth performance, it is recommended to use the replacement level of raw soybean below 35%, as it does not affect the fish health (Martins et al., 2017).

Anti-Nutritional Factors and Their Impairing Impacts

Feed is one of the most important inputs that are related to the livestock production and profits (Edwin, 2021). In addition to having high amounts of both macronutrients and micronutrients, some feed ingredients contain ANFs (Gemeda and Ratta, 2014; Bueno et al., 2018; Samtiya et al., 2020). Anti-nutritional factors are compounds in feeds /foods, which tend to decrease the availability of nutrients to consumers.

Although, different species and ages of animals react in different ways to the presence of ANFs in their feeds, these ANFs are still causing to despair the growth, performance and lives of these animals. High concentration of ANFs can also minimize the quality of the feed-ingredients (Stein et al., 2008; Erdaw et al., 2016; Erdaw and Beyene, 2018).

The ANFs are accountable for the harmful effects on the nutrient absorption; however, some anti-nutrients have beneficial effects at their low concentrations (Gemeda and Ratta, 2014). Digestibility of the protein, bioavailability of the amino acids and protein quality of the feeds are negatively affected by the presence of ANFs (Gilani et al., 2012). For example, Gilani et al. (2012) reported that the presence of high levels of dietary trypsin inhibitors (TI) from leguminous plants may impose for a considerable individual digestibility reduction in protein or amino acids (up to 50%) and protein quality (up to 100%) in the rat and/or pig feeding. Correspondingly, the occurrence of high levels of tannins in sorghum can meaningfully diminish (up to 23%) in protein and amino acid digestibility in non-ruminant animals. Phytates can also decrease the protein and amino acid digestibility by up to 10%. Due to the presence of D-amino acids and lysinoalanine, the protein-quality and digestion are also reduced by up to 100% and 40%, respectively. Concentration of TI and lectins can vary depending on the soybean varieties (Gu et al., 2010). Protease inhibitors (PI), in unheated beans, can harmfully affect the internal protease activities (Mogridge et al., 1996). Birds fed diets containing unheated beans showed both the low performance and negatively affected pancreases (Newkirk, 2010). The TI is naturally rich in sulphur-containing AA, and thus as an anti-nutrient the TI can produce pressure that create deficiency of methionine, which is basically the main deficit among the AA in leguminous plants, such as soybeans. Feeds that are toxic to mono-gastric animals may not be toxic to the ruminant animals because ruminal activity has a natural capacity to transform or degrade these compounds into a less toxic or harmless products (McSweeney et al., 2002).

Reducing the Influences of Anti-Nutritional Factors in Feeds

The main anti-nutritional factors that are available in plant-derived feedstuffs and key suggested solutions are shown in Table 1. Heating the feeds outweigh the other solutions that to reduce the negative effects of ANFs. Supplementing the feeds with microbial enzymes or chemicals are also the other suggested solutions to minimize the impairing impacts of ANFs.

kamalasundari et al. (2019) added also that the best treatment to reduce ANFs is soaking/roasting followed by pressure cooking. Even after processing and cooking, certain foods may still contain certain amounts of residual anti-nutrients, but the health benefits of eating these foods outweigh any potential negative nutritional effects. Soetan and Oyewole (2009) found and then reported that a limit for mycotoxins in dairy feed is ranged between 5 to 50 mg/kg or ppm; whereas a concentration limit of aflatoxin-B1, in a dairy feed is ranged between 5 to 20 μg/kg or ppb. The limit for aflatoxin-M1 concentration in the milk is also ranged between 0.5 to 0.02 μg/kg or ppb.

Amino acids' digestibility was extensively different, but this variation wasn't associating with the levels of TI concentrations in different soybean varieties (Clarke and Wiseman, 2005). But, diets, with raw soybean, had triggered an internal protein loss (Barth et al., 1993). Microbial proteases are protein-digesting enzymes that can chemically decompose both deposited proteins and proteinaceous anti-nutrients in the plant proteins (Barletta, 2011). Therefore, by supplementing microbial protease, the feed efficiency and utilization of the crude proteins and energy would be advanced (Freitas et al., 2011). Oxenboll et al. (2011) suggested also that due to supplementation of this microbial-feed enzymes, it enabled to diminish the N_2 excretions. Not only this, but also protease supplementation decreased the negative effects of anti-nutritional proteins on some animal species (Petterson and Pontoppidan, 2013).

