The Potentiality of Major Crop’s by Products as Livestock Feed in Bangladesh- A Review

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Abstract | In Bangladesh, large-scale animal production (cattle, buffalo, sheep, goats, and poultry) is generally based on commercial feeds rather than the provision of fodders and forages. Marginal and small farmers, on the other hand, feed their livestock with different crop residues and grasses. The feed milling industry is remarkably dependent on imported concentrate feeds for the animal ration. In addition, there is an ongoing competition of grains between animal feed and human consumption due to the excessive demand for simultaneous growth of livestock industry and human population. In our country, the production of the main crop's (rice, wheat, corn, legumes, and oilseed) is enormous all year round which offers a great opportunity to use the by-products of these main crops as animal feed (both concentrate and roughage) commercially if proper ways are followed. Feed resources are in abundance, but these are considered a waste because they pollute our environment. To maintain environmentally friendly animal production, it is highly appreciated to commercialize these by-products in such a way so that large and small-scale farmers can take over the advantages of animal husbandry. The coordination among government livestock extension departments, non-governmental organizations, and research associations is highly noteworthy for raising awareness among farmers and feed manufacturers. Hence, this review article is written to emphasize the value of major crop's by-products in Bangladesh under the scheme that highlights homegrown food as feed and not waste.

Keywords | Livestock, Crops by-products, Livestock feed, Animal production, Bangladesh

INTRODUCTION

Bangladesh is an agricultural country and its economy is mainly based on agriculture. Crop and livestock production have a significant contribution to the economy of agriculture (Rahman, 2017). In the period 2019-20, the contribution of agriculture including livestock to the GDP is around 13.02% and the growth rate is estimated at 3.11% (BBS, 2020a). In the crop production of Bangladesh, rice, maize, wheat, oilseeds, and legumes are the most important crops in this context. While rice is the primary and most important staple food, the second and third important crops are wheat and corn. Oilseeds and legumes are also indispensable as these provide vegetable proteins and fats for the rural population (Timsina and Gulipart, 2013).

In Bangladesh, livestock farming can be characterized by friendly agro-climatic conditions, different animal species, and the integration of livestock production into agriculture with the involvement of small and large farm holders. The competition between livestock and land to produce food has increased for the rapid population growth. Nowadays, it is difficult to find available land resources in our country for growing feed or developing pastures for animals. In addition, the excessive demand for animal feeds and a change in animal husbandry are prompting the feed industry to produce quality feeds to maintain animal production (Banglapedia, 2021a; Sarker, 2019; Kazi, 2017).

As a rule, high-quality concentrate feed for livestock can be produced from pulses, coarse grains, tuberous crops, roots,
and the by-products that arise during grain processing for human consumption. Generally, these feeds come from the main crops such as rice, corn, wheat, oilseeds, and legumes that are produced by small farmers in remote and marginal areas (Huque and Sarker, 2014; Timsina and Gulipart, 2013). The rapidly growing demand for animal feed in our country offers the opportunity to utilize these by-products of the main crops and to commercialize them for the promotion of the farming economy and rural development.

This review article provides the current scenario of major crop production and the ability to use the by-products as animal feed, highlighting the nutritional quality of each by-product. The information will be very helpful in encouraging feed manufacturers and the feed industry, even small and marginalized farmers, to appropriately use these valuable byproducts as animal feeds in proper ways.

