

The Use of Agricultural Crop Residues as Alternatives to Conventional Feedstuffs for Ruminants: A Review

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Abstract

The development and application of modern technology for upgrading crop residues has stimulated great interest in developing countries. Researchers are working on the development of crop residues particularly vegetable discarded leaves in agriculture fields as feed, with emphasis on improving their intake and digestibility in ruminants. Despite much research at universities and research stations, farmer uptake and utilization of the residues is still minimal. Reasons for this include the difficulty of transporting and storing crop residues, insufficient trials at farmer level, inappropriate technology and absence of agriculture extension services. Literature showed that crop residues have good nutritive values of crude protein (CP), metabolizable energy (ME), total digestible nutrients (TDN) and mineral contents. Results of various studies demonstrated that cereal straws and vegetable leaves from field crops and non-conventional feed resources had a significant influence on the growth performance of ruminants. The literature further revealed that vegetable leaves could be stored in the form of silage and hay and they have the potential to be used as alternative forage in the ruminant ration. This review summarizes the data of Turkey and Pakistan related to animal feed resources and availability of forage, problems associated with utilization of crop residues and recommendations about the offering of agriculture field crop residues and wastes to animals as alternatives to conventional feedstuffs.

Keywords: livestock, ruminants, crop residues; agriculture

Review article

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INTRODUCTION

There are two types of crop residues which include agriculture field crop residues and agro-industrial process residues. Agriculture field crop residues are materials left in an agricultural field or orchard after the crop has been harvested. These residues include leaves, tuber and bulbs, stems, stover, straws and sea pods (Mottet et al., 2017; Owen and Jayasuriya, 1989). The utilization of crop residues as roughages has been the subject of intense research worldwide since the 1970s. Despite this, there appears little evidence that large research has resulted in great utilization of crop residues in developing countries (Owen and Jayasuriya, 1989). When the field crops are harvested, crop residues become available. For instance, when cabbage is harvested, discarded leaves comprise up to 6 tons of edible dry matter (DM) per hectares. In the Niğde province of Turkey, approximately 109000 tons of cabbage is produced annually. Out of this only 11% is being used for livestock feed (Personal Communication). Often markets collapse (e.g. potatoes) and it is too expensive to send products to market and this "waste" (crop residue) becomes available for animal feeding. Carrots damaged at harvesting or discarded because of poor quality, comprise a good ruminant feed when fed with carrot tops. After getting grains, wheat and rice straws and maize stover become available in the field for animal feeding (Sarnklong et al., 2010; Gertenbach and Dugmore, 2004). Plowing or burning of crop residues is the first approach of farmers after harvesting. Composting the residues is another alternative. The decision to plow the residues into the soil or composting them should be changed. These crop residues can be stored for the time of drought and feed shortage periods. Low nutritional value is more important than unavailability and relatively higher costs of feeds could make crop residues a viable option (Gertenbach and Dugmore, 2004). The human population explosion is a source of worry throughout the world. Food shortages and famine are becoming endemic in many places. The population explosion is associated with a reduction in farmable land. Future population pressure in developing countries will require greater utilization of crop residues as animal feed. Feeding grains to ruminants is questioned because human and monogastric animals can utilize them better than roughages. On the other hand, the value of ruminants lies in their ability to change low-quality feed into high-quality products. This happens due to the symbiotic relationship between ruminant animals and rumen microflora. Rumen microbes can degrade the cell wall which is fibrous in nature. The second reason behind the utilization of crop wastes and residues is that most of the countries do not have enough fodder availability to meet the demand of animals. Round a year, in some months a fodder shortage is unavoidable therefore crop residues can be the best alternatives of fodders. This review enhances the importance of using agriculture field crop residues as animal feed to cope with the requirement of animals, particularly in draught and feed shortage periods. It also describes the present status, ongoing advances and future perspectives about the utilization of crop residues as an alternative to conventional feedstuffs. Problems and recommendations are discussed for sustainable animal production in these countries.

