



(RESEARCH ARTICLE)



Global view of animal feed in halal perspective

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GSC Advanced Research and Reviews, 2022, 11(01), 037-069

Publication history: Received on 26 February 2022; revised on 28 March 2022; accepted on 30 March 2022

Article DOI: <https://doi.org/10.30574/gscarr.2022.11.1.0093>

Abstract

Purpose: Islamic concept of food consumption for human beings is derived from the term Tayyib which depicts both food safety and quality. Unlike the humans, though animals are not bound to any code of practice, yet with reference to the food animals their diet seeks the attention of Islamic jurisprudence. Animal feed is the preliminary Halal control point in Halal food supply chain when the matter comes to the animal derived ingredients. This paper aims to put forth a global view of animal feed in Halal perspective by showcasing firstly the global scenario of feed industry, feed compositions, hazards and regional regulations, secondly by highlighting the Halal and Tayyib integrity concerns over different feed compositions and addressing them through the global Halal standards and Islamic rulings issued by various Halal industry players.

Design/methodology/approach: This research presents an interdisciplinary work of Islamic jurisprudence and feed science, which intertwines research on global feed compositions and the fundamental requirements of Halal and Haram jurisprudence.

Findings: Animals are not the addressees of Quran and Sunnah; hence they are not bound to follow any code of religion. They are free to live and consume the way they like; in addition, Islam holds mankind responsible for their welfare and rights. Animal feed becomes an important subject for Islamic Jurisprudence only when the matter comes to the food animals. With reference to the food animals, animal feed is the preliminary control point of food supply chain, hence, it must be from halal source and must not cause harm to the human health.

Originality/value: To our best knowledge, this paper is the first that attempts to elaborate on the global feed scenario including compositions and regulations in halal perspective.

Keywords: Animal; Feed; Halal; Haraam; Tayyib; Najis

1. Introduction

Farm Animals have been a fundamental source to fulfill the multiple needs of mankind. They belong to kingdom ANIMALIA and comprise of mammals and bird which are deliberately raised for food, fiber, fertilizer, draft work and other similar agricultural purposes. The most common of these animals are cattle, sheep, goat, camel and poultry worldwide [1].

About 12,000 years ago inhabitants of fertile crescent which was an ancient, civilized area extending between Mesopotamia, Assyria and some nearby Egyptian regions had begun to raise animal for getting their meat as food, bone for making tools, skin for making bags, fur for making cloths, and for drafting, and ploughing purposes [2]. It is quiet

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unknown how animals were fed intentionally or what could be their feeding system because the practices regarding the rearing animal for food and services had occurred before humans learned writing. Moreover, during early stages of animal husbandry people mostly follow free range grazing of animal to fulfill their own family needs. The secure and reliable availability of food supplied from animals led human beings toward population growth, development of residencies, trade and economic and urbanization. From the birth of Prophet Christ enough food had been available for feeding world's population that was exceeding than a figure of 200 million [2]. Moreover, at the end of 18th century, sound and robust strategies for a fruitful agriculture had appeared which were causing a shift from subsistence farming practices toward commercial farming that in turn guided way for desirable feeding system around 19th century. As the time passes by, science and technology kept on progressing and improving techniques and methods, resultantly animal husbandry embraces more efficient and dynamic form of technology and innovation. Thereby a road map toward evolution of feeding industry comes into being.

All living organisms require food to live and so do the animals. However, the term food is mainly associated to human beings and the word feed although defined slight differently by the standards of the various countries is used for any food producing animals [3-6]. Hence feed is any material either in processed, semi-processed or in raw form when fed to animals furnish nutrition and upon digestion and assimilation of such feed which is utilized by body results in procuring energy, growth, development, reproduction and the maintenance and repair of body cells and tissues [3].

Basically, Animal feed is categorized as forage, fodder, and mixed feed, which is a commercial feed that usually exists in the form of pellets or mash. The forages include non-processed plant material that is offered to animals in the form of pasture, crop remains and vegetation (cereals) grazing while fodder are the processed plant materials both as roughage which include freshly cut grass, hay, silage, haylage or other similar things and as concentrates that include cereal grains, legumes and other by-products resulted during their processing. Mixed feeds include both forages and fodder together with some other organic or inorganic materials called feed additives for achieving a particular objective such as nutritional quality and usually comes in mashed form or as pellet.

Earlier, evidences of feed dated back to 19th century were found, when animals were fed grounded grain. However, it was not a primary source but a secondary mean provided by early mills who were installed for human consumption. In such case non-food or the leftover materials from these mills were fed to animals. Among cereals, oat was cheap and less demanded for humans at that time; hence it was specifically grown and fed to animals, particularly horses. Although in the beginning of 1800, there were commercial opportunities for feed formulation but such was limited to horses and mule that were the mean of transportation and draft work in agriculture. They were reared separately in special houses called "stables" and such houses were like modern petrol stations [7]. The demand of feed for mule and hoes was also high and most of the biggest feed industries even existing today such as Cargill, ADM, Purina Mills and Ridley continued production of value-added feed while requiring less scientific expertise.

Late in 19th century feed formulation had begun to govern under feed standard. Massachusetts was the first region to be reported with batch method of feed manufacturing in 1870 [2]. But such manufacturing happened because the industry followed the first book written on animal nutrition by Armsby and Henry in 1880s [8-9]. Cargill which was typically a flour milling industry began to manufacture animal feed by 1884 after the corn gluten was manufactured for the first-time in 1882. Similarly, in 1894 Purina Mills entered the race of feed manufacturing. During 1890s, these emerging feed industries had utilized brewery as well as meat scrapes that were among the most nutritious by-products to be incorporated in feed manufacturing [10]. Besides, the birth of feed industrialization came into being when the first ray of 20th century's sun lit up the universe and of 19th century remained in memories. There were several background events that had caused such industrialization. One of such was the dumping of milling waste into water bodies. At that time, feeding animals a balance diet was also being recognized as a valuable intervention regarding animal nutrition. The chemical analysis of such mill waste initiated the commercialization of feed industry [2]. Being the religion of love and affection Islam introduced a complete code of animal rights and welfare. Animals are the part and parcel of human society, therefore Islam held mankind responsible for their lives, feed and good treatment. Islamic jurisprudence does not proclaim any code of practice for animals; hence they are free to live and consume the way and whatever they like, but it is not the case when mankind is addressed. Islam has laid down a complete code of human consumption by decreeing the principle of Tayyib which encompasses food safety and food quality. Though the universe is crowded with living and non-living organisms but each and everything is not allowed for human consumption. There are certain restrictions Islam imposes on human diet. Since animals fulfill the multiple food needs of humans, hence their feed is vital in the preview of Halal (allowed) or Haraam (prohibited). With the industrialization of feed and commercialization of feed industry there are several doubtful and questionable ingredients in the context of Islam that are included to the composition of animal feed. In this piece of literature, animal feed is discussed in halal perspective by summarizing firstly the global scenario of feed industry, different feed standards and regulations, multiple feed ingredients and feed

hazards, then by explaining the classical views of Islamic Jurists, latest Islamic rulings and global halal standards, and lastly by giving the outcome of whole discourse.

2. Material and methods

This is a multi-disciplinary work stretching from important regional regulations to Islamic jurisprudence injunctions. To constitute the research on global animal feed in halal perspective firstly the global scenario of feed production was discussed along with the important regional regulations. These regulations were derived from multiple studies; each of them was referenced respectively. Then the Halal and Tayyib integrity concerns were highlighted along with the classical views of Islamic jurists. In the portion of integrity of Halal logo some crucial Islamic rulings and global Halal standards were discoursed to address those concerns and highlight the sanctity of Halal logo. Different terminologies from Islamic Jurisprudence were used, like, Hadith meaning sayings of the blessed Prophet (P.B.U.H.), Halal meaning allowed, Haraam meaning prohibited, Makrooh meaning bitterly disliked, Najis meaning filthy in the eye of Islamic jurisprudence, Tayyib meaning safety and quality. The reference Hadith books including Sunan an-Nasa'i, Sunan Abi Dawud and Sunan Al Tirmidhi were used for Hadith derivation along with their relevant Hadith number. Some revelations from Quran, the book revealed to the blessed Prophet Muhammad (P.B.U.H.) were also cited with their respective numbers.

The material presented here is referenced to the multiple journals, books and a few reports written by international organizations belong to animal feed industries. The paper is divided under various headings related to animal feed industry and its halal perspective describing about the history, technological advancement in feed and feeding system, concept of Halal and Tayyab in animal feed, Islamic jurisprudence about animal feed and a few feed borne-diseases of importance to farm animals. The journals which have been referenced are Journal of Applied Animal Nutrition, MOJ Food Processing & Technology (MOJFPT), Engineering, Research Journal of Agricultural Sciences, Journal of Nutritional Health and Food Engineering, Environ Health Prospect, Aquaculture, Journal of General Internal Medicine, Environmental Science & Technology, Bulgarian Journal of Agricultural Science, Journal of Environmental Science and Technology, Journal of Animal Science and Biotechnology, Nutrition Research Reviews, Emerging Infectious Diseases, Clinical Infectious Diseases, Poultry Science, American Journal of Food Science and Nutrition, Toxins, Asian Journal of Animal Sciences, Toxicon, Animal Feed Contamination, African Journal of Food Science, Proceedings of the Nutrition Society, Journal of Nutrition, Veterinary & Human Toxicology, Chinese Journal of Animal Nutrition, Nutrition, Aqua feed Formulation, Aquaculture Research, Animal Feed Science and Technology, Molecular Nutrition & Food Research, Veterinary Record, British Medical Bulletin, Cerebellum, Asian-Australasian Journal of Animal Sciences, and Preventive Medicine.

Among the books from where material has been taken are Principles of Animal Nutrition 3rd Edition (1908), Feed Manufacturing Technology 5th Edition (American Feed Industry Association, 2005), Feeds and Feeding (1988), International Directory of Company Histories (James Press, 2000), Recent Developments in Feed Technology (Ferket and Stark, 2011), The Formula Feed Manufacturing Industry (USDA, 1988), Handbook of Naturally Occurring Food Toxicants (Langer, 2018), Handbook of Zoonoses: Identification and Prevention (Colville and David, 2007), and Contemporary Issues and Development in the Global Halal Industry (Saidin and Rahman, 2016).