**Production of Major Crops in Bangladesh**

In Bangladesh, rice, wheat, corn, legumes, and oilseeds are known as the main crops due to their large annual production. Rice is the main staple food for the people of Bangladesh. After the Great War of liberation in 1971, rice production changed dramatically. Almost every region of Bangladesh produces a large amount of rice every year (Alamgir, 2019). Wheat is the second-largest important crop in Bangladesh (Hossain et al., 2013). It is the oldest grain but it was produced in Bengal in 1930-31. Wheat production in Bangladesh has been expanding for years. In particular, Rajshahi, Rangpur, and Dhaka are the most important regions in Bangladesh for wheat production (Table 1). Wheat production is considered as the second alternative culture just after rice. Wheat is mainly used for baking purposes in Bangladesh but the by-products such as bran, grain, and vegetative parts are also valuable components for poultry and livestock feed (Banglapedia, 2014a). Based on the phenomenal growth of corn production, Bangladesh is currently looking forward to a further increase in the production and acreage of the third key grain. Higher farm profits, proper policies, and a thriving feed industry have supported annual corn production which increased seven-fold from 0.75 x 10^6 tons in 2009 to 4.4 x 10^6 tons in 2020 (Dhaka Tribune, 2020). Therefore, after repeatedly receiving bumper production at an excellent price, farmers are interested in growing corn. The corn-growing regions in Rangpur, Kurigram, Gaibandha, Lalmonirhat, and Nilphamari are marked as the northern part of Bangladesh (Dhaka Tribune, 2019). In 2020, corn production for Bangladesh was 4.4 million tons. In the past ten years, corn cultivation in Bangladesh has grown significantly from 1.954 to 4.4 million tons at a rising rate that reached the highest value of 17.14 percent in 2019 (Knoema, 2020). In Bangladesh, lentils (masur), green gram (mung), black gram (mashkalai), gram (chola), grass pea (kheshari), and pea (motor) are popular legumes. Legumes are edible dried seeds that are grown annually in Bangladesh (Banglapedia, 2014b). Since the pulses are legumes, they are rich in proteins and minerals. It also provides carbohydrates and fats (FAO, 1994) that can be used for animal feeding. Oilseeds are one of the most important sources of vegetable oil. It plays an important role in the agricultural sector of Bangladesh. Mustard, soybeans, and linseed are the oilseeds common in Bangladesh. The production of the main crops (rice, wheat, corn, legumes, and oilseeds) in different regions of Bangladesh in the period 2018-2019 is shown in Table 1.

The immense production of important crops throughout the year in Bangladesh also generates a huge amount of by-products that have a chance of being used as animal feed not only for marginal and small farmers but also for large commercial farms. Therefore, the value of these by-products should be well known and dispersed among farmers and milling industries.

**Nutritional Value and Importance of Major Crop By-Products as Animal Feed**

**Rice**

Rice is the main food in Bangladesh. The processing and grinding of rice produce sustainable and edible by-products.

**Table 1: The production of major crops in different regions of Bangladesh in 2018-19 (Metric tonnes).**

| Regions     | Rice  | Wheat | Maize | Lentil | Green Gram | Black Gram | Chick pea | Grass pea | Pea | Mustard | Linseed | Soybean |
|-------------|-------|-------|-------|--------|------------|------------|-----------|-----------|-----|---------|---------|---------|
| Barishal    | 2121979 | 6441  | 3721  | 3532   | 19183      | 590        | 1441      | 42789     | 40  | 2175    | 80      | 7572    |
| Chattogram  | 4967089 | 7452  | 97093 | 1650   | 1621       | 964        | 79        | 7410      | 570 | 22018   | 33      | 103209  |
| Dhaka       | 4477262 | 181355| 239453| 52157  | 1023       | 2352       | 493       | 19561     | 1886| 30401   | 1254    | 0       |
| Khulna      | 4991683 | 95218 | 753801| 60480  | 2242       | 2352       | 493       | 19561     | 1886| 30401   | 1254    | 0       |
| Mymensingh  | 4096741 | 21317 | 108287| 783    | 120        | 3232       | 81        | 520       | 86  | 14573   | 67      | 0       |
| Rajshahi    | 5982446 | 403614| 421689| 54775  | 9563       | 22685      | 2243      | 12181     | 1983| 147417  | 502     | 0       |
| Rangpur     | 6458898 | 298624| 1945214| 1852   | 345        | 2807       | 186       | 1138      | 48  | 31504   | 368     | 1       |
| Sylhet      | 3151860 | 2707  | 63    | 155    | 5          | 497        | 4         | 38        | 7   | 3958    | 47      | 0       |

Source: BBS, 2020b.
such as bran, which can be used as animal feed. Rice bran is the most preferred because it contains functional properties. It consists of fat, protein, crude fiber, and ash. Rice straw is another byproduct of rice after harvesting rice. The nutritional properties of rice bran are highlighted in Table 2.