Status of Crop Residues in Turkey and Pakistan

Turkey is located between Europe and Asia has a total area is 78.35 million hectares (MH) of which 76.96 MH is a land area. The total agriculture land is decreasing gradually for the last two decades. Total utilized agricultural land is 37.80 MH of which 18.93 MH for cereals and other crop products, 0.784 MH for vegetable gardens, 0.005 MH for ornamental plants, 3.462 MH for fruits, beverages and spice crops and 14.62 MH land under permanent meadows and pastures (TUIK, 2018). The share of animal husbandry in Turkey's agriculture sector is about 30%. Most of the livestock depend on rangelands and harvest residues for feeding during grazing seasons. Rangelands are very important particularly during crop

growing seasons due to the unavailability of artificial pastures or feed resources for extensive animal husbandry during these periods. Turkey's ruminant population consists of 17,042,506 cattle, 46,117,399 small ruminants (TUIK, 2018). Cattle number has not changed significantly, but the small ruminant number decreased seriously from 1985 to 2010. After 2010, the small ruminant number is gaining boost and increasing gradually. Due to advance agricultural techniques and mechanization, equids number decreased in the country. Turkey has more than 10 million animal units and round a year roughage demand is about 37 million tons (Holechek et al., 2004). The average altitude of Turkey is about 1000 meter and the grazing season for animals is merely 180 days (Altin et al., 2011). Out of 10 million animal units (AU), about 7.5 million AU are getting their feed from rangelands and approximately their demand is 13.5 million tons (MT) of roughages. The contribution of rangelands in Turkey is about 7.6 MT of roughages but that amount is far away to cover demands of animal (Koc et al., 2012). There is a huge gap in the supply and demand of roughages during the grazing season in Turkey. This demand is accomplished with the help of poor quality feed stubble, fallow fields and understory vegetation. Roughly, 2.65 million AU ruminants especially cattle are reared in the intensive system and their roughages demand during the summer season reached 4.75 MT. On the other side, in winter, 18.75 MT of roughages are required and the total roughage need for intensive rearing system is about 25.5 MT. The total production from hay lands (meadow plus forage crop cultivation) is about 13.3 MT in the country. Accumulatively, there is a 12 MT roughage gap in Turkey in summer and winter. There are some alternative roughage sources, such as vegetable residues, sugar beet leaf and pulp and fruit garden understory, which account for an amount of about 5.0 million tonnes. Finally, 7.2 MT of the roughage gap is compensated by cereal straw (Koc et al., 2012).

The total area of Pakistan is 79.61 MH and only 21.86 MH are available for cultivation. Out of 21.86 MH, only 14% area has been used for fodder production. Another area is being used for rice (12%), sugarcane (3%), oilseeds (3%), pulse (3%), maize (5%) and other (8%). Feed resources for animals in Pakistan are rangelands (38%), fodder/crop residues (51%), oil cakes (2%), cereal by-products (6%), and post-harvest grazing (3%) (Sarwar et al., 2002). Livestock having share of 58.92 % in agriculture and 11.11 % in Gross Domestic Product (GDP), recorded a growth of 3.76 % compared to 2.99 % during the corresponding period last year. Pakistan has two cropping seasons, "Kharif" being the first sowing season starting from April-June and is harvested during October-December. Rice, sugarcane, cotton, maize, moong, mash, bajra (millet) and jowar (sorghum) are "Kharif" crops. "Rabi", the second sowing season, begins in October-December and is harvested in April- May. Wheat, gram, lentil (masoor), tobacco, rapeseed, barley, and mustard are "Rabi" crops. Pakistan's agricultural productivity is dependent upon the timely availability of water (Pakistan Economy Survey, 2018). Currently, 196.1 million heads of animals in Pakistan are deficient of 38.10 and 24.02% of CP and TDN respectively (Sarwar et al., 2002). Pakistan is producing 52 MT fodder and 43 MT of crop residues annually. Pakistan is producing fodder like 22 MT of berseem, 6.3 MT of sorghum, 5.3 MT of lucern, 3.05 MT of guar, 1.4 MT of sadabahar, 0.9 MT of maize, 0.7 MT of millet, 03 MT of mustards and 11 MT of others. On the other side, crop residues production is 16 MT of wheat straws, 4 MT of rice straw and husk, 1.5 MT of maize stover and 21.5 MT of others (Sarwar et al., 2002). Feed resources in Pakistan are green fodder, crop residues, grazing lands, cereal by-products, cakes, and meals. Fig-1 shows the average fodder availability per animal per day is 6-7 kg but it becomes less in extreme summer and winter (Hanjra et al., 1995). To meet with the requirement of animals for their maintenance and production levels, crops residues, forages and their conservations (silage and hay) would be the best options (Sarwar et al., 2002).