A combined use of microbial phytase and protease enabled to enhance the nutrient withholding and enhanced the performance of the chickens by 14% (Cowieson and Adeola, 2005). Murugesan et al. (2014) reported also that the nutrient use was boosted when the chickens' mixed-feeds were added with that of protease and phytase enzymes. But there was no extensive evidence amongst the rations and enzyme products, which are containing xylanase, amylase and protease in terms of an ileal digestibility of N2 and amino-acids (Cowieson and Ravindra, 2008). Because of using the acetic acids (10% (w/v), in soybean, the allergenic protein was completely disappeared, and the TI content was also reduced from 5.15 to 1.03 mg/g (Huang and Xu, 2018). Steam cooking has such a promising option to diminish the ANFs up to 96%; while, soaking can diminish up to 45%. Germination /sprouting can also reduce around 33 to 72% of the tannins and 96% of phytates. Additionally, an extrusion technic diminishes up to 55.83% of the ANFs (Diouf et al., 2019).

Treating the feeds to improve the quality, efficiency and utilization

As Erdaw et al. (2016) reviewed and reported that treating feeds with heat is normally a well-thought-out as the most effectual technique to denature some of the TI, but not the phytates, or Bowman-Birk Inhibitors, oligosaccharides, and antigenic proteins. Furthermore, Perilla et al. (1997) reported that either below- or extensive-warming/heating of any bean seeds at times of treating has usually reported to reduce the nutritional values of the meal for mono-gastric farm animals. With regards to the commercial SBM that is being found as the byproducts after extracting the beans' oil by chemicals, such as solvents are also questionable as the presence of residual chemicals in the SBM may pose the risks on human health.

Feed supplementation with microbial enzymes, such as phytase and protease, is attractive and common biotechnological techniques for enhanced nutritional values of the meals. The feed intake of the broiler chickens was reduced due to the raw soybean supplementation, but when supplementing with that of the microbial protease the BWG and FCR were improved (Erdaw et al., 2017b). Addition of the microbial protease, on feeds considerably enhanced the apparent ileal digestibility and standardized ileal digestibility of the lysine (Erdaw et al., 2017b). Erdaw et al. (2017b) added also that it was observed that around 9% upgrading of apparent digestibility of AA in broilers when their feeds were added with the microbial protease enzymes.

The digestibility of most of the AA were decreased when rising the levels of supplementing the raw soybean, but supplementation of microbial protease had no significant effects (Erdaw et al.,2017b). This means that supplementation of the microbial protease reduced the negative effects ANFs in the raw soybeans. Similarly, Grosjean et al. (2000) reported also that standardized ileal CP and most AA digestibility of the pigs decreased with increasing the TI activities of the peas, but it was not affected by the fiber contents. However, protein utilization, by the old rats was noticeably inferior, compared to results in young rats when fed the products that containing anti-nutrients (Gilani and Sepehl, 2003).

The BWG and FCR of the broilers were improved when a 25% of the commercial SBM was substituted by an unheated full-fat soybean that was also added with microbial protease or phytase into the diets (Erdaw et al., 2018a, b). The same authors added also that the apparent illeal digestibility of the CP and AA was improved when protease was supplemented.

A study was conducted onto the diets that was supplemented with an increasing level of both unheated full-fat soybean and microbial protease, and then the result showed that the digestibility of indispensable and dispensable of AA was not statistically affected by that of adding graded levels of protease enzymes (Erdaw et al., 2017a). The same authors reported also that the AID value of the methionine was 94.1%, which is the highest value, compared to the other indispensable AA.

Improving the feed quality and efficiency

Although it is believed to have low productivity, SSA has diverse agro-ecology, abundant land, and this region possesses around 14% of the global croplands and 21% of the pastures (OECD/FAO, 2021), which shows a high potential to improve the production. These all show that Africa has the potential, at least to produce high amounts of the feed /quantity.

