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Amaranth in Animal Nutrition

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ABSTRACT

Amaranth (Amaranthus spp.) is a nutritious rich pseudo-cereal crop grown as a grain and leafy vegetable. The grain amaranth can be used for human consumption and silage or forage for many animals. Grain amaranth is also included in the category of superfood based on all essential nutrients that are required for living beings. The amaranth crop is widely cultivated in Central America, Asia, and African regions. Amaranth as a leafy vegetable has high usage as a salad for humans and good quality silage for animals. As compared to other forages, it plays a good role in the growth and productivity of animals as it contains several compounds in it that help the animal to grow better. This review aims to highlight the nutritional quality of amaranth for the animals and to enhance the knowledge of these plants and their uses in animal nutrition as an alternative source of protein, fiber, and other essential amino acids.

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INTRODUCTION

"Amaranthaceae" is a family of Amaranth. The word "Amaranthaceae" is derived from the Greek word "Anthos" which means flower. It is also called third-millennium crop at present. Based on its taxonomy it is divided into two types (Allen, 1961). Amaranth (Amaranthus spp.) is a small, seeded grain crop that is free from gluten and contains high protein content. In the world there are approximately 70 different species of amaranth (O'Brien and Price 2008), that all are annuals and have small seeds (seed weight=0.65 grams/1000 seeds). Grain of amaranth is highly nutritious (Thakur et al., 2021) and has various colors (yellow, dark pink, purple and red) that highlight its ornamental values (Tapia et al., 2000). Amaranth originated from Central America and Mexico but latterly in the 20th century, it was domesticated in Asia, Africa, Europe and North and South America. Anthropological studies revealed that the extract of amaranth species have been used in traditional medicine in many countries including Asian and African culture.

CLASSIFICATION and MORPHOLOGY of AMARANTH

The genus Amaranthus L. belongs to the Amaranthaceous family and to the Amaranthoideae subfamily popularly known as amaranth. It occurs naturally in temperate and tropical regions worldwide (Peter and Gandhi, 2017). Amaranth belongs to the C4 plants family, and it performs well under stress conditions like low or high temperature and drought and its photosynthetic pathway is more efficient than that of C3 (Stallknecht and Schulz-Schaeffer, 1993). From tropical marshes to Himalaya's area the grain Amaranths species is widely diversified and distributed to many geographic territories (Joshi and Rana, 1991).

It is fast growing annual herbaceous plant and can reach more than 2.0 meters in height (Thakur et al., 2021). This plant has a deep tap root system and even under drought

conditions also have tap roots to support the plant to cope with water deficit conditions (Sumar-Kalinowski 1986). Generally, the stem of amaranth is calm with the same color as its leaves. Leaves are petiolate without stipules and oval or elliptical shaped which can be in both shapes opposite and alternating (Tapia et al., 2000). The fruit of amaranth are dehiscent pyxis, with only one seed inside and has a light color (Sphehar et al., 2003) and germinate faster in a humid environment (Tapia et al., 2000).