3. Global Scenario of Feed Industry

According to Alltech, which is a globally recognized organization conducting surveys on animal feed industry, the feed industry has come out with great productive potential and exceeded a figure above 1.2 billion metric ton [11]. Among the North American region, which is the second largest producer of feed worldwide, two countries Canada and USA dominated feed industry particularly the horse feed industry in the region [12]. The region produces about 1/3 of feed for beef production while the prices are usually lower as compared to other regions and growth rate is almost flat. In the Latin America, three countries; Brazil, Mexico and Argentina cover 75% of total regional production. Brazil, which is World's 3rd largest feed producer enjoys leading role in the production while Mexico, which is 5th largest leads the regional feed production for beef and layer. The region's growth rate remained 3rd highest for more than five years mostly in aqua, horses and pet feed.

Europe is one of the fastest growing regions in the feed production and has been accounted for about 3% of feed tonnage growth. The reason behind the growth is increased production of aqua and boiler feed. Regional feed production is dominated by Russia which is 4th largest feed producer and has produced 37.6 million tons feed during the year 2017. The other European countries contributing in feed production are Czech Republic, Poland, Hungary, Belgium, U.K., Ukraine and Romania. The region also remained the top pet feed producer.

Asia-Pacific region is the leading feed production zone in the world contributing 35 % of global production. The dominating country is China. Although the China's growth rate of feed production was declined during the last 2 years but remained as top feed producer and produced 186.86 million metric tons feed in the year 2017. There has been 3% increase in regional feed growth rate resulting from increased pet feed production. The region also covered 77% of aqua and 44% of layer feed production globally. Other countries contributing in the feed production are India, Thailand, Pakistan, Japan, Taiwan and Vietnam.

Likewise, Asian region, Africa also contributes progressively to feed production especially to broiler and dairy feeds. Although the region remained expensive for feeding layers and broiler, it has achieved a growth rate near to 30% for more than the last 6 years. The region also enjoyed the maximum increase in growth rate of about 10% in broiler feed. Among the contributing countries are Egypt, Botswana, Mozambique, Zambia, Morocco, Nigeria and Uganda [13].

3.1. China Feed Industry

China, which is the largest country in terms of population, also keeps the similar position in feed industry [14]. In the early days, wheat bran from the modern flour mills operated since 1930s was utilized by farms to feed their animals. For the next 19 years starting from 1930s to 1949, no single feed mill was established in the country. Moreover, in the following years political chaos along with the retarded economy and centralized governmental system caused the grain production to be carried out exclusively for human's consumption. As a result, the potential for establishing the feed industry was hindered.

It was 1976 when dawn of the new era started dazzling China. A transition happened in Chinese policy building by global trading and adopting new ideas and technological development from other regions of the world. This transition gave a complete potential chance to build feed mills. During 1976, feed research institute was established. By the following year, the ministry of commerce was also assigned a duty to do research over the methods and strategies followed by Japanese, French and American feed industries [15]. Consequently, 14000 mills were built up to 1985 including both large and small mills with an installed capacity of <1 ton/hour. During 1984, a draft plan was developed and published to support goals and strategies for a period of 16 years starting from 1984 to 2000 [15]. Meanwhile, government provided incentives and suspended imposition of taxes on the feedstuff, feed processing equipment along with 3-year tax adjustment for the new mills and allowed tax free profit [16]. The initiative was much more welcomed by the industries. 2 years later in 1986, specialized feed ingredients and supplementations were presented at a national level conference. Resultantly, about 12 products got approval for the year 1987. Within a decade, compound feed became the new focus and led the production up to 62.99 million tons during the year 1997 [17].

The ministry of commerce published China's first feed standard in the year 1993, while the regulations regarding the development of mixed or compound feed, packaging, storage and transportation of feed came in the year 1996. Unfortunately, only about 10% of the industries qualified against the standards [15]. Therefore, State Council, LAO had made enactments in the regulation of feed and the feed additives in the year 1999 [18]. From that time, Chinese feed industry faced severe safety concerns for their feedstuffs. Resultantly in 2007, the presence of melamine and cyanuric acid in pet feed, which were deliberately used to give high content of crude protein, resulted in kidney failure in animals. This had elevated serious issues for the feed industry causing the recall of their feed by South Africans, Europeans and Americans. Moreover, USDA had made it mandatory to inspect any sort of plant proteins which were to be imported from China. Chinese officials had tried hard to resolve the problem and allowed U.S. FDA for inspection of their premises and facilities. In the period 2008-2009, more focus was shown on feed adulteration and the associated crises. Hence, during 2010, a revision was done in feed and feed additive regulation [18]. The period starting from 2010 to 2015, showed an annual growth rate about 15% which was enough to declare the China as the largest feed producer of the world [19]. But still China had to import soybean and distiller's dried grains or DDGs in significant amount [20]. Beside this, China has focused the attention to put the country on track of self-reliance thereby avoiding western and other imported items [21-22].

3.2. U.S. Feed Industry

The advancement in the U.S. feed industry came by the 20th century [2]. The need of industrialization though resulted from establishment of farms, was significantly supported by allied factors such as the use of synthetically prepared fertilizers in 1990 that resulted in increased crop yield [2]. This has further contributed a great deal of specialization and expertise in crop and as well as livestock production, paving the way for feed industry to flourish. During early periods before 1900, hammer mills were used to produce feed while by 1909, horizontal batch mixers came. Rapid progress had been seen during 20th century's first quarter but the whole industry became reformed after the introduction of feed in pellet form by Purina Mills in 1920s. This technique usually involves the compressing of fine,

variably dense, and unappealing feed ingredients into more uniform, palatable and easeful pellets. Mostly it was adopted by the industries and as a result by 1930s, most industries excelled in producing pelleted feed.

Traditionally, Chicago and Minneapolis had hosted feed mills. Companies running the business of milling had excessively been producing animal feed by utilizing the by-products resulting from the milling operation thereby avoiding their disposal for profit. In early formulations milling by-products were blended with nutrients. Between 1940s & 1950s, rapid progress in science and technology was seen, thus, making feed formulation more complex than before by incorporation of essential vitamins, trace minerals, and other antibiotics. At the sometime, the industry progressed from milling companies to exclusive feed firms reaching above 2000 in numbers throughout the country. Leaving the feeding hubs, small feed industries also stepped toward producing newly complex feed formulation through utilization of batch mixer near the farms. This sort of transitional step opened way for more specialization and resulted in extruded pet feed during the mid of 1950s.

The improvements and technological reforms consolidating the feed industry had continued to occur till the end of 1950s. The period ranging from 1960-1970s, showed the establishment of large feed mills alleviating normal production about 200-500000 tons yearly. Another trend was also being seen in which large farms or the feedlots started to build their own feed mills in an attempt to be more competent. Although, the trend had caused reduction in number of farms but the existing ones became multiplied in size. Resultantly, in 50 years from 1950s to 2000, five million farms declined to about 2.2 million. By 1975, focus toward automation of the industry was also carried out with the main aim to increase efficacy of feed production while reducing the cost of feed per animal unit. The automation technology continued improving various element of the feed industry some of which are logistics of receiving and delivering ingredients, size and grounding of ingredients, batch mixing or other method, control of the process, extrusion technology and pelleted feed formation etc. [23]. Consequently, the technology became much more diversified over the last 5 decades leading to completely computerized system of operation, analysis of nutrients by in-line NIR system and well-organized collection of data inside the feed.

3.3. Brazil Feed Industry

Since 1960, Brazil feed industry has been producing animal feeds and has become third largest feed producer of the world [14]. Just like US and European feed industries, Brazilian companies that were doing milling and processing of wheat, maize and barley became the early feed industries of the country. In 1940, wheat bran was used by early feed industries to produce animal feed as such or for incorporation as an ingredient to make a complete feed for the first-time. Resultantly, in the year 1941 a feed mill was established in Sao Paulo particularly to fulfill layer production that was in its growing stage. With the passage of time demands became higher and higher, thus another feed industry named cooperative's feed mill entered the path to fulfill country needs especially for meat and broiler production.

The interesting feature of Brazilian feed industry which is normally integrated with production is that the feed is produced by and fed to animals by the same company. This level of integration is highest among the poultry feed about 99% while about 80% for all feed types [2]. Additionally, most Brazilian feed industries are linked to each other. The former employees of Purina Mills had established Mogiana or Guabi feed company in 1974. Within 6 years, Mogiana attained significant share in the market even transcending then its parent company Purina. The executives of Mogiana left the company and established Nutron after a period of 16 years in 1990s. Currently, pet feed industry escalated Brazil to the second largest slot across the globe. Although, before 1990s the pet feed industry was hard to find, the introduction of extruder together with improvement in techniques and equipment made Brazil to prosper about 25 times more productive than before within 25 years. Moreover, being leader in production of maize, soybean and other feed ingredients, the future of Brazilian animal feed industry is more promising than the others.

4. Feed Ingredients

The study of animal nutrition and feed science has been divided into two sections. The first section focuses upon the nutritional requirements while the other on the availability of these nutrients both naturally in plants and animals and artificially or synthetically [24]. These essential nutrients are classified into macro nutrients and micro nutrients. Among the macro-nutrients are carbohydrates and fat for energy or draft work and protein for growth, development and maintenance. On the other hand, micro-nutrients include minerals, vitamins, antibiotics, and others play vital role in the metabolism and utilization of macro-nutrients by the animals. For a balanced supply of feed to fulfill animal requirements, scientists in their respective research organizations have formulated their own sets of standards and regulations for each nutrient and specie's type. Feed ingredients are not only derived from plants and animals but also from pharmaceutical and other sources described as follows.

4.1. Plant Based

Among the plant based materials used to develop the feed are forages, roughages, by-products of milling and sugar-cane processing in the form of molasses, brewery industry in the form of DDGs, fruit and other similar food and non-food industry [4].

4.2. Animal Based

There are certain Ingredients used in manufacturing of feed are significantly derived from animals. These ingredients are legally used to manufacture the feed worldwide and are rendered protein meals and dried waste [25]. The rendered protein comes in the form of meals of meat, blood, feather, eggs shells and hair of poultry, swine and ruminants while the dried wastes of poultry, swine and ruminant are used either in dry processed form or as non-dry processed form. Apart from these, by-products of marine industry also provide valuable feed ingredients in the form of fish liver oil and meals of fish, crabs and shrimps [26]. Dairy industry also contributes its share in the form of dried milk, casein, whey and cheese [27].

