PROCESSING OF CROP RESIDUES AS FEED RESOURCE FOR RUMINANTS. A REVIEW

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ABSTRACT
Crop residues and their biomass are generated as by-products of crop cultivation. Its availability is linked to factors that affect crop production. They are characterized as wastes and have low nutritive content when used as feed in livestock production. On-farm strategies have been developed to maximize the potential of crop residues in livestock production. Due to the characteristic low nutrient content of crop residues which impeded their efficiency in livestock production, processing of these crop residues will enhance nutrient content, digestibility, minimize feed wastage, maximize profitability through efficient feed processing and reduce the moisture content of feedstuffs, thereby, improving the general well-being of these animals. Improving the nutrient content of crop residues and their digestibility can be achieved through different processing methods such as physical (grinding and chopping amongst others), chemical treatments (alkaline treatments using sodium hydroxide, sulfur dioxide, urea or chlorine) and biological approaches (fungal treatments, inoculants, enzymes or alternative additives) either individually or in combination. It is concluded that processed crop residues are ideal feed ingredients in ruminant production.
Keywords: Ruminants, Crop residues, Processing

INTRODUCTION
Ruminants serve as a crucial element of security for numerous small-holder farmers in developing countries (Owen *et al*., 2004, 2005) and are often utilized as indicators of wealth. They are particularly beneficial in converting abundant renewable resources from rangeland, pasture, crop residues, and other by-products into food that is suitable for human consumption. Huge quantities of crop residues and biomass are generated as by-products of crop cultivation accounting for approximately one-third of the global agricultural production (FAO, 2011). C**rop residues** are materials left on cultivated land after the crop has been harvested, while, (Mottet *et al*., 2017: Shunlin and Jindi 2020), such as leaves, tubers, stems, stover, straws, and seed pods. They comprise cellulose, hemicellulose, lignin, protein, and soluble sugar (Fu *et al*., 2021). Its utilization as animal feed has been a focal point of extensive global research and development endeavours. Meanwhile, Kubkomawa *et al*. (2015) asserted in their analysis that crop residues stand out as a remarkable feed supplement for livestock in Nigeria. Consequently, the conversion of crop residues into ingredients for animal feed has been regarded to be an efficient tool that may reduce food-feed competition, decrease animal feed costs, alleviate the environmental impacts of livestock production, and diminish the dependence on grains widely used in human consumption (De Carvalho *et al*., 2017; Roos *et al*., 2016; Ottoboni *et al*., 2019; Gasco *et al.,* 2020; Parisi *et al.,* 2020; Pinotti *et al*., 2020). However, the quality of these residues is poor, because most of the crop residues are low in nutrients and high in fibre content (Akinlade *et al*., 2005). Alebel *et al*., (2019) stated that treated crop residues have the advantage of efficient utilization as their nutrient quality is improved compared to general roughages.

Processing Methods Used to Improve the Quality of Crop Residues
Feed processing typically involves modifying the physical and chemical characteristics of feed commodities to optimize their utilization by animals and improve the quality, mixing, and stability of the diet. These operations aim to eliminate anti-nutritional components and toxins, enhance palatability, digestibility, and nutrient availability, adjust feed particle size for specific species and sizes, minimize feed wastage, maximize profitability through efficient feed processing, and reduce the moisture content of feedstuffs to 10 % or less (Golez, 2002). Researchers have processed crop residues in different methods, concluding that such processing methods improve poor quality, nutrient content, and digestibility. (Vadiveloo *et al.*, 2009; Sarnklong *et al.,* 2010; Akinfemi and Ladipo, 2011; Abdel-Azim *et al.*, 2011; Safa *et al.*, 2011; Salman *et al.,* 2011; Gado, 2012; Huyen *et al.*, 2012; Mustabi *et al.*, 2013; Khan *et al.*, 2016; Tekliye *et al.*, 2018; Asmare, 2020; Koc *et al.,* 2021; Okyucu and Esen, 2022; Ikyume *et al.*, 2023). These processing methods include;

a) **Physical treatment**

This includes chopping, grinding, milling, pelleting and haymaking and it aims to reduce the particle size of residues and increase the surface area exposed to digestive enzymes in the animal's body.

b) **Chemical treatment**

Chemical processing effectively reduces starch degradation in ruminant feeds, potentially enhancing their utilization by ruminants (Rahmadani *et al.,* 2023) and this includes;

- Urea Treatment

Ngele (2008) documented a surge in crude protein content from 4.4 % in untreated rice straw to 12.4 % in rice straw treated with 4 % urea. Despite the straightforward nature of the procedure that allows for easy adoption by farmers, caution should be exercised to prevent instances of urea poisoning. Lukuyu *et al.* (2021).

- Soaking with or without salting

Chopped straw could potentially be soaked with either plain water or a diluted solution of salt or molasses before being provided as feed. According to findings from farmers who have implemented this practice, it has been shown to result in heightened consumption of feed (Lukuyu *et al.,* 2016).

- Supplementation with additives

The incorporation of urea, molasses, yeast, minerals, alkaline compounds, organic acids and salt into the feed mixture offers the dual benefit of providing energy and nitrogen to the microorganisms present in the rumen, thereby enhancing the digestion of crop residues. Among the organic acids additives, formic acid and propionic acid preparations have been extensively used in silage fermentation and/or preservation of livestock diets (Dias *et al*., 2021; Gheller *et al.,* 2020; Jiang *et al.,* 2020). The addition of calcium carbonate can be used to adjust silage acidity (Yitbarek and Tamir, 2014).

c) **Biological treatments**

Biological treatments offer better substrate and response specificity, lower energy requirements, reduced pollution generation, and increased yield of desired products (Fadel and El-Ghonemy, 2015) and they include;

- Fungi treatment

This process increases the digestibility of nutrients, increases crude protein content, and provides more fermentable substrates in the rumen (Khattab *et al.*, 2013; Asmare, 2020; Suryadi *et al*., 2022).

- Enzymes

Enzymatic treatments can improve the chemical composition of crop residues, increase the digestibility of nutrients, and improve animal performance (Gado *et al.*, 2013)

- Bacterial cultures

The addition of lactic acid bacterial cultures during filling-up of silage increases their population rapidly, encouraging lactic acid fermentation and pH reduction to a level that inhibits *clostridial* development (Shah *et al.,* 2017, 2018; Muck *et al*., 2018; Kim *et al*., 2021).

- Fermentation process

The fermentation process is called ensilage, ensiling, or silaging (Oude Elferink *et al.*, 2000). Haylage is a feed for livestock made from perennial forages (grasses and legumes) that would otherwise be used for hay. Haylage is a higher-moisture, fermented feed of perennial forages very similar to silage (Costa *et al.*, 2018).

CONCLUSION

Processing of crop residues using different methods or in combination has been established to improve its quality thereby making it an adequate feed ingredient that will fit in the scarcity of feed for ruminants and avoid tasks of eliminating them as wastes.

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