PRODUCTION TECHNOLOGY

Its common name depends upon its region as in the regions where English speaks as a local language it is known as red amaranth, smooth pigweed purple amaranth, princess's feather, blood amaranth and Mexican grain amaranth, etc. and in other regions of the world it is known as, Hanekam (Afrikaans), Thepe (Sesotho), Een Choy and Yin Choy (China), Hiyuna (Japan), Yan yang (Vietnam) and Coimi and Millmi (Bolivia), etc. (Rastogi and Shukla, 2013; Kumar et al., 2020). Currently, all around the globe Amaranthus has spread widely and is considered a rapidly producible crop. Its cultivation has been started in many countries (Nepal, Philippines, India, China, Whole of Central America, Nepal, Malaysia, Africa, and Indonesia) many years ago and consumed in the most utilizable way (Peter and Gandhi, 2017). Mid-May to mid-June in the African region. Mid-March to mid-June in Turkey (Geren, 2015). Normally, the optimum temperature for this crop is 18 to 25°C. So, it is grown in the season of early Spring and planted out in summer. All the amaranth species are annual and short-lived perennials that have different types and colors of leaves. Amaranth has oval and points with red, pink, yellow, and purple color leaves. The development of the flowers is very minute that are many types (drooping and tassel-like spikes) and they remain at the end of the summer (Mlakar et al., 2010). The plants of the Amaranth do not need a high amount of water, only 1 inch per week is sufficient for their growth and development. If it is irrigated with high water, there is a high risk of fungal and root rot diseases. 3 to 5 irrigations are enough for the whole crop season (Sosa et al., 2018). Most of the amaranth plants are taller rather than bushy and wider. So, planting them within 10 to 18 inches is an ideal way and as close as they grow, they look better and once they are fully grown, they get enough space for good air circulation. Broad

casting and Drill with a sowing depth is ½ inch (1.3 cm) are recommended but broadcast prefers because of the very small seed size (Kanthaswamy, 2006). Normally, 2.2 kg/ha in dryland, and 2.2-3.4 kg/ha in irrigated areas are used (Pospisil et al., 2006). It is considered that about 1.5 to 4 pounds per acre seed rate are suitable but most recommended is about 2 pounds in most crops. It is studied that in Missouri the performance of the amaranth is best at the 30 inches row width. Due to its wider shades and rows, it is used to control weeds also. There is not any specific need for fertilizer for the growth but the high amount of nitrogen dose causes leggy and affects its harvesting. A recommended dose of N:P:K: 64:46:40 kg/ha respectively is applied (Ohshiro et al., 2016). Amaranth also belongs to a weed but when they grow for grain purposes its production is also affected by weeds. Common weeds during crop are red root pigweeds, cheatgrass, Lamb quarter, Kochia, and other grasses (Pospisil et al., 2006). As it belongs to the weed family so, there is no specific herbicide that can be used in the amaranth crop to control weeds. The better height for the amaranth to compete with the weed is about 10 to 12 inches. During the growing season if there is any weed problem with the amaranth then can be controlled by hand weeding and proper way of cultivation. The lack of synthetic pesticides registered for amaranth coupled with the low disease and insect pressure could make amaranth a good candidate for organic production (Mureithi et al., 2017). The amaranth crop is ready in 4 to 6 months (120 to 180 days) (Das, 2016) depending upon the species used and depending on your climate, and when you planted. Mostly *Amaranthus hypochondriacs* mature in 5 months (Gimplinger et al., 2007). They are ready to harvest when they begin to fall from the flower head (tassel). Give a shake to the tassel if you see the seeds are shattering and moisture content is about 12 to 14%, harvest the crop and place it in the field for sun drying for 3 to 4 days until its moisture content reaches 8 to 10% (Hoidal et al., 2019). Some diseases cause the serious losses in amaranth production.

The main disease that is reported is seedling blights, dumping off, Rhizoctonia and Aphanomyces. One of the diseases (Stem cankers) is reported to occur due to phoma and Rhizoctonia. If the proper site selection and good cultural practices are followed, then there are high chances to control the different diseases. There is not any study using the fungicide for amaranth use (Alemayehu et al., 2015). There is not any effect on the yield of amaranth if there is an attack of insect leaf feeding. But, in Missouri, some study shows that there are economical losses if the crop is under the alfalfa webworm and blister beetle's attack. Some insect pets (Lygus, amaranth weevil, and flea beetle) are identified. There is not any use of synthetic insecticides to control insects, but an organic compound can be used for amaranth crops. Lygus Lineolaris is the primary insects & pets of amaranth in the United States. Others are Grass-hoper, all wormy worms, blister beetles, and weevils (Aragón-García et al., 2011; Kagali, et al., 2013). The average biological yield of an amaranth crop is up to 40-50 ton per hectare (Li et al., 2019). Some studies indicate that (Madulu and Chalamila 2005) in Sub-Saharan Africa the average leaf yields of amaranth are less than 1.2 tons per hectare against (Oluoch et al., 2009) the potential yield (32-40 tons per hectare).