4.3. Mixed

Apart from the individual incorporation of ingredients from animals and plants combination of these from the two aforementioned sources are also being used. Such a case includes used animal or plant fat, leftovers from restaurants, bakeries, and cafeterias and the contaminated food that has been subsequently treated to make it suitable for feed manufacturing [28].

4.4. Miscellaneous

These include the ingredients that are required for the maintenance and regulation of body functions and to promote growth and development. These are antibiotics, vitamins, enzymes, additives, nutraceuticals, preservatives, drug industry by-products, Arsenicals and Non-protein Nitrogen or NPN [4, 29].

5. Results of Global Feed Regulations

5.1. Feed ingredient Standards of China

The major standards that regulate manufacturing, packaging, storage and transportation of feed and feed ingredients are as follow:

Table 1 Major Feed Standards of China

Name of Standard	Code	Ref
Feed Label Standard	GB 10648-2013	[30]
Feed Industry Terms	GB/T 10647-2008	
Fish Meal	GB/T 19164-2003	
Meat and Bone Meal	GB/T 20193-2006	
Wheat Bran	NY/T 119-1989	
Soybean Meal	GB/T 19541-2004	
Rice Bran	NY/T 122-1989	

China's Feed Label Standard GB 10648-2013 defines the feed as a material processed by industries to feed animal and include:

- Single feeds
- Feed additives
- Premixes
- Concentrates

- Formula Feed

Feed ingredients: The major raw materials used in manufacturing of feed by Chinese industry are corn, soybean and fish meal. Mostly the feed ingredients are imported because of intensive agriculture system in the country. According to [30], the ingredients along with their source are as follow:

5.1.1 Plant based

- Barley grain
- Brewers' grains (wet)
- Broad bean, seed
- Corn grain
- Distiller's grains (w)
- Oat grain
- Pea, seed
- Rapeseed meal
- Rapeseed oil
- Sesame oilcake
- Soybean meal
- Soybean oil
- Sunflower seed meal
- Wheat grain
- Wheat bran
- Wheat flour

5.1.2 Animal derived

- Blood meal
- Cattle stomach meal
- Fat (pig)
- Fat (fish oil)
- Fishmeal (Peruvian)
- Feather meal
- Liver meal
- Lung meal
- Meat and bone meal

5.2. U.S. Feed Laws

Table 2 U.S. Feed Regulations

Feed ingredients	Feed mixtures	Ref
Food (FFDCA 201(f); 21 CFR 570.3(m))	Animal Feed and Food (FFDCA 201(f); 21 CFR 570.3(m))	[32]
Food Additive (FFDCA 201(s); 21 CFR 570.3(e))	Type C Medicated Feed (21 CFR 558.3)	
Animal Feed (FFDCA 201(x)) GRAS (FFDCA 201(2); 21 CFR 570.30)		
Feed Ingredients (AAFCO Official Publication)		
Animal Drugs (Medicated feeds) (FFDCA 201(w))		
Medicated Type A Article (21 CFR 558.3)		

The United States Food and Drug Administration (U.S. FDA) in their F, D, & C Act with section "f" defined feed as any material used for feeding animals. The Association of American Feed Control Officials (AAFCO) in their Official

Publication considers raw materials along with other ingredients for use to feed animals and pets. The American feed industry also uses a diverse range of feed ingredients and has specified the limits for each type of the animal species [6, 31]. In U.S.A., feed and feed ingredients along with their definition and regulatory measures are governed under the following laws.

Feed ingredients: According to The United States Federal Food, Drug, and Cosmetic Act (abbreviated as FFDC, FDCA, or FD&C) the feed ingredients is any components either wholly or partially or in combination added to the feed and includes cereal grains and their by-products, oil seed meals, vitamins, minerals and additives.

Table 3 Raw material used by feed industries during the year 2015

Ingredient	Usage by Feed Industries (%)	Reference
Maize	50.3	[33]
Soybean meal	12.7	
DDGs	12.6	
Wet Distiller's grain	8.5	
Bakery meal	4.2	
Others	3.1	
Corn Gluten	1.7	
Cotton seed meal	1.7	
Wheat middling	1.6	
Sorghum	1.5	
Soybean hulls	1.2	
Oat	1	

5.2.1 Plant based

Following are the plant-based ingredients used in the formulation of feed.

Cereals

Among the cereals used in feed manufacturing are:

- Wheat
- Maize/corn
- Barley
- Oats
- sorghum

More than 50% of the grain produced by U.S.A., which is 72% of total crop production, is fed to animals. Of these cereals about 80% of maize is utilized for animal feed production and is mostly used for developing feed for poultry, swine and beef cattle. Although corn is also organically produced but industrially the usage of genetically modified (GM) corn is more than the organic corn. In the year 2005, about 52% of the US corn is genetically modified. Beside corn, sorghum is also used by beef, poultry and swine feed industry [4].

Cereal Grain by-products

Beside the use of intact cereals grains, their by-products resulting from milling industries are also typically used by feed manufacturers of dairy cattle. According to [25], These include the following ingredient:

- Wheat mill feed
- Germ

- Gluten
- DGGs,
- malt sprouts
- brewer's yeast
- Hominy

Oilseed meals and cakes

According to [34], these are the by-products resulting from the processing or solvent extraction of oilseed crops and include:

- Soybean
- Cottonseed
- Canola
- Sunflower
- Linseed
- Safflower
- palm kernel
- copra
- Groundnut

Oilcakes are the by-products derived from the pressing operation carried during the oil extraction process whereas meals are from solvent extraction. Soy meal individually supplies 75% of the protein fed to livestock. Moreover, about 60% of soybean produced is used by poultry, swine and cattle or livestock industry. Like Corn, Soybean being grown in USA is also genetically modified and about 87% of the U.S. soybean was GM in the year 2005 [35-36].

Other Food Industry By-Products

Apart from oilseeds and cereals some other food industries such as sugarcane and fruit industries by-products are also used by feed industries. These include the following ingredients.

- Molasses
- Citrus pulp
- Apple pulp
- Pomace pulp
- Cranberry pulp meal
- Pear cannery residue

Of these ingredients, citrus pulp is mainly used by feed manufacturer for feeding dairy cattle.

Forages

Among the forages, alfalfa and its associated product are only used by the feed industries. It is mostly utilized by ruminants and includes the following feed ingredients

- Sun-dried or dehydrated alfalfa meal
- Alfalfa pellets,
- alfalfa nutrient concentrate
- concentrated alfalfa soluble

Miscellaneous plant products

Various other products from plants can also be used for feed development. A few of these are:

- Oat and rice products
- Nuts, seeds, and their by-products
- Legumes and their by-products
- Dried bakery waste
- Dried bread

- Chocolate by-products
- Coconut meal
- Cookie by-products
- Dried kelp
- Dried roots and tubers

5.2.2 *Animal based Ingredients*

Animal feed ingredients also make a significant portion of the feed. During the year 2002, about 8.5 M metric tons of rendered animal's product had been used in feed development [28]. Of these rendered animal by-products, the ingredients which are used in the formulation of feeds are as follow:

- Meat meal
- Bone meal
- Poultry by-product meal
- Poultry meal
- Dried animal blood
- Blood meal
- Feather meal
- Hydrolyzed leather meal
- Egg shell meal,
- Glandular meal
- Hydrolyzed whole poultry,
- Hydrolyzed hair
- Unborn calf carcasses,
- Animal digest,
- Bone marrow (cooked or mechanically separated),
- animal plasma,
- Leather hydro lysate

The sources of such ingredients are divided into categories as follow

- Slaughtered food producing land animals

The slaughtered animals are amongst the important source of by-products to be used in feed manufacturing. About 1/3 or even more of their body weight which includes blood, bone, feathers, and hides is non-edible for humans [37].

- Died or Non-slaughtered animals

Apart from the by-products derived from slaughtered animals, non-slaughtered animals which according to compliance policy guide no 7126.24 of U.S FDA are those animals that have died other than being slaughtered and include diseased animals belong to food producing group and other non-food producing animals which are died as a result of road killing or euthanization. The possible by-products to be legally used in animal feed as per U.S. FDA regulations are meal of blood and meat, hydrolyzed hairs, digests and blood protein from these animals and various other similar by-products [38].

- Animals belong to 4 Ds “Dead, Dying, Diseased and Disabled”

The U.S.FDA has formulated the regulation of animals belong to 4-Ds group which include dead, nearly dead or dying, diseased or ill and disabled animals [39]. As per regulation it is only allowable to use their by-products for non-ruminants and for pet food [40]. Mostly animals belonging to 4-Ds are downer and dead cows.

- Road killed or Euthanized Animals

Steve Traylor reported that it is not illegal to use road killed and non-food producing animals which are usually dogs and cats in feed manufacturing [4]. FDA had conducted different surveys through 0.005% accuracy testing methods to detect the presence of dog and cat DNA and of pentobarbital which are typically used for euthanization of cat and dogs and other animals. But, they failed to get the both, the presence of DNA and the pentobarbital [39]. But beside all, some

have doubted FDA's result and assert some evidence regarding the use of euthanized pets to be used in feed manufacturing [39].

- Deer and Elk

Deer and Elk are also a source of ingredients used in feed manufacturing but their use for feed development is prohibited for ruminants. Since they are very vulnerable toward TSE also called chronic wasting diseases or CWD, therefore according to FDA's regulation any deer or elk suffering from such disease is prohibited to be used in feed manufacturing for any animals [41].

- Blood

In the year 1997, FDA announced the banning of mammalian protein meal (including blood meal) to be used in feed manufacturing for ruminants. However, the ban was delayed in an attempt to give feed manufactures and distributors a proper duration to comply with the regulation [42]. Up to 1999, about 69% of feed mills in America were still using blood commercially. This was however declined to 50% in 2003 and 39.6% in 2004 [43]. In 2004, after seeking recommendations from international experts, FDA had made a draft proposal to curb the use of mammalian blood and its associated products for ruminant feed manufacturing [44]. But the next year, the proposal could not be finalized due to the fact mentioned above that most industries were using blood meal. Anyhow, after giving enough time to industries for complying with the regulation, FDA had finalized its proposal that came into effect since 2008 [42].

Though U.S.FDA finalized its proposal, yet the immense pressure regarding blood products was developing. By year 2011, in its final ruling the U.S.F DA allowed blood and blood product that might pose risks for transmitting BSE in mammals as feared by international experts in 2004, but according to FDA, such risk was very minimal as blood and blood products used in ruminant feed manufacturing were heat processed prior to adding in feed. Hence, they included blood products in non-prohibited mammalian protein. The categories are coming ahead.