Table 2: The nutritional composition of rice bran based on the dry matter (%).

| Nutrient         | Percentage (%) |
|------------------|----------------|
| Acid detergent fiber | 20             |
| Neutral detergent fiber | 33            |
| Crude Protein    | 14.4           |
| Ether Extract    | 15             |
| P                | 1.73           |
| Ca               | 0.1            |
| Ash              | 11.5           |

Source: Gadberry et al., 2007.

Rice bran has prebiotic properties that can prevent colonization with *Salmonella* in the digestive tract (Bodie et al., 2019). The bran is considered an important by-product as it contains 14-18 percent oil. In compound feed, defatted rice bran is a useful binding agent that, compared to ordinary bran, can be incorporated very well (Heuzé and Tran, 2015). The germs and bran from rice processing make up 10 percent of the rice grain, which contain enormous nutritional properties. It is a very valuable ingredient in feed formulation because it contains 30-40% digestible carbohydrates, 14-18% oil, and 15-18% protein. The composition of the rice bran depends on the type of rice and the grinding capacity. The amount of bran, rice hulls, polished rice, and broken rice after grinding is 10%, 20%, 50-60%, and 1-17%, respectively. Pollard is a mixture of polish and bran that contains approximately 5% polish, 60% hulls, and 35% bran. The rice bran is an effective ingredient for using as a feed for laying hens and broilers with an inclusion level of 1.5-2% (Benjamin, 2016). One experiment found that rice gluten meal at 464 g per kg of crude protein could be successfully incorporated into the concentrate mix, replacing 75 percent of groundnut cake with no apparent compromise in growing calves’ performance (6 to12 months). Rice gluten meal can be incorporated as a substitute source of groundnut cake with no apparent compromise in growing calves’ performance (6 to12 months). Rice gluten meal can be incorporated as a substitute source of groundnut cake with no apparent compromise in growing calves’ performance (6 to12 months). Rice gluten meal can be incorporated as a substitute source of groundnut cake with no apparent compromise in growing calves’ performance (6 to12 months).

Table 3: The nutritional composition of wheat by-products based on the dry matter (%).

| Nutrient          | Wheat gluten | Wheat bran | Wheat germ | Wheat pollard or middling |
|-------------------|--------------|------------|------------|----------------------------|
| Dry matter        | 91.4         | 88.7       | 88.7       | 89.4                       |
| Crude fiber       | 0.5          | 12.3       | 3.5        | 7.8                        |
| Crude protein     | 80.1         | 15.6       | 28.5       | 16.9                       |
| Crude Ash         | 0.7          | 5.6        | 4.9        | 4.7                        |
| Crude fat         | 1.5          | 4.7        | 8.8        | 4.4                        |
| Nitrogen free extract | 17.2     | 61.8       | 54.3       | 66.2                       |

Source: Hertrampf and Piedad-Pascual, 2000.

The by-products of wheat have some effective uses in the formulation of pig and poultry feed (Slominski et al., 2007).
Wheat germ is a yellow, brown, and creamy white fibrous feed ingredient, in granular form that is produced by separating, compressing, and crushing processes. It is a good supplement in animal feed as it is high in protein and energy (Bunge, 2021). To improve feed efficiency, five-gram of wheat germ can be added to the diet of individual growing goat every day (El-Tarabany et al., 2013).

In cattle feeding systems, wheat midds are an alternative to forage because forage contains low protein. It can be supplemented in a ruminant diet compared to monogastric because it contains a significant amount of digestible fiber and starch. Because of the rapid breakdown of the starch content, it should be limited to 50% of the dry matter (Poore et al., 2002).