Farmers reported amaranth seed yield like that of maize (~0.7 to 1.2 t/ha) (Hoidal et al., 2019)

NUTRITIONAL CHARACTERISTICS OF AMARANTH

The nutritional quality of amaranth may vary from cultivars to cultivars, use of fertilizer during the plant development, and agronomic and environmental conditions of the crops (Ascheri et al., 2004). The three main species to be considered as protein-rich species, mainly cultivated in American Continent (*A. cruentus, A. hypochondriacus, A. caudatus*) have 13.2-18.2%, 17.9%, 17.6-18.4% on a dry basis (Coelho et al., 2018) respectively. Amaranth protein has high biological quality (Ascheri et al., 2004), mainly due to the good balance of amino acids, (Teutonic and Knorr, 1985) such as lysine, Sulphur containing amino acid, methionine, and cysteine. Some other amino acid is present in a smaller quantity like leucine, isoleucine, threonine, and valine (Bressani 1988). Due to the absence of gluten, it is considered that amaranth is a great food for people (Almeida and Sa, 2009) that have celiac disease or gluten sensitivity so, they are intolerant to gluten intake.

Nutritional Value of Amaranth

According to a comprehensive study conducted in 2012 by Valcarcel-Yamani and Lannes, Amaranth posses a high nutrition quality and quantity, because of which it is named as superfood and functional food in the world. In that study they have described the nutrition quality in the tables below. Additionally, these researchers also compared its nutrition value with some other cereals (Table 5).

Table 1. Mineral composition in Amaranth, wheat, barley (mg/100g) (Valcarcel-Yamani and Lannes, 2012)

Minerals	Amaranth	Wheat	Barley
Calcium (Ca)	180.1-217.0	34.8	29.0
Iron (Fe)	9.2-21.0	3.3	2.5
Magnesium (Mg)	279.2-319.0	96.4	79.0
Zinc (Zn)	1.6-3.4	1.2	…..

Table 2. Composition of essential Amino acid contents of Amaranth, Wheat, and Maize seeds (mg/100g) (Valcarcel-Yamani and Lannes, 2012)

Amino acid	Amaranthus spp.	Maize	Wheat
Histidine	1.78-11.23	2.6	2.0
Isoleucine	1.46-5.71	4.0	4.2
Leucine	3.19-9.23	12.5	6.8
Lysine	0.66-11.12	2.9	2.6
Methionine	0.35-4.80	4.0	3.7
Phenylalanine	1.20-9.8	8.6	8.2
L-Arginine+Theorine	5.99-19.97	3.8	2.8
Valine	1.70-7.52	5.0	4.4

Table 3. Chemical Composition of Amaranth seeds (%) (Valcarcel-Yamani and Lannes, 2012)

Chemicals	Amaranthus spp.	Wheat	Maize
Protein	7.84-18.01	13.4	10.2
Oil Content	6.42-12.53	2.3	4.7
Carbohydrates	68.8-70.3	78.4	81.1

Table 4. Vitamins Composition in Amaranth seeds (%) (Valcarcel-Yamani and Lannes, 2012)

Vitamins	Amaranth	Barley	Quinoa
Thiamin (B1)	0.07-0.10	0.191	0.29-0.36
Riboflavin (B2)	0.19-0.23	0.114	0.30-0.32
Niacin(B3)	1.17-1.45	4.604	1.24-1.52
Ascorbic Acid (C)	4.50	-	-

Table 5. Nutritional content of roughages in Amaranth, wheat straw and alfalfa hay (Filik, and Filik, 2021)