- Animal waste

Animal waste which is commonly called manure has been used by American feed manufacturers for the last three decades. The waste can be from ruminants, poultry and swine and available both in dried and un-dried form. The association of American Feed Control Officials (AAFCO) recommended that the animal waste that is to be used as feed ingredient should be free from pathogenic organisms, pesticide residues, parasites and drug residues or at state permitted levels [45]. The poultry waste as defined by AAFCO is the waste obtained from such commercially raised layer or broiler that has not received any medicated or other hazardous substances. As per AAFCO regulation adopted since 1979, the waste material to be used in feed manufacturing must conform to the following's recommendations.

- License or registration from the state
- Waste material to be assayed for the followings
 - Salmonella
 - *E. coli*
 - heavy metals
 - pesticides
 - drugs
 - parasitic larva or ova
 - mycotoxins

5.2.3 Marine by-products

There are certain by-products from marine industry used in the manufacturing of feed. On annual basis in U.S.A., about 30% of fish are caught for other than human consumption, hence used in making fishmeal and fish oil [46]. Generally, fishmeal is produced from the fish that is not used for human consumption or used in limited amount such as small, bony and oily species of pelagic, anchovy, herring, mackerel, and capelin. The trimmed parts of fish during its dicing for human consumption and the other non-edible parts of fish are also used to manufacture fish meal. Fishmeal is maximally utilized for making feed for fish. Following are the salient marine by-products used in formulation of animal feed [47].

- Fishmeal
- Condensed or dried fish solubles

- Crab meal
- Shrimp meal
- Fish oil
- Fish residue meal
- Fish liver and glandular meal
- Fish protein concentrate

5.2.4 *Fats*

Fats to be used as feed ingredients can be obtained both from plants as well as animals. Among the possible ingredients to be used by feed manufactures are as follow [45].

- Tallow
- Lard
- Poultry fat
- Vegetable fat/oil
- Esters of fatty acids from plants and animals
- Ethyl and non-glyceride esters from plants and animals
- Vegetable-animal fat blends
- Hydrolyzed polyesters of sucrose in the form of olestra (a substitute fat)
- Corn syrup refinery insoluble

The feed generally contain fat up to 8% and as per AAFCO recommendations the fat or fat derived ingredients to be used in feed manufacturing must fulfill the following conditions [45].

- Free of Dioxin or similar substances
- Fat from acceptable sources for feeding animals

5.2.5 *Dairy products*

The U.S. dairy industry also yields material for making animal feed. Among the possible ingredients are dried skimmed milk, buttermilk, chocolate milk, whey or whey products, cheese rind, dairy food by-products, dried milk protein and dried cheese and its associated dried cheese product [48].

5.2.6 *Banned Harmful ingredients*

The U.S. FDA and AAFCO have barred some ingredients to be incorporated in feed manufacturing. Following is a brief note on such ingredients along with their sources.

Plants

FDA and AAFCO have made necessary regulation toward use of various herbs, botanicals and the dietary supplements. Although various unapproved substances are being used by feed manufacturer, the AAFCO had conducted nationwide interventions for curbing the use of such substances. Of these, the two substances such as “Kava” and “Comfrey” have been banned to use as feed ingredient because of incidences of liver damage and other harmful outcomes both in humans and animals [49].

Chemical Substances

Amongst the chemical substances, ball clay had been used as anticaking agent in the feed but upon its detection with dioxin it has been banned in feed manufacturing [50].

Protein

Like European countries, FDA and AAFCO also have taken steps to curb against TSE and BSE through categorizing the processed animal protein or PAP into the following three categories: Prohibited Mammalian Protein; Non-Prohibited Mammalian Protein; Non-Mammalian Protein [51].

- Prohibited Mammalian Protein

It includes the following possible ingredient that are prohibited to be fed ruminants which include cattle, sheep, goats, deer, elk, buffalo and antelopes [41].

- Animal By-Product Meal
- Animal digest
- Animal liver
- Bone meal, cooked
- Bone meal, steamed
- Cooked bone marrow
- Dried meat solubles
- Fleshing hydrolysate
- Food processing waste
- Glandular meal and extracted glandular meal
- Hydrolyzed hair
- Hydrolyzed leather meal
- Meat
- Meat and bone meal
- Meat and bone meal tankage
- Meat by-products
- Meat meal
- Meat meal tankage
- Meat protein isolate
- Mechanically separated bone marrow
- Restaurant food waste
- Stock/broth
- Unborn Calf Carcasses

- Non-Prohibited Mammalian Protein

The following protein ingredient from mammals or ruminants is allowed to be used for ruminant feed manufacturing [42].

- Milk products (milk and milk proteins)
- Gelatin
- Pure porcine
- pure equine protein
- Blood products

- Non- Mammalian Protein

This class of protein Includes protein from plants, earth and from non-mammalian animal sources such as [4].

- Poultry
- Feather meal
- Fish meal
- Soymeal
- Gluten

Apart from the abovementioned ingredients, derived from multiple sources including plants and animals, there are some other ingredients utilized for feed manufacturing. In this regard food producing places such as restaurants, cafeterias and other similar places can also generate ingredients for feed manufacturers particularly for swine or non-ruminants. As per regulations prevailing in the country, any food from the aforementioned places must be free from any piece of glass, crockery, metal or other similar item and boiled for half an hour prior to feed animals [52].

Antibiotics industry also supply necessary microbial material in the form of spent mycelium of penicillium, Streptomyces and other alike microorganisms for the synthesis of enzymes, amino acids, vitamins which are the widely

used ingredients by the American feed mills. Although the use of these ingredients are legal according to FDA but the organization is bound to set a limit for the microbial activity to maintain it below or equal to 2g/ton of cake which in turn should be incorporated in feed about 3lb for every tonnage of feed [53].

Probiotics are also used in feed manufacturing. These are live strains of beneficial microorganism such as bacteria and yeast and are widely utilized by feed industries. AAFCO has listed about 45 microorganisms that can be used for this purpose. The common of these organisms are the species of *Lactobacillus* and *Aspergillus Niger* [54]. Also, the American feed industries utilize a diverse range of minerals from micrograms to traces. Among the mostly utilized mineral are Ca, P, K, Zn, and some potentially toxic ones such as Ar, Cd, Hg, Pb and Se etc. within the specified limits as per FDA an AAFCO regulations. Furthermore, animal feed is fortified with vitamins to fulfill the nutritional need of animals. Enzymes are the other elements used in American feed industry.

5.3. European Feed Regulations

According to European Standard EC 767/2009, the feed is any material either in raw or processed form obtained from plants, animals and industrial by-products with the principal objective to fulfill the nutritional needs of the animals. It may or may not contain feed additives which are normally incorporated during oral feeding of animals [55].

Table 4 EU Regulatory standards defining terminologies and Legal definitions for Feed Ingredients and Feed Mixtures

Feed ingredients	Feed mixtures	Ref.
Feed (Reg.178/2002)	Premixtures Reg. 1831/2003	[32]
Feed Material (Reg. 767/2009)	Compound Feed	
Feed Additive (Reg. 1831/2003)	Complete Feed	
Processing Aids (Reg. 1831/2003)	Complementary Feed	
Daily Ration (Reg. 1831/2003)	Mineral Feed	
Veterinary Medicinal Product	Milk Replacer	
	Dietetic Feed (Reg. 767/2009)	

During the year 2016, meat, poultry and other animal derived products had contributed an approximate share of 150 billion €, generated jointly by 28 EU member states which was equal to 39% of total value resulting from farm production [56]. During the same year, animal feed being an important driver of the feed industry was fed with the approximation of 480 M Tones in the member states. It includes about 50% of roughages, 10% farm produced grains, 30% industrially produced compound feeds and 10% other purchased feed stuffs [56].

EU contributes 16% of the global compound feed production which has been reached up to 1103.4 million metric tons [14]. During the year 2018, there had been an increase in growth rate of about 4% as compared to 2017 [14]. Among the important regional players of compound feed are Germany, Spain and France that remained the leaders as compared to other EU countries in terms of total production. Germany leads in cattle and pig feed while France enjoys the leading position in the poultry feed industry. In the year 2016, the production of poultry feed industry was risen by 2% while the cattle feed industry remained constant and the swine feed industry suffered 1% decreases in its production [56].

5.3.1 Ban on use of processed animal protein or PAP

Since 2001, there had been a ban on the use of processed animal protein or PAP for food producing farm animals particularly ruminants. Initially the ban was imposed for feeding such protein to sheep, goat and cattle but later on it was expanded to cover all the farm animals [57]. The reason behind the ban was health concern regarding the spread of Bovine Spongiform Encephalopathy or BSE and Transmissible Spongiform Encephalopathy or TSE in humans. The European TSE regulations enforced from July 2017, have laid down the following regulatory measures toward utilization of animal based protein in the development of animals feeds [58].

Table 5 Allowed and not allowed protein type with regard to animals

Source/ Protein Type	Ruminants	Non-Ruminants (Except Fish)	Fish
PAP derived from ruminants including blood meal	N/A	N/A	N/A
PAP derived from non-ruminants including blood meal and PAP from insect, but excluding fishmeal	N/A	N/A	A
Ruminants derived gelatin and collagen	N/A	N/A	N/A
Ruminants Blood products	N/A	N/A	N/A
Fish Meal	N/A*	A	A
Non-Ruminant blood products	N/A	A	A
Hydrolyzed protein derived from skin and hides other than ruminants and non-ruminants	N/A	N/A	N/A
Hydrolyzed protein derived from skin and hides of ruminants as well as non-ruminants	A	A	A
Non-Ruminants derived gelatin and collagen	A	A	A
Egg or egg products	A	A	A
Milk or milk products including colostrum	A	A	A
Animal derived di and tri phosphate of Ca	N/A	A	A
Other animal proteins excluding the aforementioned ones	N/A	A	A

In the above table, A stands for Allowed or Authorized while N/A for Not Allowed or Not Authorized; N/A* means it is authorized to incorporate fish meal in milk replacer only for non-weaned ruminants.; Data obtained from European Commission regulations [59] laid down for TSE or BSE contamination with the animal's feed.