In addition to increasing that of producing high amounts of feeds (in quantity), quality improvement strategy must also be considered. Heating the feeds that are containing the ANFs and also supplementation the feed with that of microbial enzymes are the two main suggested solutions to improve the feed utilizations. Microbial protease is one of the protein-digesting enzymes, which is generally being used in the mono-gastric animals, including in feeds of pig and poultry nutrition to chemically decompose that of a stored proteins and protein-like anti-nutrients in various plant materials (Barletta, 2011; Hell and Mutegi, 2011). Microbial phytase can also hydrolyses the phytic-acids (Rostami and Gri, 2013), thereby improves the phosphorous availability and the CP as well as AA utilizations in birds ([Barletta, 2011; Guggenbuhl et al., 2012). The performance of mono-gastric animals, including poultry and pigs enhanced when the particle size of the feed is finer. This might be due to an increased surface area that allows for the better contact with the digestive enzymes (Kiarie and Mills, 2019).

Animal feeds and feeding practices can be changed by the biological-catalysts, such as fungi; with the objective that to improve the nutritive values and thereby to reduce an environmental waste (Mahesh and Mohini, 2013). Probiotics and nanotechnology are also the two pathways that to improving the feed resources and nutrition of the livestock (Tona, 2018). Samtiya et al. (2020) reported that by using an individual method alone or in combination, it is possible to reduce the level of anti-nutrients in foods / feeds. An increase in nutrient efficiency represents an economic gain while maximizing environmental performance (Pomar et al., 2021).

It is very significant to avoid or limit the aflatoxin contaminations in the animal feeds that to reduce the danger of contamination of these metabolites in foods of animal origin (Khan et al., 2021). Though the greater numbers of ANFs have been recommended to be deactivated by heating, over- or under-heating still disturbs the superiority/quality of the feeds. Breeding for a low TI content of soybean-cultivars, presently has also partial applications as the TI contributes the main quantity of the sulfur-comprising AA (Clarke and Wiseman, 2000). Although many of ANFs are denatured by different processing methods that emphasizing on their toxicity and negative effects of these compounds on animals, and yet recently an increasing interest is also differently occurring on the biologically active compounds that have medicinal values (Soetan, 2008).

The Benefits of Anti-Nutritional Factors When They are at Low Concertation

Strong emphasis has always given on the toxicity and anti-nutrient effects of ANFs, but these factors also have health and other benefits (Soetan, 2008). Phytic-acid is normally considered to be an ANFs; however, these same minerals have the binding property that can provide a number of health benefits, such as reducing the risk of certain cancers, supporting heart health, and managing the renal stones (Feizollahi et al., 2021). Gemede and Ratta (2014) added also that some anti-nutrients, such as phytates, lectins, tannins, amylase inhibitors and saponins may exert the beneficial health effects by reducing the blood glucose and insulin responses to the starchy-foods and/or the plasma cholesterol and triglycerides.

Presence of ANFs, in feeds/foods might not always destructive, but what matters is the concentration, chemical structure, time of exposure and interactions with other dietary components (Gemede and Ratta, 2014). Anti-nutritional factors can also be the source of a changeable positive effects on animals, such as reducing the parasite burdens, helping for the protein degradation in the rumen, and reducing the methane emissions, reducing both methane emissions and bloating effects in farm-animals. Anti-nutrients act as useful natural drugs to ameliorate the human health; if they are consumed in adequate amounts, and the ANFs may also have the physiological benefits that in the nutrition of the organisms (Nath et al., 2022).

Aflatoxins that are Affecting the Feed Quality and Their Carrying-Over Impacts

An acceptable level of aflatoxin, in animal feeds, mainly in the corn and peanut-products are shown in Table 2. As indicated in this Table, aflatoxin is highly and mainly contaminating and negatively influencing both the feed quality and efficiency in the tropics. The presence of a warm-humid temperature, in the tropics may greatly favor the growth of fungal species that is also indirectly favoring the aflatoxins to voraciously develop and contaminate both the raw materials of the food and mixed feeds, particularly in this part of the world.

However, in reducing the risk of aflatoxin contaminations, scholars (Table 2) are also suggesting to use the binding agents, such as zeolite clays and aluminosilicates and also to blend those contaminated grains with the clean grains. Ammonization and treating the contaminated grains, such as maize by alkaline are also another suggested solution to minimize the risk of aflatoxin contaminations in both the food and feed ingredients. These all-suggested activities, that to reducing the aflatoxin contaminations are actually in addition to the main suggestion that is firstly to apply those good agronomic practices in the crop-farming.