Parameters	*Amaranthus powellii* wild.	Wheat Straw	Alfalfa Hay
DM g/kg	941.90	961.00	922.90
Ash %	13.22	7.16	13.68
CP %	4.84	4.47	19.59
EE %	2.16	1.22	6.55
CF %	28.14	31.86	41.52
ADF %	37.12	49.47	58.01
NDF %	53.38	78.77	78.23
ADL %	35.06	35.44	43.01
HCel %	16.27	29.30	20.22
Cel %	79.85	86.97	60.20
TC %	45.81	51.17	10.86
NFE %	45.81	51.17	10.86

DM: dry matter, CP: crude protein, CF: crude fiber, NDF: neutral detergent fiber, ADF: acid detergent fiber, ADL: acid detergent lignin, EE: ether extract, TC: total carbohydrates, HCel: hemicellulose, Cel: cellulose, NFE: nitrogen free extract.

BENEFICIAL/ MEDICINAL PROPERTIES OF AMARANTH

Amaranth as a grain and leaves both are a good source of protein and lipid and also have maximum minerals contents like P, K, and Ca than other oat grains (Barca et al., 2010). It is found that amaranth has higher health benefits than rice and other cereals (Nascimento et al., 2014). Particularly, in low-pay countries amaranth could give basic supplements that require for body development and the basic health issue (Kachiguma et al., 2015). This food is rich in bioactive compounds like phytosterols that helps to lower the cholesterol level in the body. Amino acids like lysine, L-arginine, and lunasin this help to absorb the calcium and decrease the calcium extraction via urine, have cancer -preventing properties and boosts the activity of osteoclast cells (Mlakar et al., 2009). It also plays an important role in combating inflammation properties that are related to the many health diseases (heart disease, stroke, and diabetes, etc.) Amaranth contains phenolics that help as a secondary plant metabolite and give protection to the

plants against much ultraviolet radiation, herbivores, and pathogens attack. Rutin is a flavonoid that is present in the amaranth that helps in the anti-inflammatory properties (Rastogi and Shukla, 2013) and has a neuro-protective effect as it decreases the cytokines level and helps to repair the damaged brain cells. Amaranth oil contains the best squalene properties, which is a solid cancer prevention agent and shields the skin from untimely maturing by forestalling cell harm (Khamar and Jasrai, 2014). Amaranth seeds can be exposed to a few medicines, for example, puffing, toasting, or pounding. It can be expended as a drink after mixing with water or milk or it can be incorporated into bread, tortillas and finally, it can also be treated with different arrangements (Sanchez 1983; Bhat et al., 2015). Amaranth is a gluten-free crop so using its seeds as flour after grinding can be useful for health. Without any physical losses, it can be used as edible for amino profile, oat items, fat substance, and protein quality (Bressani et al., 1992).

USE OF AMARANTH IN MONOGASTRIC ANIMALS

Amaranth crops are mainly grown for grain and leaves development all around the world (Manyelo et al., 2020). Both part of amaranth is utilizable for the monogastric as a feeding purpose.

Uses of amaranth leaves and grain in monogastric nutrition

Amaranth laves and grain are a protentional source of methionine and protein for monogastric animals. The status of monogastric nutrition (Montero-Quintero et al., 2015) involve in providing the best nutrition quality and amount that fulfil all animals' requirements according to growth, egg production and maintenance. Now adays amaranth gained more attention worldwide due to its hard behavior in a harsh climate, its availability, good nutritional quality, and composition, and the main thing is economic feasibility (Bautista et al., 2019).