5.3.2 Feed Ingredients

The Product Environmental Footprint Category Rules (PEFCR) published a five year (2009-13) average report to elaborate the major feed ingredients. It is explored as follows:

Cereals

Cereals are one of the major feed ingredients used for manufacturing feed and include common and durum wheat, barley, maize, rye, sorghum, oats, triticale and others.

Table 6 List of ingredients used in percentage for feed development in Europe

Feed ingredients	Usage by Feed Industries (%)
Cereals	50
Food & Bioethanol Industry by products	11
Dried forage	1.5
Pulses	1.5
Dairy products	0.5
Oil and Fat	2
Oil seed cake or meal	26.5
Additives, Minerals and Vitamins	3.5
Others	4

Data on Feed material consumption by the compound feed industry in EU 28 member countries [56].

Tapioca

According to the European Feed Manufacturers' Federation (FEFAC), about 100% of tapioca produced in the region is used as feed in the Europe and accounted for 0.1% of the total raw material used by feed manufacturers [5].

Food & Bioethanol Industry by products

The total contribution of this group has about 15% of the feed production. It includes the following ingredients from the domestic as well as imported food industry [56].

- Domestic wheat bran from wet milling
- Domestic wheat feed from wet milling
- Wheat bran from flour milling
- Wheat middling from flour milling
- Imported Corn gluten as feed
- Domestic maize germ from wet milling
- Domestic maize gluten as feed from wet milling
- Domestic maize gluten meal from wet milling
- Domestic maize bran from maize dry milling
- Protamylasse from potato starch production
- Domestic molasses from sugar beet
- Imported molasses
- Domestic dried pulp from sugar beet
- Imported dried beet pulp
- Imported citrus pulp

On the other hand, it includes the following from the ethanol producing industry.

- Domestic DDGS from Wheat
- Domestic DDGS from Maize/Corn
- Domestic DDGS from Barley
- Domestic DDGS from Rye
- Domestic DDGS from Triticale
- Imported DDGS only from Corn/Maize

Vegetables oils

Among the vegetable oil or related products, the ingredients include palm oil and rapeseed oil.

Oil seed meals

Among the oil seed meals both from domestic as well as imported meals used for feed development are

- Groundnut meal
- Domestic soya meal
- Domestic rapeseed meal
- Domestic sunflower meal
- Domestic cotton meal
- Palm kernel meal
- domestic linseed meal
- domestic maize meal
- imported copra meal
- Imported soya meal
- Imported sunflower meal

Animal derived products

Normally the animal derived ingredients are regulated under the special regulation passed mostly due to health concerns to humans, like PAP when fed to ruminants. Only those animal by products are allowable that are listed as

category III of EU Regulation EC-1774/2002 [59]. The ingredients both domestically obtained and the imported ones used in feed development are as follow:

- Animal fat
- Imported fish meal or marine meal
- Domestic fish meal
- Marine meal
- Fish oil (marine oil)
- Whey powder
- Milk powder

Minerals, Additives, Vitamins

The following ingredients come under this group to be incorporated in EU feed by industries

- L-Lysine HCl
- DL-Methionine
- L-Threonine
- L-Tryptophan
- Calcium carbonate
- Mono calcium phosphate
- Sodium chloride
- Sodium carbonate
- Phytase
- Trace elements premix including ZnO, CuSO₄ and ZnSO₄
- Vitamin's premix

5.4. Feed Regulations of Malaysia

In Malaysia, the feed industry is regulated by “Animal Feed Act 2009” that came into force by the year 2013, with principle focus on ensuring safety and quality of the animal feed during the whole supply chain starting from manufacturing till consumption by animals. The act was supported by the Animal Feed Board. In order to facilitate the implementation “Feed Regulations 2012” and “Animal Health and Welfare Bill 2012” were also enacted. The act defines feed to be all forms of single or multiple material including fresh as well as processed or semi-processed that is meant for feeding animals which according to act are mammals (except humans), marine creatures, amphibians, reptiles, birds (including chicken, duck, quail and ostrich) and insects. The ingredients used by Malaysian feed industries [60] are as follow:

5.4.1 *Plants based*

Following are the plant-based ingredients used by the Malaysian feed industry.

Cereal and Cereal by-products

These are mostly used for feeding monogastric animals such as poultry up to the extent of 80%. Among the commonly used cereal by Malaysian feed industries are:

- Wheat and its by-products
- Maize
- Sorghum
- Millet
- Rice and its by-products

Oilcakes and oil meals

These are the by-products obtained from vegetables oil extraction industries. The materials to be used in feed manufacturing are meals and cakes which are obtained through the process of pressing and solvent extraction respectively.

- Groundnut oilcake
- Coconut oilcake
- Palm kernel oilcake
- Cottonseed cake
- Sunflower seed cake
- Soyabean meal
- Rubber seed oilcake
- Linseed oilcake
- Sesame oilcake

Legumes Legumes are also used by feed manufacturers but not commonly as feed ingredient. Normally these are used as fodder. The possible sources are:

- Red gram or Dahl
- Chick pea
- Egyptian bean
- Lentil
- Leucaena
- Lucerne or alfalfa
- Saman or cow tamarind
- Mung bean
- Horse gram
- Cow pea
- Sesbania

Forages/Fodder

- Lucerne or Alfalfa
- Kangkong or swamp cabbage
- Sago palm

Roots and Tubers

Roots and tubers are commonly grown for human consumption but can be used for feeding fish because of high starch content and also being useful material for industries. The most commonly used are:

- Sweet potato and its by-products
- Cassava

5.4.2 *Animal based*

Among the animal-based ingredient are

- Land animals and their byproducts
 - Meat meal and its associated by-products
 - Blood and its associated by-products
 - Bone meal
 - Hydrolyzed poultry feather meal
 - Milk or milk by-products
- Pupae and larvae of silkworm and other insects
- Marine animal by-products
 - Shrimp meal
 - Fish silage
 - Fish oil
 - Fish meal
 - Trash fish

5.4.3 Mixed feedstuffs

Besides animals and plants, there are some other ingredients to be used in feed manufacturing for a particular purpose. These include

- Leaf protein concentrate, LPC
- Cane molasses
- DDGs
- Brewer's spent grains
- Brewer's yeast
- Fats
- Algae
- Yeast
- Bacterial protein or SCPs (single-celled proteins)

5.5. Feed Standards of Pakistan

Pakistan being an agriculture country is attempting to gain global market share of the feed industry. Like other countries it also has formulated standard and Acts for feed ingredients. Poultry feed is the largest feed sector of feed industry in Pakistan with 1,168 billion Rupees investment. Unfortunately, the cattle feed industry could not flourish like poultry feed industry. Mostly, it starts and ends on fodder, crop residues and agro-industrial by-products such as oil seed cakes and meals [61].

Table 7 Cereal and Cereal by-products for Poultry feed

Nutrient	Maize	Wheat	Sorghum	Barley	Broken Rice	References'
Crude Protein (%)	8	10	9	8	7	[63]
Crude Lipid (%)	3	1	2	2	1	
Crude fiber (%)	4	5	4	10	4	
Moisture (%)	13	12.5	12	12.5	12.5	
Ash (%)	2.5	2.5	2.7	3.5	2	
Aflatoxin (ppb)	50	10	10	10	10	

Table 8 Vegetable protein as feed ingredient

Nutrient	Crude Protein (%)	Crude Lipid (%)	Crude fiber (%)	Moisture (%)	Ash (%)	Aflatoxin (ppb)	Ref.
Rape Seed Meal	32	1	13	10	7	20	[63]
Canola Meal	32	1	12	10	7	20	
Sunflower Meal	22	1	24	10	8	200	
Soybean Meal	42	1	8	10	7	20	
Sesame Meal	35	1	8	12	12	20	
Linseed Oil Cake	25	5	10	10	7	50	
Maize Oil Cake	16	7	14	10	4	100	
Maize Gluten Meal	20	1	9	10	8	100	
Maize Gluten feed	52	1	1	10	3	100	

Rice Protein Meal	30	2	2.5	10	3.5	20
Rice Polishing	10	13	12	12	10	50
Wheat Bran	12	4	11	12	7.5	20
Rice Bran Meal	12	0.2	14	12	12	50
Gaur Meal	10	4.5	12	10	7	50
Pulses Meal	10	2.5	20	10	8	50

Among the materials to be used by feed industries are crop residues, cultivated fodder (19%), cereal/legume grains and by-products, and oil cakes, meals and animal protein with their shared values 45 %, 19%, 6% and 2% respectively [62].

According to PS: 233-2013(4th Rev), which is the standard for poultry feed, feed is a complete ration to be fed to the pullet developer from 12 weeks of age up to a period when 5% of egg production stage is reached. Poultry feed is derived from the multiple sources in Pakistan, the important feed ingredients along with their composition are given below as per PS: 233-2013 (4th Rev).

Table 9 Animal protein as feed ingredients

Nutrient	Crude Protein (%)	Crude Lipid (%)	Crude fiber (%)	Moisture (%)	Ash (%)	Ref.
Fish Meal	44	5	1.5	10	26	[63]
Meat Meal	60	15	3	10	22	
Blood Meal	41	7	3.5	6	6.2	
Poultry Meal	45	10	1	10	8	

6. Feed Hazards

The animal feed industry is an important driver of poultry and livestock industry worldwide with 40-60% of the cost related to feed [64]. Feed safety is one of those parameters that determine the feed quality and make the feed free from any hazardous ingredient or by allowing such ingredient with in the tolerable range [64]. Among the hazards mostly encountered in feed worldwide are environmental, bacterial, fungal, viral, plant and animal-based contaminants [65].

6.1. Environmental

Environment is the home to many natural, organic, inorganic and various other contaminants such as heavy metals including Ar, Cd, Pb and Hg, pesticides such as organ chlorine, organophosphate and pyrethroid compounds along with their residues, radio nucleotides and industrial effluents containing dioxins and polychlorinated biphenyls or PCB [66-67].

6.2. Bacterial

The bacterial contamination of animal feed that normally happen during the whole supply chain from pre-harvest to post-harvest is either due to use of contaminated material for manufacturing of feed or due to contamination during transportation at mill or farm. The possible pathogens having hazardous impact on both humans as well as animals include Salmonella, *E. coli* O157:H7, Enterococcus, Yersinia, Campylobacter and Clostridium [68-69]. The widespread availability of animal manure on farm and the practice of feeding poultry litter to ruminants were the 2 the most prominent indicator of *E. coli* contamination of feed. The prevalence of *Listeria monocytogenes*, which is associated with silages and their processing methods, may result in abortions, meningitis, encephalitis and septicemia in animals as well as humans if remain in the feed particularly pet feed that has more human contact than other feeds [65]. However, adequate treatment of the raw material during the feed processing may either eliminate or reduce the presence these pathogens to acceptable limits [70].