Wheat straw is a source of roughage. It can be used in stud cattle and horse rations (Riverina, 2015). Although wheat straw does not contain high energy or protein, it can be used as a supplementation in the diet of breeding cows, with 5

### Table 4: The inclusion level of wheat bran and wheat straw in different species.

| Species                  | Maximum inclusion level |
|---------------------------|-------------------------|
| Wheat bran                | Wheat straw             |
| Cattle                    | 50%                     | 40%                     |
| Sheep                     | 50%                     | 20%                     |
| Goat                      | -                       | 20%                     |
| Horse                     | 50%                     | 30%                     |
| Poultry (layer)           | 15%                     | -                       |
| Poultry (Broiler)         | 10%                     | -                       |
| Pig (Growing stage)       | 15%                     | -                       |
| Pig (finishing stage)     | 25%                     | -                       |
| Pig (breeding stage)      | 30%                     | 2%                       |

Source: Riverina, 2015

### MAIZE

In Bangladesh, corn is used for two distinct purposes. It is mainly used as a feed ingredient for fish and livestock, and human consumption as corn flour and popcorn (Dhaka Tribune, 2020). The by-product after harvesting corn known as maize stover, is utilized as fuel in rural areas and contributes to greenhouse gas production. But this maize stover has the potentiality to be used as animal feed. It is an important source of fiber, especially for ruminants. As the maize stover is available in large quantities and mostly can be fed mainly to cattle, goats, and sheep. It can be offered as a whole plant alone or chopped and mixed with other green forages (Lallemand Animal Nutrition, 2021).

Corn stover is a resource in mixed farming systems. It can be utilized for fodder and silage production (Pandey et al., 2017). It contains a higher amount of digestible and other nutrients (Table 5) that are essential for animal feeding. In addition, pre-treatment of corn stover with physical and
Microbial inoculation such as *Phanerochaete chrysosporium* and *Penicillium decumbens* improves the protein content (12.71%) and reduces feed shortages in animal production (Sun et al., 2018). Corn stover fermentation with fungus such as *L. edodes* or *P. eryngii* for 28 days can enrich the nutritional value due to the degradation of lignin for the ruminant feed (Zhao et al., 2020). The co-fermentation of rice straw and corn stover with enzymes and probiotics improves the rumen efficiency in the beef cattle feeding system (Hu et al., 2020). Ensiling corn stover with vegetable waste provides an optimistic strategy to preserve the stover of an animal feed for a longer period (Ren et al., 2020). The nutritional composition of different by-products of maize is shown in Table 5.

Corn cobs are the by-product of corn crops. The meal of corn cobs is a great source of feed for livestock and cheaper compared to other meals. It contains all the nutritional values (Table 5) and 1 kg of corncob meal can provide animals with 4,000 calories (Kanengoni et al., 2015). Maize cobs, green, and dry maize stalks can be used together with rice bran, wheat straw, alfalfa, oilseed cakes, grasses and forages, hay crops, tree leaves, shrubs, molasses, vegetables, and fruits pulps. Sometimes a single item can be included alone or a combination of two or more items can be prepared to be used as feed for farm animals (All about feed, 2015). Corn cobs are the carriers of antibiotics and vitamins in livestock feed (Heuzé et al., 2016a). The high fiber corn cob has excellent potential as a pig feed as it increases nutrient retention by improving the passage. Pigs can intake up to twenty-five percent of the energy required for maintenance. Moreover, the dietary fiber of corn cobs can improve the intestinal health of pigs by promoting the growth and the development of lactic acid-producing bacteria, which inhibits the proliferation of pathogenic bacteria in the small intestines (Kanengoni et al., 2015). In addition, ground corn cobs can be utilized as a source of roughage in a total mixed ration with 60% concentrate feed, which significantly improves nutrient uptake and milk production in lactating Holstein crossbred cows (Wachirapakorn et al., 2016).