Amaranth Leaves

The use of amaranth leaves which is a high source of protein and energy shows good improvement in the monogastric feed formulation. One amaranth type is *Amaranthus cruentus* used as a leaf meal in the broiler finisher diet as a source of protein (Fasuyi et al., 2008). It is considered that 10% of *A. cruentus* leaf meal if mixed with broiler feed showed that there is a reduction in cholesterol contents of eggs, serum peroxidation level, and enhancement the egg weight also gives better performance (Longato et al., 2017). It is stated that the addition of 10% of amaranth leaves in the pigs feed increases the digestibility, (Shilov and Zharkovskii, 2012), the productivity of weaners, and the degree of assimilation of nitrogen (Zraly et al., 2006). It is stated that there is an improvement in the growth rate of the fish when feed with up to 5% of amaranth leaves (Adeniji et al., 2007). Fasuyi and Akindahunsi (2009) concluded that about 25% of sun-dried leaves of A. cruentus if used as a meal and addition to some enzymes in the meal (cellulose, amylase, and glucanase) give better results in the broiler chicken performance. It is observed that 75% inclusion of amaranth leaf reduces the fish growth rate (Nuggi et al., 2017). Adeniji et al. (2007) stated that if there is any reduction

and negative effect occur due to amaranth feeding, it may be due to some anti-nutritional factors that are present in the amaranth. These factors involve to an imbalance of the amino acid structure that affect animal performance. 10 to 20% of amaranth leaf in the poultry improved the egg weight and improved the performance characteristics and nitrogen utilization (Fasuyi et al., 2007). The addition of 8% of amaranth leaves in poultry creates no any adverse effects on the live weight gain, meet quality, carcass characteristics, and feed conversion (Longato et al., 2017). In the pig, 10% of amaranth leaf increases the digestibility, nitrogen assimilation, and productivity of weaners (Shilov and Zharkovskii 2012 and Zraly et al., 2006).

Amaranth Grain

In poultry diets, amaranth grains have a good protentional to partially replace maize and soybean meals (Aderibigbe et al., 2022. If treated the grain amaranth (cooking, pooping, heat treatment, extrusion of amaranth, and autoclaving) give positive result as compared to feed with soybean and maize (Aderibigbe et al., 2022). In the chicken finisher diets, some studies recommended that amaranth can only be used as a raw material (Pisarikova et al., 2006). However, there is another study that observed that normalized treating grains (grains that are heated at a specific temperature and then cool down at room temperature to remove impurities) can be consumed by chickens (Pisarikova et al., 2006). In fish, the application of 5% grain amaranth enhance the growth rate and does not give any harmful effects (Niewiadomski et al., 2016). The addition of 20% and 32% of grain amaranth in the rabbits' feed involve in reduction of blood cholesterol oxidation and increased fat and protein content respectively (Molina et al., 2018; Caselato et al., 2014; Berger et al., 2003). Different studies concluded (Sokol et al., 2001) that in the pigs the 10%, 2.5-10%, and 25% addition of amaranth grains create not any harmful effect (Shilov and Zharkovsii; 2012) on the health and metabolism, although it enhances the digestibility and produces without any negative effect on the chemical (Kambashi et al., 2014), physical-chemical or on the sensory properties of the meat respectively (Zraly et al., 2006). There is not any effect on the protein digestibility if amaranth grain uses as a raw form as compared to popped form which reduces the biological value of protein content due to high temperature (Písaˇríková et al., 2005). However, there is another study concluded that in the broilers, heat-treated amaranth grains involve reduced digestibility as compared to raw amaranth grains (Fasuyi et al., 2009). In the pig diet if amaranth grain is added then it enhances the rate of digestibility (Kambashi et al., 2014, (Shilov and Zharkovsii; 2012). Feed the grain amaranth to the layers the production of the eggs is enhanced day by day (Popiela et al., 2013). The production and survival rate of the weaners pigs increase when they are feeded with grass meal and 2.5 and 10% of the A. (Shilov and Zharkovsii; 2012). When the 5% of the soybean meal is replaced by the amaranth gain then there is an improvement occuring in the growth rate of the trout fish (Niewiadomski et al., 2016). In tropical and sub-tropical regions, it is supposed that in rabbit feeding, the use of A. dubis provide a good source of protein and fibers (Niewiadomski et al., 2016). It is also concluded that in rabbit meat, there is an increase

in the fat and protein with decreasing the moisture content when A. dubis applied in their feed (Molina et al., 2018).