6.3. Fungal

Like bacteria, it is quite common that feed or its raw material may become contaminated by fungi or its subsequent mycotoxin causing mycosis in animals. Globally, their prevalence among the animal feedstuffs is a serious problem particularly in tropical and subtropical region where climatic conditions favor their proliferation [71]. The feedstuffs vulnerable to fungal contamination include cereals and legumes such as wheat, maize, rice, rye, sorghum, millet, and groundnuts [72]. The important species include *Aspergillum*, *Penicillium*, *Fusarium* and *Alternaria* while the toxins such as aflatoxins, ochratoxin A, citrinin, zearalenone and fumonisins [73].

6.4. Plant based or Phyto-toxins

Plants have adaptive mechanism supported by certain toxins and anti-nutritional substances such as lectins, goitrogens, protease inhibitor, gossypols, cyanogens, phyto-oestrogens, tannins, pyrrolizidine alkaloids, glucosinolates and saponins for providing protection to their stored food material against microorganism, insects, birds and other plant eating animals [74]. Lectins usually abundant in cereal, legumes and tubers, in higher concentration cause local necrosis, edema, inflammation and hemorrhages of GI tract, impaired immunity, reduction in body weight, anorexia and eventually death of animal [75]. About 6000 plant species, belonging to borages, legumes and sunflower family contain over 350 pyrrolizidine alkaloids which cause hepatotoxicity, genotoxicity and cancer in animals [76]. Saponins, which are the low molecular weight secondary metabolites have been found in 100 plant families particularly Agavaceae, Dioscoreaceae, Liliaceae, Fabaceae, Araliaceae and Caryophyllaceae and cause hepatogenous photosensitization hypocholesterolemia, haemolysis and spermicidal effect in animals particularly sheep [77]. Tannins, mostly present in leguminous forages particularly sorghum may reduce rumen activity, enzymatic activity, voluntary feed utilization, nutrient absorption, wool growth and weight gain by animals [78]. Gossypols, which are the pigment found both freely and in bounded form in cottonseed meal used for feed manufacturing, may lead to several physiological abnormalities in animals such as hypertrophy, dilated cardiomyopathy, decreased oxygen in blood, and reduced reproductive potential [79-81]. Protease inhibitor, normally rich in legumes, particularly trypsin and chymotrypsin inhibitors are associated with enlargement of pancreas, reduced enzymatic activity in GI tract, abdominal and facilitating endogenous loss of amino acids, hence effecting the overall growth and performance of animals [82-84].

Glucosinolates or GLs, represent another important toxin belonging to crucifers such as mustard, rapeseed, broccoli, Brussels sprouts, cabbage and cauliflower of which rapeseed is normally used in feed manufacturing and result in reduced feed intake, goiter, hepatic and renal hypertrophy and eventually death upon higher concentrations [85]. Cyanogens are the “Hydrogen Cyanide or HCN” forming secondary metabolites commonly present in plants such as cassava, linseed seed, sorghum, clovers and other leguminous forages [76]. They include amygdalin, dhurrin, linamarin, linustatin, lotaustralin, neolinustatin, prunasin and sambunigrin, which upon hydrolysis release HCN that is associated with retardation of growth and neurological complications in animals [86]. Phyto-oestrogens refers to a wide range of isoflavonoid compounds particularly genistein, genistin, zearalenone, zearalenol and formononetin, present in forages, legumes and clovers, causing tumor and reproductive disorders in animals particularly cattle where it leads to Mastitis and Infertility and sheep where it causes clover diseases in which animal has reduced ovulation and conception [87]. Goitrogens, include a diverse range of antinutritional substances such as glucosinolates, isothiocyanates, thiocyanates, cyanogenic glucosides and nitriles possessing anti-thyroid activity and are responsible for development of goiter in animal upon long-term feeding with plant materials such as white clover, cassava, cabbage and other crucifers [87].

6.5. Animal based or Zootoxins/Mad Cow Disease as the potentially harmful Disease

Bovine Spongiform Encephalopathy or BSE, commonly known as Mad Cow Disease is one of the fatal neurodegenerative diseases of food producing animals, appeared for the first time in Great Britain during 1983. Since its outbreak, this disease has resulted 180,000 cases globally. [88]. It has been suggested that the disease was indeed the mutated form of “scrapie” which is also a fatal neurodegenerative disease of sheep and goat resulting from a misfolded protein called prion [89]. Its prevalence in cattle particularly the dairy cattle might be the result of feeding animal derived protein from the infected sheep or goat to cattle or other ruminants. The reason behind using word “spongiform” is due to the spongy or holey appearance of BSE infected animal brain [89]. The main feed ingredient that was among the vector for BSE are PrP^S infected meat and bone meal which are acronymically known as MBM [88]. This MBM and the by-products resulting from the process to develop MBMs is extracted from the non-edible waste material from poultry and other food producing animals and from the carcasses of died stock [90]. The mostly practiced technique was rendering, in which the obtained raw material was firstly dewater, defatted and then grinding the remaining proteinaceous material for making MBMs.

6.6. Global Prevalence

The global prevalence of BSE was resulted from trading of cattle and other bovine related products particularly the feed composing MBMs, and other mammalian derived rendered proteins. Therefore, the risk of BSE was addressed by classification into 4 categories by the Scientific Steering Committee of the European Commission [90]. The European countries are among the native region to be affected with BSE while BSE can also be detected in USA, Canada, Falkland and in Oman [90]. The following table highlighted the first appearance of BSE in many countries across the globe.

Table 10 Country wise cases

Country	Year of First Case	No. of cases reported	Reference
Great Britain	1986	180892	[90]
Northern Ireland	1988	2160	
France	1991	969	
Portugal	1991/1994	988	
Switzerland	1999	460	
Germany	1992/2000	389	
Netherlands	1997	78	
Japan	2001	22	
Canada	1993/2003	6	
USA	2004/2005	2	
Saudi Arabia		0	

6.7. Ban on mammalian derived protein

Lately in 1987, for the purpose of addressing the problems caused by the epidemics of BSE, countries such as UK and USA imposed ban on the use of mammalian protein in feed manufacturing for ruminants [91]. Unfortunately, being allowed to use in swine and poultry feed, the cross-contamination appeared to occur for years. Additionally, together with longer incubation period, the disease was failed to be diagnosed through preclinical tests. Although the ban was imposed and cattle were prohibited from feeding mammalian derived MBMs, the animals were still carrying the infected PrP^s due to year long incubation periods [90]. As a result, the entry of BSE into food supply chain was expected. Therefore, in 1989, for the purpose of protecting public health ban was also imposed on the offal that might be carrying BSE agents. The ban was also imposed on the use of over 6-month-old cattle's head except tongue in animal feed and even the head of sheep and goat for humans [92]. By 1990s, BSE was discovered in felines or the domestic cats and became transmitted to pig experimentally [90,93]. Addressing the prevalent problems, the offal ban was expanded to cover all species of mammals and birds in the same year 1990. In Europe Union, the ban regarding the BSE was converted into law by the year 2000 [90]. The virulence of disease was even more for 4–6-year-old cattle and having an average incubation period of 2 months.

7. Discussion

The division of feed in to multiple categories is dependent upon the nutritional value and intended use. Different countries have differently stated and defined these feed types but common of all these are compound feed, energy feed, protein feed, supplement feed, premixes, concentrates, and roughages, medicated feed and feed additives. Amongst these the compound feed is said to be a mixture manufactured while using two feed materials with or without the incorporation of feed additives and intended to be fed orally to animals. Moreover, it is recognized either as complete or as complementary feed. The word "complete" means feed which is compositionally suitable as daily ration while the word "complementary" means feed that is required to be mixed with other feed because of high amount of some substances (EC 767: 2009) [55].

Energy of feed usually manufactured from varying refined cereal grains and other vegetable crops such as wheat, maize, oats, barley, sorghum, potato, wheat bran and middling, corn cobs, rice bran and beetroot pulp. Of all these ingredients the most commonly used ingredient is maize [118]. Protein feed prepared from ingredients containing more than 20% protein both from plant as well as animal source. The plant-based ingredients are seed oil meal and cakes and maize gluten meal while the animal based are meals derived from various land animals such as blood, bone and meat meal and from marine animals such as fish meal [4]. Supplementary feed is a type of feed normally used along with basic feed ingredients for improving the nutritional value of the final feed and may be either rich in protein, energy or rich in minerals and vitamins [94].

Premixes are a feed type that comprises high concentration of one or more substances such as Vitamins, mineral or drug and is usually offered along with complete feed [95]. Concentrates often include grain and grain by-products such as wheat bran, oil seed cake and skim milk. These are usually diluted or mixed with other feed thereby making a supplementary or complete feed. Roughages are the plant-based category of feed consisting of hay, silages, pasture, and rangeland plants [96]. Medicated feeds a special type of feed offered to animal only in case of disease and usually contain one or more veterinary drugs as considered by U.S. FDA and usually categorized as Type A, B and C depending upon whether used directly or by dilution [96].

Feed additives are non-nutritive substances including enzymes, probiotics, herbs and antibiotics which are intentionally added along with basic feed ingredients for manufacturing compound or other feed type for the purpose of enhancing growth, feed uptake, palatability, and for preservation purposes [97].

Various ingredients are allowed to be used by different feed manufacturers all over the world. Chinese feed manufacturer mostly use corn, soybean, sorghum, barley, DDGs, cotton seed meal, rape seed meal and fish meal [98]. EU regulatory standard have listed about 166 ingredients belonging to cereals, pulses, forages, roughages, oilseed cakes and meal, other plants and fruits, vitamins, mineral, feed additives and animal by-products to be used in manufacturing of animal feed [32]. American feed industries use about 900 approved ingredients of which the three feed ingredients corn, soybean meal and DDGs together contribute more than 75% of the raw materials used by American feed industries. The Canadian feed regulation classified feed ingredients into 7 classes which are dry forages and roughages, pasture, range plants and forages fed Green, silages, energy feeds containing cereal grains, by-products from milling and brewing industries, molasses, vegetable fat and other wastes from bakeries and other food industries, protein feeds containing oil seed meals and cakes, fish meal, meals of blood, bone and feather, animal fat, and other by-products from poultry, cattle and marine animals, mineral products and Vitamin and yeast products [99]. According to Indian standards the ingredients are categorized as greens containing berseem and alfalfa meal, grain and their by-products, oilseed meals and cakes, root crops and tuber, animal by-products containing fish meal, meat meal, bone meal and blood meal and meat scrap, minerals and vitamins and waste containing material resulting from brewing industries, silkworm industry, fruit processing industry and other similar industry by-products provided that animal protein is not allowed for cattle feeds [100-101]. In Pakistan, the standards allowed ingredients from plant in the form of various forages, cereal grain and their by-products, oil seed meal and cakes and animal derived ingredients such as fish meal, blood meal and bone meal [63].