Problems associated with crop residues

Crop residues have less nutritive values as compared to fresh green fodders. For example, straws have only 4-5% average crude protein and 1.5-1.6 Mcal/kg ME. If we talk about fresh leaves of vegetables especially cabbage, cauliflower, potatoes, and carrot, we can find an average of 16-17% crude protein (as % of their DM) and 1.8-1.9 Mcal/kg ME, which is sufficient for maintenance requirement of animals. It will be a good idea to use vegetable fresh leaves as alternatives to fodder in feed shortage times. In the matter of crop residues, farmers confront many problems. The use of residues is still minimal due to some reasons including storage issues, transportation problems, lack of awareness and knowledge about the nutrient value and potential use of crop residues, absence of agriculture extension services, lack of advanced technology and insufficient trials at farmer levels (Lukuyu et al., 2011; Devendra and Leng, 2011; Anandan and Sampath, 2012; Loehr, 2012). Farmers do not have proper guidance to handle and store the residues. When they harvest, either they plow the residues with soil or burn them.

Animals face problems when we offer feed to them without calculation. Same in the case of crop residues, leaves of some leguminous plants may cause metabolic disorders like bloat (Wadhwa and Bakshi, 2013; Njidda, 2010; Soetan and Oyewole, 2009). Most of the residues possess anti-nutritional factors. Some crops have mineral deficiencies, i.e. Brassica family is deficient from Iodine. It is a goitrogenic crop, if we will not offer iodine supplements with them. Sometimes, ruminants graze on turnip, tuber, bulbs and maize cobs (Wadhwa et al., 2006; Cassida et al., 1994). These large pieces of food stuck into the esophagus and block the digestive pathway. In Table 1, we have summarized some anti-nutritional factors in various crops and their effects on animals.

Experimental reviews about the usage of crop residues as feed

The effects of feeding brassica vegetable leave on feed intake, body weight changes in goats were evaluated. Goats were fed four diets from cabbage, cauliflower, Chinese cabbage with Para grass. Due to low DM content, feed intakes of cabbage and Chinese cabbage groups were lower. The highest feed intake and body weight gain were obtained in the cauliflower group (Ngu and Ledin, 2005).

El-Shinnawy et al. (2011) designed a study to examine the possibility of utilizing cabbage wastes as an unconventional feed source for ruminant feeds and tried to improve its nutritive values by hay and silage making. The effect of urea solution either sprayed or ensiled of cabbage hay and silage making with or without urea adding as a processing technique were also investigated. The experiment was conducted on Rahmani rams using simple technologies for improving the nutritive value of cabbage. The results indicated that all cabbage wastes silages were excellent, had a normal value of pH (3.82 to 4.12) with the superiority of silage untreated with urea. The overall means of total volatile fatty acids (TVFA's) concentration for the two silages ranged from 2.15% for urea un-treated silage to 2.45% for urea treated silage. The urea un-treated silage recorded the least concentration of NH₃-N (1.65%). Ensiling either with or without urea resulted in higher ($P<0.05$) digestion coefficients of organic matter (OM), CP, crude fiber (CF), nitrogen-free extracts (NFE), neutral detergent fiber (NDF), acid detergent fiber (ADF) and cellulose. These results indicated that feed intake and utilization of cabbage wastes hay could be improved by 1% urea treatment with the superiority of the ensiling process than the spraying method.

The nutritional worth of crop residues and wastes such as cauliflower leaves, cabbage leaves, pea pods, and pea vines was evaluated in comparison to conventional green oats fodder in bucks. The leaves of cauliflower and cabbage had low ($P<0.05$) concentration of

cell wall constituents, but high ($P < 0.05$) concentration of CP, except that CP of pea pods was comparable with cabbage leaves. Cabbage leaves had the highest (20.6%) and pea pods had the lowest (4.8%) concentration of water-soluble sugars. Cauliflower leaves had the highest concentration of phenolic (5.9%), comparable with cabbage leaves, but the lowest concentration was observed in pea pods (0.3%). Digestibility of nutrients except that of NDF was comparable in cabbage and cauliflower leaves, but higher ($P < 0.05$) than in other vegetable wastes and conventional green oats fodder. Microbial protein synthesis was high ($P < 0.05$) in animals fed cauliflower leaves followed by those fed pea pods and low in bucks fed pea vines. The ME value of both cabbage and cauliflower leaves was significantly higher than that of pea vines (Wadhwa et al., 2006).