USE OF AMARANTH IN RUMINANTS NUTRITION

Amaranth has a high potential for the ruminants as a forage which have always been eaten as wild amaranth. The interest in amaranth as a feedstuff increase day by day due to its good fatty acid content and rich nutrition value (Peiretti et al., 2018). Amaranth can be used in multiple ways (fresh, ensiled forage, dried and grain) (Abbasi et al., 2012) but not all the amaranth species are recommended to give to ruminants for feed because of the presence of some anti-nutritional factors (Gupta and Wagle 1988). One of the studies stated that the impact of the ensiling on the nutritional quality of amaranth specie (*A. hypochondricus*) identify the oxalate content that works as an anti-nutritional factor (Seguin et al., 2013) in the ruminants. It affects health, and kidney failure, and leads to hypocalcemia in the ruminants. But it also depends upon its form and content like a soluble form of oxalate is more poisonous for the animals. Amaranth can only be suitable for ruminants after given some special treatment against anti-nutritional factors (Alemayehu et al., 2015). (Skultety et al., 1991) stated that cattle fed on a pelleted amaranth diet give better results than fed on ensiled and green amaranth that showed a lower level of dry matter intake.

Ensiling of amaranth overcome the anti-nutrient level and enhance the digestibility in a proper way (Cervantes 1990). As already explained that existence of the anti-nutritional factors is a big issue for the amaranth crops and alternative feed sources also. For this purpose, it may need some physical, chemical, and biological treatment before adding into a monogastric diet (Nørgaard et al., 2019). Many treating ways can be applied to overcome the anti-nutritional factors. Most of the treating methods are performed on a large scale but some are also done domestically. For the ruminants, like other common forages, the amaranth has a high proportion of undegradable protein (Sleugh et al., 2001). It is concluded that amaranth has a protentional to fulfill the maize diet in the ruminants, by mixing both amaranth and maize. The ideal form of crude protein can be obtained by mixing both maize and amaranth (Rahjerdi et al., 2015). One of the grain amaranths specie i.e., *Amaranths hypochondriacus* can be used as a partial substitute for the barley in the sheep diet as they studied to include 80% hay with 20% amaranth instead of barley (Jalc et al., 1999). *Amaranthus hybridus* as a leaf meal has a high potential for early weaners diets as compared to lucerne. Study shows that amaranth leaf meal containing the 40% diet for the calves give better performance than lucerne meal (Odwongo and Mugerwa, 1980). *Amaranthus cruentus* (grain amaranth) has a good potential to produce good quality silage for the sheep (Olorunnisomo and Ayodele, 2009).

It is stated that during the dry seasons there is a problem in the quality and yield of forage. During this duration, this may go an insufficient supply of quality feed for ruminants (Gallaher and Pitman 2001). During the dry periods, to obtaine the maximum improvement of the animals there is a high need to store the forage. Most

of the conserved forages contains minerals, vitamins, a high concentration of soluble carbohydrates, and high-quality protein. Amaranth and maize fodder both contain a high concentration of carbohydrates (Coors and Lauer, 2000) and high yield and good quality in this short period (Sleugh et al., 2001). During this duration, these crops play an important role to fulfill the fodder scarcity period gap in feed supply to ruminants. According to a study by Rezaei et al., (2014) it is supposed in the diet of Moghani lambs the limited replacement of amaranth silage for the corn silage (up to 300 grams per kilogram) without any effect on the feed efficiency, develops a positive result in the growth performance, feed intake, microbial nitrogen, and nitrogen balance.

Due to its chemical composition, crude fiber, crude protein, and other essential nutrients, make the amaranth differ from other forages which concluded that amaranth is more suitable forages for ruminants. It is used in the ruminants both in fresh and ensiled form (Seguin et al., 2013) Amaranth's silage can improve the total weight without any hazards or any health effects of Moghani lambs (Rezaei et al., 2013; 2014) it can also maintain the nitrogen supply, nitrogen retention, feed intake, daily gain, and ruminal butyrate.