Mycotoxins that can be found in foods and feeds are the secondary fungal metabolites that can affect the biochemical, physiological and pathological changes (Bhat et al., 2010). Aflatoxins are amongst the most poisonous mycotoxins and are produced mainly by fungi *Aspergillus flavus* and *Aspergillus parasiticus.* Cassel (2001) added also that many different fungi species may grow as molds on the stored grains, but Aspergillus is the poisonous and the most carcinogenic one. Mahato et al. (2014) suggested also that the documentation and quantification of aflatoxins in foods and feeds are the main encounters to assuring the food safety. Peles et al. (2019) added also that aflatoxins are widely spreadable and harmful carcinogenic secondary metabolites that are produced by *Aspergillus* species, which can contaminate the feeds and foods. When the ruminants eat such contaminated feedstuffs by the aflatoxins, its form is known as aflatoxin-B1 and this toxin is then further metabolized and changed into aflatoxin-M1, and this is finally excreted into the milk.

The main sources of contamination may be happening through chemical, bio-physical reactions, or due to the involvement of the microorganisms (Balina et al., 2018). Aflatoxins are unavoidably acceptable toxins of the foods and feeds with severe influence on animals and on their derived products (Benkerroum, 2020). Therefore, around 25% of crops, around the world are contaminated by the molds and fungi (Pandya and Arade, 2016). Therefore, due to the weak regulatory standards, Southeast Asian and SSA countries remain at high risk of contaminations (Benkerroum, 2020). Feed contamination is greatly common in the poor countries and it can be also available in animal-derived-products, such as milk, meat and eggs, and consequently there is a possibility to be carried-over to the human consumers that can affect their body systems (Pandya and Arade, 2016). Risks of the aflatoxin infections of the foods and feeds, especially in Africa are augmented due to many factors, such as environmental, agronomic and socio-economic factors (Hell and Mutegi, 2011).

Reduction of both the feed intake and nutrient absorption are some of the negative contributions of mycotoxins (D'Mello, 2006). If the concentration is not limited in foods/feeds, mycotoxins are carcinogens and many of them have also an ANFs effects that can negatively affect the growth and development of young animals (Cardwell, 1999). Molds actually reduce the nutritional values of the feedstuffs and also elaborate several mycotoxins, which have adverse effects on the animal health and productivity, which may also be carried over into the meat and eggs (Greco et al., 2014).

The residues of aflatoxins are being carried-over into the foods of animal origin, which become additional risks to the human health. Khan et al. (2021) added also that aflatoxins are converted into metabolites, which can be accumulated in the foods of animal origin, such as eggs, milk, cheese, and honey. Although several physical, chemical and biological techniques could be applied to minimize the contaminations, mycotoxin is very stable compounds. Daou et al. (2021) added also that food processing plays a minimal role in controlling the mycotoxins contaminations. However, Masoero et al. (2007) reported that residues of the aflatoxin-M1 in milk are relatively regulated by the farmers with high cost.

The rumen flora inactivates many mycotoxins, but some others are still passing the digestive system unchanged/ or are converted into metabolites that still retaining their biological activities (Pink-Gremmels, 2008). Unregulated local markets of developing countries are very conducive to grow molds and then to create a negative health impact. The impact of mycotoxin is obviously higher in under-developed countries (Shephard, 2008).

Table 1. Major anti-nutritional factors, which are available in plant-derived feedstuffs

ANFs	Nutrients originated from plants	Alleviating methods
Proteins reacting with: Protease inhibitors	Soybean meal, Jatropha-kernel meal, rape seed meal, lupin seed meal, peas seed meal, sunflower oil cake, alfalfa leaf meal, sesame meal. Jatropha-kernel meal, pea seed meal, alfalfa leaf meal, Jatropha kernel meal, lupin seed meal, PSM, sunflower oil cake, Tannins, sorghum, Jatropha kernel meal, peas seed meal, mustard oil cake. Supplementary methionine or choline	Heat, autoclaving
Lectins, Saponins Tannins, Chlorogenic-compounds		Heat, autoclaving
Minerals Reacting with: Phytic acid, Oxalic acid Glucosinolates, Gossypol	Soybean meal, Jatropha-kernel meal, peas seed meal, cottonseed meal, sesame seed meal, Leaf proteins Rapeseed, mustard oilcake plants with low content, cottonseed meal	Supplements, use of phytase Treating by heat Genetic improvement of plants
vitamins Reacting With:		
Vitamins A andD	Soybean	Heat treatment
Vitamin E	Kidney beans	Autoclaving,
Anti-nicotinic acid	(niacinogen) corn	
Anti-pyridoxine	Linseed meal	Water extraction, heating
Anti-vitamin B12	Raw soybean	Heat treatment
Cyanogens	Cassava, sorghum, peas seed meal,	Heat treatment
Mimosine	Leucaena leaf meal	-
Arginase inhibitor	Sunflower oil cake	-
cyclopropenoic acid	cottonseed meal	-
antivitamins	alfalfa leaf meal, cottonseed meal, peas seed meal, soybean meal	
Alkaloids	Lupin seed meal	-
Phytoestrogens	soybean meal, lupin seed meal	-