The other by-products after the wet milling of corn are endosperm, germ, and bran. The corn by-products including germ, gluten, and bran, are effective and suitable as feed for farm livestock. Moreover, corn gluten is particularly rich in metabolizable energy, xanthophyll pigments, and proteins, which are the potential feed for poultry production (Dei, 2017).

**Legumes**

Legumes play a significant role in animal feeding systems by providing valuable by-products that contribute to food security. The use of legume by-products such as other plant parts and straws that are leftover just after the harvest of seeds has considerable potential for use as ruminant feed. In addition, the endosperm fractions, husks, and seed coats obtained from processing legumes for human consumption are also a good source of animal feed. The by-products of legumes are rich sources of energy and protein. They contribute to reducing soybean and cereals levels in livestock diets. They can be utilized by small farmers in times of feed shortage as mixed livestock farming. Legume by-products also offer important environmental, social, and economic advantages by extenuating grains used in animal feeding systems (Calles et al., 2019).

Table 5: The nutritional composition of different maize by-products.

| Nutrient                     | Maize stover (%) | Maize cob (g/kg DM) | Maize endosperm % | Maize tip cap % | Maize pericarp % | Maize Germ % |
|------------------------------|------------------|---------------------|-------------------|-----------------|------------------|--------------|
| Dry matter                   | 82.50            | 908.3               | -                 | -               | -                | -            |
| TDN (Total digestible nutrient) | 50.6             | -                   | -                 | -               | -                | -            |
| Crude Protein                | 5.45             | 38.9                | 73.8              | 0.9             | 2.6              | 26.2         |
| Crude Fiber                  | 34.06            | 286.9               | -                 | -               | -                | -            |
| Ether Extract                | 1.45             | 5.7                 | -                 | -               | -                | -            |
| Nitrogen Free Extract        | 50.79            | -                   | -                 | -               | -                | -            |
| Ash                          | 8.24             | 76.7                | 17.9              | 1.0             | 2.9              | 78.4         |
| NDF                          | -                | 706.3               | -                 | -               | -                | -            |
| ADF                          | -                | 515.8               | -                 | -               | -                | -            |
| Acid detergent lignin        | -                | 168.8               | -                 | -               | -                | -            |
| Hemicellulose                | -                | 190.5               | -                 | -               | -                | -            |
| Cellulose                    | -                | 347.0               | -                 | -               | -                | -            |
| Starch                       | -                | -                   | 97.8              | 0.1             | 0.6              | 1.5          |
| Sugar                        | -                | -                   | 28.9              | 0.8             | 1.2              | 69.3         |
| Oil                          | -                | -                   | 15.4              | 0.8             | 1.3              | 82.6         |

Reference: Khan, 2008, Kanengoni *et al.*, 2015, Dei, 2017.
Table 6: Nutritional composition of lentil by-products (on DM basis).

| Nutrients                      | Straw (%) | Screening (%) | Pod Husk (%) | Bran (%)   |
|-------------------------------|-----------|---------------|--------------|------------|
| Dry matter                    | 90.4-93.8 | 87.9-90.4     | 88.0         | 87.6-91.1  |
| Crude fiber                   | 29.9-41.1 | 5.3-19.4      | 29.0         | 8.4-32.2   |
| Crude protein                 | 5.8-8.6   | 22.7-25.9     | 12.6         | 15.0-26.4  |
| Ether extract                 | 0.8-2.2   | 1.7-2.6       | 0.8          | 0.6-1.4    |
| ADF (Acid detergent fiber)    | 27.1-51.3 | 10.9          | -            | 35.9-48.6  |
| NDF (Neutral detergent fiber) | 42.8-71.0 | 20.9          | -            | 48.6-53.0  |
| Ash                           | 6.0-11.2  | 3.8-10.7      | 3.5          | 2.8-9.8    |
| Lignin                        | 5.9-13.3  | 9.6           | 7.4          |            |
| Phosphorus                    | 0.11-0.19 | 0.47          | -            | 0.22-0.56  |
| Calcium                       | 1.50-3.01 | 0.20          | -            | 0.51-0.82  |

Source: Feedipedia, 2016

Lentil ranks first position in Bangladesh in terms of consumers’ preference and second place in terms of area and production. It is an important source of protein in the daily diet of most people in the country (Uddin et al., 2013). The lentil by-products have a nutritional value (Table 6) that can be used as animal feed.