It is observed that by the application of amaranth silage the intake of dry matter and the improvement of the lactating cows increased in a positive way (Rezaei et al., 2015). Amaranth silage has a better effect on milk quality. According to a study conducted by Pavlenkova et al., 2019, the result showed that experimental groups of cows gave high-quality milk (fats and protein are 0.46% and o.18% respectively) as compared to the control group. This study indicates that *A. hypochondriacus* have phenolics compounds in which sugar is present in the form of beta linked. These sugar-containing compounds give nutraceutical properties (de La Rosa et al., 2009) by doing easily degraded in the intestine of animals and humans. Many species of amaranth (Skwaryło-Bednarz et al., 2020) contain high quality and quantity of protein content, balanced form of amino acid, crude fat, and crude fiber. Bioactive compounds (polyunsaturated fatty acid, both n3 and n6 PUFA series) all these work as (Ulbricht and Southgate, 1991) antioxidants that involve reducing cardiovascular diseases.

The animals remain in good health and milk protein and solid non-fat is always remain in a good range. It is considered that the cows start to feed the amaranth crop residues there is increasement in the milk fat (Chairatanayuth, 1992). At the different stages of amaranth production ruminants can eat all parts like young leaves, grain amaranth, young plants, and flowering stage but more potential in the cattle and cows seems to be when they feed the amaranth at the flowering stage. So, the selection of amaranth plants (Cheeke and Bronson, 1979) with efficient biomass production and high feed value is the initial and main requirements.

Table 6. Anti-nutritional factors of amaranth

ANF	Effects	Reference
Phytic Acids	Involvement affects the bioavailability of many micronutrients (zinc, copper, and iron,) and calcium also.	Muramoto, 2017; Kaushik et al., 2018; Samtiya et al., 2020
Tannin	It makes some complex proteins. During this, it involves inactive the function of a protein and many other enzymes. It also decreases the digestibility of protein and enzymes.	Samtiya et al., 2020; Joye, 2019
Oxalates	It reduces the bioavailability of minerals and foods products.	Kaushik et al., 2018; Samtiya et al., 2020
Enzyme Inhibitors	It decreases the growth rate and overcomes the digestibility of protein.	Samtiya et al., 2020; Nørgaard et al., 2019; Salas et al., 2018; Ercan and El, 2016
Saponins	It works to reduce the activities of necessary enzymes (glucosidase, lipase, trypsin, amylase, and chymotrypsin). Due to reduction, they may inhibit the absorption of many nutrients and create many health-related disorders also.	Addisu and Assefa, 2016; Kregiel et al., 2017; Ercan and El, 2016
Nitrates	Weaknesses and rapid pulse causing fatal methemoglobinemia in cattle	Nayonje, 2015; Sinha and Khare, 2017

CONCLUSION

This review indicates that amaranth has differential nutritional quality according to its consumption in different animals. In animal nutrition, it has an alternative source of protein and has good fiber content and a source of antioxidants (vitamin A, C, E, beta-carotene, and manganese), bioactive compounds (carotenoids, flavonoids, polyphenols and phytosterols) and rich in protein contents. Amaranth is mainly used in the feed of ruminants and other animals as its high nutritional quality, is rich in protein and other necessary nutritional elements. Some amaranth species have an anti-nutritional problem so one-grain amaranth is submitted to the heat treatment to reduce its effects and then it is converted into a useable form for many monogastric animals. Among many health, nutritional, good quality fodder amaranth shows a beneficial health property as it involves in the cholesterol-lowering effects on those animals that feed these types of plants. Like if there is the addition of 10% of *A. cruentus* leaf meal with broiler feed showed that there is a reduction in the cholesterol contents of eggs, serum level peroxidation level, and enhance egg weight also gives better performance.

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