The discussion around the feed types and ingredients in Halal feed supply chain is dependent upon the basics of Halal and Tayyib integrity in feed production. Halal industry is stretching its wings and paving its way with phenomenal velocity. Halal logo is becoming the mark of soul satisfaction as well as product safety worldwide, which can be easily witnessed through the remarkable growth of the Halal industry. After food, cosmetics, pharmaceuticals, nutraceuticals, tourism and some other industrial products and services animal feed is also attracting the attention of global halal market. Thus, the need to highlight the concerns repugnant to Halal and Tayyib integrity and to address them from the latest Halal industrial regulations has become need of the time.

7.1. Halal and Tayyib Integrity in Feed Production

Islam is one of the fastest growing religions in the world with major religious status in 49 countries worldwide and population status prospected to a range of 2.97 billion which is 29.7% of total world's population. Asia and Africa are the 2 most inhabited Muslim regions covering 61.7% and 35% population share respectively while about 10% of the world Muslims lives in Europe. Besides, it has been forecasted that by 2050 US Muslims population would reach to a figure of 8.09 million becoming the second largest religious group [102]. As Muslims continue their robust growth it is quite expected that Islam would replace Christianity as the world's largest religion by 2070 [103].

Eating and drinking are very sensitive issues in Islam. The universe is packed with living and non-living organisms but each and everything is not allowed for consumption in Islam. Islam has imposed certain number of restrictions in this

regard. Halal connotes permissibility and Haram denotes prohibition. In halal related literature, the discussion often revolves around the main prohibitions, namely the consumption of pork, blood, carrion, and even Halal animals not slaughtered according to Islamic requirements, intoxicants and products thereof. In contrary to what is explicitly prohibited, there are Halal (allowed) food sources, like a mammal or bird amongst the land animals and their products, like eggs and milk, to be deemed as suitable for Muslim consumption they should be solely herbivores (e.g. sheep, goat, camel, cattle, rooster, pigeon, dove, quail and sparrow), similarly for an aquatic animal to be held suitable for Muslim consumption, that must be from fish family and also be fit for human consumption [104]. Since Muslims are meat lovers, they eat certain animals after being slaughtered in accordance with the Islamic rules, therefore the feed of the animals on which they grow and live is also very important as per the Islamic Jurisprudence.

As aforesaid that the development of animal feed requires a blend of animal and plant raw material together with some material from pharmaceutical and other industries. These raw ingredients although economical and readily available raise serious concerns for Muslims due to presence of Haraam and doubtful ingredients. One of the common practices followed worldwide both in developed and developing countries including Pakistan is utilizing animal waste in feed formulation. It is mostly practiced compensating expense related to feed and to reduce the disposal problem of the bulk waste generated from these animals [105]. Therefore, Muslims all over the world begun to uplift the significance of Halal and Tayyib integrity in developing animal feed and raise questions over the Halal status of the current feed.

Currently the feed industries around the globe utilizes a very diverse range of ingredients and raw materials for manufacturing feed, starting from plant derived ingredients to the animal derived and other ingredients resulting from non-food industries and some food service premises. About the plant and plant derived by-product's ingredients, the Halal and Tayyib integrity shows no concerns except for the DDGs which are the by-products resulting from brewery industry thereby raising concerns since the alcoholic beverages are held prohibited in Islam. Amongst the animal derived ingredients such as marine derived ingredients are allowed but the ingredients derived from land animals and other non-food sources there are several critical control points to be checked. One of the most critical issues is the derivation of ingredients from the pig that has been declared totally unlawful and impure. Similarly, the dogs and the cat which are euthanized and evident to be used by some feed industries in USA for ruminants could also be a critical control point in Halal integrity as both these animals are held Haraam in Islam. Blood which is used as an ingredient also causes questions since it has been rendered Haraam in Islam. Fat is also significantly utilized by feed manufacturers, therefore raises CCPs due to the possibility of the non-Halalness of the source. The animal by-products such as meat meal, bone meal and feather meal including the animal waste which are either obtained from swine or cattle and poultry seek the attention of Halal and Tayyib integrity. The use of PAP from mammalians or ruminants which has been found to be associated with TSE and BSE also raises concern for meeting the Halal and Tayyib integrity from public as well as animal health point of view. The use of probiotics is also a questionable area as the microorganism could be from the Haraam media or Haraam animal source. These are the critical concerns to be addressed by Islamic Jurisprudence.

7.2. Islamic Jurisprudence with regard to Animal Feed

Islam lays no code of life for the animals to live, consume and behave; it is the mankind that has been addressed in this regard. They are free to live the way they like and consume and behave the way they have been natured to do so. Islamic Jurisprudence does not restrict them as it does when the matter comes to the mankind. Islam provides them with the code of welfare binding the humans to take care of the animal's lives and feed. Animal welfare denotes the state of the animal and the treatment it receives during the whole life span. This includes animal care, animal husbandry and humane handling.

Fundamentally they have been created to fulfill the multiple needs of the mankind. Islam directs humans not to waste their lives and holds them responsible for their well-being and feed. Once the Prophet (P.B.U.H.) said, "there is no person who kills a small bird or anything larger for just nothing, but Allah, the Mighty and Sublime, will ask him about it". When the Messenger of Allah was asked about "nothing", He (P.B.U.H.) replied: "that you slaughter it and eat it, and do not cut off its head and throw it aside" (Sunan an-Nasa'I, 4349). On another occasion the Messenger of Allah said: "An ant stung a prophet. He ordered a colony of ants to be burned. Allah revealed to him: because an ant stung you, you have perished a community which glorifies Me" (Sunan Abi Dawud 5266). It is reported that the Messenger of Allah (P.B.U.H.) said that a woman punished her cat by imprisoning it until it died of hunger. Because of this, she entered the Fire (was sent to hell). [106].

In Halal Food Supply Chain, animal feed is considered as the initial Critical Control Point in ensuring the halal integrity of animal-based food products. The threats and uncertainties in the halalness of the animal feed may consequently affect the halal status of the halal food products, thus drive the attention of the Islamic Jurisprudence. In this context the Islamic Jurisprudence defines and describes some important principles for the animal's feed mentioned as follow.

- Animals are not the addressees of the Allah (SWT) with regard to Halal and Haraam, hence they are not bound to the code of Islam. Primarily they have been created to cater the multiple needs of human beings, as Allah (SWT) proclaims in Quran, "Allah it is Who hath appointed for you cattle, that ye may ride on some of them, and eat of some - Many benefits ye have from them - and that ye may satisfy by their means a need that is in your breasts, and may be borne upon them as upon the ship" (Quran, 40:79-80). In the said context they attract the injunctions from Islamic Jurisprudence.
- The jurisprudence of pure Najis and Mutanajjis (contaminated with Najis) shall apply to the animal feed. In the first case any substance which is purely Najis shall not be fed to the animals either halal or Haraam as per the Hanafi', Maliki and Shafil' Schools of thought, whereas Imam Ahmad bin Hanbal and Imam Malik in another view is of the opinion that pure Najis can be fed to the Haraam animals (non-edible). Since they are not meant for consumption, therefore, they can be fed with such substances, they added [107]. Hanafi' and Shafil' Schools argue that any substance which is rendered purely Najis by Islam is not amongst the goods that have economic value in the eye of Islamic Jurisprudence, thus cannot be sold or purchased, hereafter cannot be fed to the animals either Halal or Haraam e.g., wine, blood, pig etc. In case of Mutanajjis feed the animals either Halal or Haraam can be fed with such feed as per all the prominent Schools of Jurisprudence. For instance, if any Najis component, e.g. blood as blood meal along with the other non-Najis components is incorporated in the feed, then the consideration with regard to Halalness of that feed shall be given depending upon the quantity of that Najis component, if the Najis component is lesser in quantity as compared with the other non-Najis components of the same feed then the feed shall be rendered Halal, otherwise it shall be deemed Haraam as per the Hanafi', Maliki' and Shafil' Schools of Jurisprudence, whereas Imam Ahmad bin Hanbal is of the view that an animal can be fed with such feed with the condition that such animal shall not be slaughtered before the expiry of three days from the day when that was fed with such feed. In the mentioned case the rule of Mutanajjis (contaminated with Najis) has been applied with regard to the juristic deduction of the multiple schools of Jurisprudence [108].

7.2.1 Integrity of Halal Logo

These are the classical juristic views of the prominent Schools of jurisprudence. With reference to the modern-day Halal industrial standardization and certification, the Halal integrity demands even stricter criterion. The relaxation which was shown regarding the Mutanajjis (Contaminated with Najis/non-halal) feed in classical juristic views of the prominent schools in the pre-industrial standardization and certification era might not be shown in modern-day halal industrial standardization and certification age. When the feed is claimed, proclaimed, labeled and sold to be Halal, it requires the complete traceability of the Halalness of the feed supply chain. Halal logo represents the sanctity of Halal, hereafter it is repugnant to the sanity of the halal certification that a feed is rendered halal while having non-halal components. There is a need to understand the distinction between the halal certified feed and non-certified feed, as per the Islamic jurisprudence the later one can have the non-Halal components in minute amount while the first one cannot, cementing and shielding the sanctity of halal logo. In the recent past some crucial Fatwas (Islamic rulings) have also been issued by the important halal industry players restricting the scope of classical adjudications and reflecting the said distinction mentioned above.