Similarly, in another study, tyfon (turnip x Chinese cabbage hybrid) was increased in the diet; there was a linear increase in ad libitum dry matter intake (DMI), total water intake, digestible DMI, and apparent digestibility of DM, CP, and neutral detergent soluble. Plasma thyroxine and triiodothyronine, packed cell volume, red blood count, and haemoglobin concentration were not affected by diet. Tyfon influenced DMI and the apparent digestibility of diets like that of a concentrate (Cassida et al., 1994).

In another study, broccoli was used as a substitute for concentrates in dairy cattle. It had no significant influence on milk protein, lactose, total solids or solids-not-fat. However, a significant increase was found in milk fat content. These results indicated that broccoli could be included in dairy cattle diets at a suitable level to replace concentrate mixture without any adverse effects on dairy performance (Yi et al., 2015).

A study was also conducted to determine the effect of dietary inclusion of discarded cabbage leaves on the intake and growth performance of lambs. Results revealed that lamb growth performance and the feed conversion rate was reduced as the level of cabbage in the diet increased. Nitrogen intake and retention were lower in lambs fed diets containing cabbage. As a result of this experiment discarded cabbage can be included in finishing diets for lambs but reduced animal performance can be expected (Nkosi et al., 2016).

Leaves of Brassica family particularly cabbage leaves can be used as roughage in the form of silage and hay. In a study, Rezende et al. (2015) made cabbage silage treated with 600 g kg^{-1} and 400 g kg^{-1} of ground corn. They recommended that the application of 400 g kg^{-1} ground corn was enough to improve the silage quality, whereas the use of the inoculant is unnecessary.

Similarly, Megersa et al. (2013) investigated the effects of substituting sweet potato leaves for concentrate on growth performance, digestibility, and carcass characteristics of bucks. Results revealed that DMI, CP intake, DM digestibility, and weight gain increased due to supplementation of sweet potato leaves in the diet. The slaughter weight, empty body weight, hot carcass weight, dressing percentage, rib-eye muscle area, and total edible offal were higher in supplemented goats compared to the un-supplemented. It could be concluded that sweet potato vine can replace the conventional concentrate and could be fed with poor quality hay to prevent body weight loss of an animal in the absence of other feed supplements.

Likewise, another study was carried out on Kurdish mature rams to determine the chemical composition, mineral content, nutrient digestibility and metabolizable energy (ME) of potato vine compared with alfalfa hay as reference forage in ruminants. Results indicated that DM, ash, minerals and NDF digestibility of potato leaves were significantly higher than alfalfa hay. NDF, ADF organic digestibility, and ME of potato leaves were lower than the

alfalfa hay. It can be concluded that potato leave has high nutritive value and therefore they can be used as alternative forage in ruminant nutrition (Salehi et al., 2014).

CONCLUSION AND RECOMMENDATIONS

Crop residues are a valuable source of animal feed and utilizing the residues by grazing is very effective in returning plant nutrients to the soil. In the USA, pigs are often used with cattle to utilize crop residues, whereas, in South Africa, beef cattle alone or cattle with sheep are more commonly used. Sweet potato vine and broccoli by-products can replace the conventional concentrate and could be fed with poor quality hay to prevent body weight loss of an animal in the absence of other feed supplements. Literature also demonstrates that vegetable leaves especially cabbage, cauliflower and potatoes can be used as alternative forage in ruminant nutrition. Crop residues are low quality feeds and should be retained for non-lactating cows, beef cattle and sheep. Supplementations must be used to enhance the nutritional value of residues. Efforts should be made to help the farmers to solve their feed problems mainly focus on improving methods of harvesting, handling, processing and incorporating crop residues into a year-round feed budget. Do not destroy burn and plow the vegetable leaves in agriculture fields. Crop residues have less nutritive values as compared to green fodders. Animals should be provided with supplementations while offering crop wastes and residues particularly with those nutrients/minerals which are deficient in crops. Crop residues can be offered with highly nutritive fodder and concentrate to cope up the deficiencies. These could be used as alternatives to roughages in lean and feed shortage periods. Previous data demonstrate that animals showed good results when they fed cabbage and other vegetable leaves as fresh fodder or in the form of silage/hay. It is concluded that agriculture field crop waste and residues like cabbage leaves, cauliflower leaves, and pea pods could serve as an excellent source of nutrients for ruminants and can economize the production of animals. These results introduce several applicable techniques towards making the best use of crop residues as good unconventional feedstuffs for ruminant equivalent to any conventional feed like clover hay, maize silage or fresh fodder.