Sources: Francis et al. (2001).

Table 2. Acceptable aflatoxin levels in Animal feeds

Animals	Feed types	Maximum acceptable levels of aflatoxins
In feeds of beef catle	Corn and peanut products	300 ppb
In feeds of beef catle , swine, or poultry	peanut products	300 ppb
Finishing swine	Corn and peanut products	200 ppb
Breeding beef catle , breeding swine, or mature poultry	Corn and peanut products	100 ppb
Aflatoxin is a naturally occurring carcinogenic byproduct of common fungi that is frequently occuring in the tropics, particularly in maize and groundnut. However, some of the effective solutions that can reduce the negative effects of aflatoxin, in feeds are suggested as follows:		
1) By adding the binding agents, such as zeolite clays and aluminosilicates, 2) by blending those contaminated grain with clean grain, and 3) Ammonization and by treating grains, for example maize by alkaline.		

Source: Unnevehr and Grace (2013)

Even-though literatures display excessive inconsistency due to contamination of the feed ingredients, there is a threat of contamination of meat products, egg and milk with mycotoxins (Feddern et al., 2013). Mycotoxins remain inclining to decline quickly after elimination of the contaminated feeds. For example, feeding animals, with diet that is free of mycotoxins, few-days before slaughter, is dignified as a solution to decrease the danger in meat (Feddern et al., 2013). The same author added that aflatoxins have high impacts on egg production and quality. The amounts of aflatoxin-M1 excreted into the milk can be up to 3% of the aflatoxin-B1 in a feed intake (Diaz et al., 2004). Bacterial, fungal, metal pesticides and veterinary drugs are also the contaminants of the animal products (Diaz et al., 2004).

Conclusion

The productivity of livestock, in Africa is generally low and it is believed to be due to the poor quality and inadequate quantity of the feeds. Both ANF and mycotoxins are the main factors that always contribute to the low quality of the feeds. Up to 50, 23 and 10% of protein and amino acids digestibility, in non-ruminant animals were reduced by the availability of the high concentration of the trypsin inhibitors, tannins and phyates, respectively. Feeds that are toxic to mono-gastric animals may not be toxic for the ruminant animals. Due to the contamination of the feeds with that of the mycotoxins, animal derived-products, including milk, eggs and meat have safety concerns to the human consumers. Soaking/roasting or cooking is one of the treating mechanisms to reduce the ANFs. Supplementation of microbial enzymes, especially when they are used in a state of combination enables to reduce the negative effects of ANFs. Around 25% of the world's crops are contaminated by the molds and fungi, and hence aflatoxin is an inevitable natural contaminant of the foods and feeds. Setting a regulatory standard seems to be very important to reduce or control the mycotoxins as well as aflatoxins contaminations.

Abbreviation

AA = amino-acids, ANF = anti-nutritional factors, AID = apparent ileal digestibility, BWG = body weight gain, CP = crude protein, FCR = feed conversion ratio, PI = protease inhibitors, JKM = J atropha kernel meal, RSM = rapeseed meal, ALM = alfalfa leaf meal, SBM = soybean meal, CSM = cottonseed meal, PSM = peas seed meal, SSM = sesame seed meal, BC = beef cattle, PP = peanut products, TI = trypsin inhibitors, SSA = sub–Saharan Africa, FAO = food and Agricultural Organization.

Implications: An **e**nhanced provision of animal-derived products to the society through improved efficiency and utilization of the feed resources.

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