The Fatwa (Islamic verdict) from Malaysian Fatwa issuing authority prohibits feeding aqua cultured fish with feed derived from Najis (filth) and animal waste [109], for the purpose of maintaining the sensitivity of Muslim community in the country [109] This is supported by the one issued by Indonesia which prohibits the production and trading of animal feed that contain swine elements or other non-halal animals [110]. The fatwa of Brunei on the other hand, discourages the practice of feeding animals with filthy feeds and selling those animals without proper quarantine process [110]. Apart from these crucial Islamic rulings global halal standards also highlight the issue in a same way:

- The Standards and Metrology Institute for Islamic Countries (SMIIC) is a subsidiary organ of the Organization of Islamic Cooperation (OIC) established for standardization purpose. Recently the SMIIC has issued a fresh version (2019) of food standard encapsulating the requirements for halal foods. The said standard (OIC/SMIIC 1) has included the feed for food producing animals in its scope, meaning by, like the halal food no non-halal ingredient shall be included to the feed of food producing animals. Hereafter, in its clause 5.1.1.2 for non-Halal animals, those farmed Halal animals which are intentionally and continually fed with harmful, or Najis (Contaminated with Najis/non-halal) feed have been categorized as non-halal animals for food purpose.
- Malaysia which is one of the halal market leaders in its freshly issued halal food standard, MS. 1500-2019, proclaims under the clause 4.5.1.1.1 that farmed halal animals which are intentionally and continually fed with Najis (Contaminated with Najis/non-halal) are non-halal for food purpose.
- United Arab Emirates (UAE), an emerging halal market leader in its standard for slaughtering, UAE. S 993-2015 under the clause 4.1.4 states that the animals should be fed fodder produced from halal sources.

- Pakistan an important member of SMIIC, in the recently issued halal food management system standard, PS: 3733-2019, Part ii, includes the feed in scope meaning by like the halal food no non-halal ingredient shall be incorporated in halal feed. Moreover, in part one of the said standard which is meant for terms and definitions under the clause 3.17 declares those farmed halal animals which are intentionally and continually fed with Najis (contaminated with Najis/non-halal) bitterly disliked for food purpose.
- In addition to the Islamic rulings (Fatwas) all these important global Halal standards ensure the sanctity of the halal logo on animal feed product by asserting that the source of the animal feed must be wholly Halal, no non-Halal component shall be allowed.

7.2.2 *Islamic Concept of Jallalah*

The concept of eating food in Islam is based upon food safety. Only that food is allowed to be consumed which is held fit for consumption. The Islamic concept of Jallalah encapsulates those halal animals that wander around feces, dung and other impurities. The word JALLALAH comes from the word JULLAH, which means feces or dung in Arabic [111]. Since these Halal animals consume filth, and resultantly the natural texture, taste and smell of the milk or meat of such animals get changed, therefore, Islamic jurisprudence while assuming the milk or meat of such animal not fit for human consumption professes certain details and criterion for Jallalah animals. In this regard it is important to highlight some related Hadiths from the prophet (P.B.U.H.) prior to discoursing the opinions of different schools of thought.

The prohibition against eating and drinking the meat and milk of Jallalah animals, even a ban on riding them has been narrated in the multiple Hadiths regarding such animals. It can be seen from Hadith narrated by Ibn-e-Umar, in which the Prophet (P.B.U.U) prohibited eating the meat and drinking the milk of an animal which feeds on filth (Sunan Abi Dawud, 3785). There were also another Hadiths compiled in Sunan Abu Daud (hadith number 3786 and 3787) and Sunan Al-Tirmidhi (Hadith number 1824 and 1825) with similar prohibitions. The prohibition of riding al-jallalah animals is narrated in Sunan Abi Dawud, in Hadith number 2557 and 2558. There are almost thirteen hadiths which narrate the bar on Jallalah animals [112].

Based upon the above-mentioned Hadiths, majority of the jurists opine, when a bad odor starts emitting from the flesh or the sweat of the Jallalah animal or a change is observed in the texture of milk or meat of such animal, it will be Makrooh (bitterly disliked) to eat its meat, eggs, and drink its milk, and even riding such animal. Imam Shafil' and Imam Ahmad Ibn-e- Hanbal in their one opinion has the same decree which the majority of the jurists have, while in another, they both are of the opinion that consuming the meat, milk and egg of such animals would be rather Haraam [113]. Imam Malik paved his juristic way differently and opined that consuming the meat, milk and egg of such animal and riding them is Halal [114]. The basic principles of sensory evaluation of food or the source of the food including the texture, odor, taste, visual, etc. have been the same over centuries in the mankind history. With the passage of time and with the induction of modern technology only the methods get changed. Regarding the Jallalah animals the classical jurists had considered this evaluation; hereafter some of the jurists cemented their opinion on the results of the sensory evaluation while some paved their way regardless of the said evaluation. Following are the detailed versions of the various jurists.

Imam Abu Hanifah

According to Hanafi' School of Fiqh, it is Makrooh to consume the meat, egg and milk of an animal (Jallalah) that eats filth and as a result of eating such filth bad odor starts releasing from its sweat or the texture of meat or milk gets changed. While decreeing an animal to be Jallalah, Hanafi' School of Fiqh considers both, firstly, consuming filth, secondly, classical sensory evaluation. Once the animal is deemed Jallalah, it requires quarantine process in Islamic Jurisprudence prior to consumption. Imam Abu Hanifah fixed the quarantine periods for various Jallalah animals depending upon their size. He fixed ten days for camels and cattle, four days for sheep and goats, three days for fowls. In another opinion attributed to him, there is no specific period for quarantine process. The Jallalah animals will be engaged and imprisoned and fed with pure feed until their filth is flushed out and the status of impermissibility changed to permissibility [113].

Imam Malik

Maliki School of Fiqh is of the opinion that it is Halal to consume the meat, milk and eggs of the Jallalah animals even when it releases the bad odor. This school of thought cemented its opinion on the fact that fundamentally the animal is halal; therefore, its dieting habit would not be considered. These Muslim jurists permitted the consumption of meat, milk and eggs of animal that is being fed with filth based on the argument that animal could not be regarded as Najs due to the habits of eating filth [107].

Imam Shafil'

Shafil' School opines in an opinion that it is Makrooh to consume the meat, eggs and milk of Jallalah animals, while in another opinion he renders the consumption of such animals' haram. Shafil' School based their opinions wholly on feeling the bad odor from such animals or observing the change in the texture of the milk of such animals. According to him, if such happenings do not occur, it would be halal to consume such animals beside the fact that these animals feed on filth. Regarding the quarantine process of the Jallalah animals, the Shafi'I School opines that camel should be quarantined for forty days, while goat and chicken are for seven and three days respectively [112].

Imam Ahmad Ibn-e-Hanbal

Unlike Imam Shafil', Imam Ahmad cemented his opinion with respect to Jallalah animals on their dieting habit. If such animal consumes filth, according to his first opinion it would be Makrooh to consume such animals and in his second opinion he rendered it Haram, regardless of the fact that either such animals release the bad odor or not, or the change in the texture of milk is observed or not. The advocates of this view use the literal meaning of the hadiths mentioned above to support their opinion on the illegality of consuming Jallalah animals [115]. As for the quarantine period, Imam Ahmad states that both birds and animals should be quarantined only for three days.

In this Islamic Jurisprudence dialogue, the reason due to which Islamic scholars had suggested the quarantine process is the unpleasant smell and other changes that a Jallalah animal possesses as a result of eating impurities. Hence, the reason for the prohibition should be removed in order to change the status of the Jallalah animal from prohibited to permitted. The quarantine process is therefore suggested as a mechanism of purification to eliminate the impurities from the contaminated animals. Though the different periods for quarantine process have been given by the jurists, yet the strong opinion agreed upon among the Islamic jurist is that there is no definite measure or period regarding the purification period [116-117]. The important matter in this regard is that the Jallalah animal shall be purified, it does not matter how many days it takes.

8. Conclusion

After an overview of the globally manufactured feed, its ingredients, global standards and regulations, the Halal and Tayyib integrity concerns, different views of classical Islamic Schools of thought, sanctity of halal logo, global Halal standards and the concept of Jallalah, following points are concluded as findings of this whole discourse. The following points are in-line with the halal certification to ensure the integrity of the halal logo on animal feed. The classical juristic adjudication on the other hand professes softer and easier outcomes as has been stated earlier.

- Animals are not the direct addressees of Quran and Sunnah; therefore, they are not supposed to follow any code of religion. They are free to live and consume the way they like; in addition, Islam holds mankind responsible for their welfare and rights. Animal feed becomes an important subject for Islamic Jurisprudence only when the matter comes to the food animals.
- Islamic Concept of food is based upon Tayyib (food safety); therefore, any ingredient in animal feed which resultantly causes hazards to human health shall be deemed non-halal. The burden of responsibility to affirm anything injurious to health lies on the shoulders of feed scientists and the concerned experts.
- All the mineral based feed ingredients are halal unless held hazardous to human health, hereafter; di-calcium phosphate, marble powder, limestone etc. may be used in the manufacturing of animal feed as long as these are not considered injurious to human health.
- Fundamentally all the agro based feed ingredients are halal unless deemed hazardous to human health. Distillers' dried grains with solubles (DDGS) that come as a byproduct of alcoholic beverage industry shall be held non-halal.
- Ingredients derived from aquatic animals for animal feed are halal unless held hazardous to human health. In this regard, fish meal is rendered halal.
- Ingredients derived from amphibious animals for animal feed are held non-halal.
- Ingredients derived from halal terrestrial, or ariel animal being slaughtered in compliance with Islamic slaughtering rules are halal to be used in animal feed except blood. Blood derived ingredients are held non-halal. Ingredients derived from other than halal animals or from halal animals not slaughtered in accordance with Islamic rules shall be considered non-halal. In this regard, blood meal is rendered non-halal, while bone meal and meat meal derived from the halal animal with the said condition are deemed halal. Same is the case in poultry by-products meal, only halal slaughtered poultry by-products meal is rendered halal with the exception of blood. All these ingredients are deemed halal provided that they must not cause harm to the human health.

- Jallalah animals shall be kept under quarantine process prior to consumption.

To conclude the whole discourse, it can be asserted that the feed of the animal must be from Halal source and is of such nature that it must not cause harm to the animal and resultantly to the human being.

Compliance with ethical standards

Acknowledgments

The authors would like to thank Dr. Abid Masood, technical advisor Halal Food Council of Europe, Mufti Yousuf Abd ul Razaq, CEO SANHA Halal Associates Pakistan and Dr. Mufti Syed Arif Ali Shah, Certification Manager SANHA Halal Associates Pakistan for their valuable support.

Disclosure of conflict of interest

The authors have no competing or conflict of interest.

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