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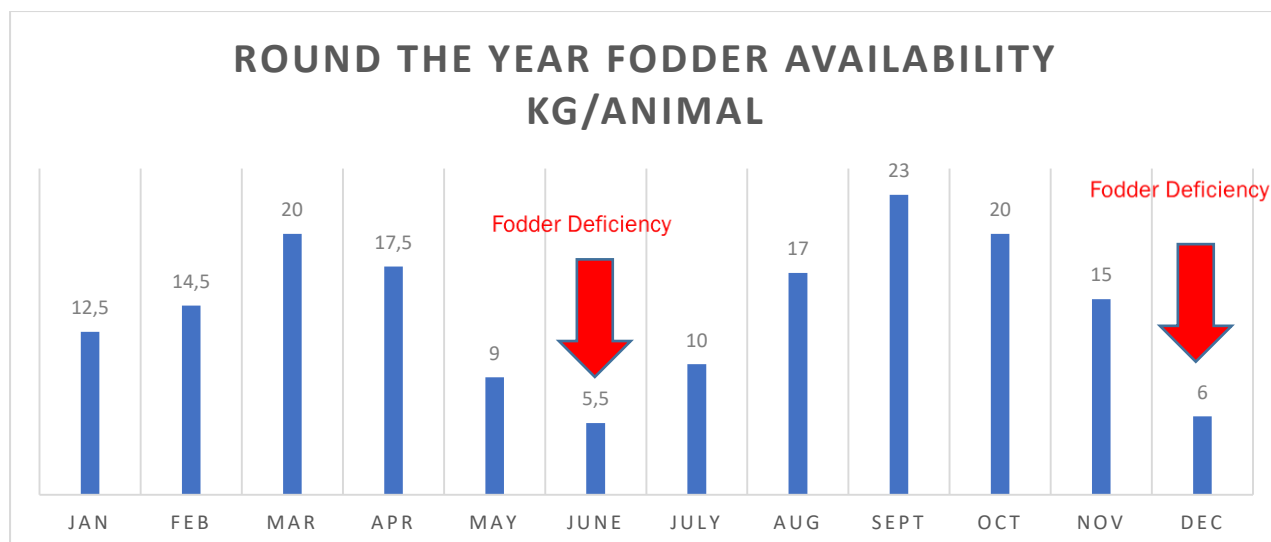


Fig 1. Round the year fodder availability per kg per animals in Pakistan

Table 1. Anti-Nutritional Factors (ANF) in various crop residues

Item	ANF	Effects
Sorghum	Prussic acid, Tannin, Glycosides	Respiratory dysfunction, Bind with protein and stop the digestion
Soybean	Trypsin inhibitor, Lectins	Protein digestion impairment, Haemagglutinins
Potatoes leaves	Trypsin inhibitor, Cyanogen, Glycoalkaloids, Nitrates	Protein digestion impairment, Respiratory dysfunction, gastrointestinal and neurological disorders and disturbance in hemoglobin function
Brassicac	Phenolics, Isothiocyanate, Glucosinolates,	Fatty liver disease, Taint milk, Thyrotoxic, Goitrogenic, Poor growth
Vegetable leaves	Nitrates, phytate, Glucosinolates, Phenolic content, Mineral deficiency	Disturbance in hemoglobin function, Chelate formation with minerals,
Rice and rice straw	Phytate, Lectins	Chelate formation with minerals, Haemagglutinins