The screenings of lentil are the waste products after cleaning the lentil seeds, which consist of cereal grains, broken and whole lentils, chaff, weed seeds, and dust (Stanford et al., 1999). However, good quality lentil screenings can be used as a source of energy and protein-rich feed for animals (Lardy and Anderson, 2009) as they have a good crude protein content of approximately 25% based on DM. Lentil screening can be used in hay and silage or pelletized form as feed (Feedipedia, 2013a; McKinnon, 2018).

During dehulling, the outer coverings of lentils have yielded lentil bran which is mixed with hull and chuni. It contains 21.8% dietary fiber (DM basis), which is higher compared to screenings and seeds. However, when a mixture of 50% wheat bran and 50% lentil bran was fed as feed for the bull, the fermentation in the rumen improved (Feedipedia, 2013b; Gendley et al., 2009).

Lentil straw is produced after threshing lentil seeds, which is high in fiber (30-40%) but has a low crude protein content of less than 10% based on DM, which is better in quality than wheat and other cereals (Lardy and Anderson, 2009). Lentil straw contains lower NDF content, which is highly degradable in the rumen and whole tracts compared to cereal straws (Haile et al., 2017). The use of lentil straw in total mixed ration improved the organic matter, the nitrogen-free extract, and the dry matter digestibility. The researcher suggested that the use of lentil straw can be used ad libitum or with a mixed total ration to improve kid’s performance (Mudgal et al., 2018). Therefore, lentil by-products (bran and screenings) can be included in the feeding system of ruminants. Moreover, the straw from lentils can be supplied as feed for grazing animals (Haile et al., 2017; Venkidasamy et al., 2019).

Green gram is an annual plant that grows rapidly during the warm seasons. The plants reach their maturity quickly in subtropical and tropical conditions. The most productive area of green gram is Barishal followed by Rajshahi and Khulna. Sylhet is the least grown region in Bangladesh for green gram. The nutritional properties of green gram straw and other by-products are shown in (Table 7).

Table 7: Nutrient components of green gram pulse by-products (Dry matter basis).

| Parameter                      | Endosperm, husk, and seed coats % | Straw % |
|--------------------------------|-----------------------------------|---------|
| Ether extract                  | 2.2                               | 2.3-2.4 |
| Crude protein                  | 19.2                              | 8.7-11.6|
| Crude fiber                    | 26.2                              | 26.6-29.9|
| ADF (Acid detergent fiber)     | 26.4                              | 32.0-47.2|
| NDF (Neutral detergent fiber)  | 43.5                              | 63.5    |
| Ash                            | 4.8                               | 6.1-12.1|
| Phosphorus                     | 0.3                               | 0.2     |
| Calcium                        | 0.4                               | 2.7     |
| Lignin                         | 4.3                               | 4.8     |
| DM                             | 95.3                              | 88.2    |

Source: Feedipedia, 2016

Green gram hulls, endosperms, and seed coats can be added 50% ratio with rice straw as buffalo feed. It does not adversely affect the utilization and maintenance of the requirements. 14% and 18% inclusion of green gram hull can be added in the ration of laying hen as it has no detrimental effects on production (Vinh et al., 2013). The hull leftover from the green gram’s husk can be used extensively as ruminant feed. In broilers, 5% green gram hull can also improve digestibility and growth (Rungcharoen et al., 2010). The green gram plant is a valuable forage that
can be fed to animals as silage, hay, or straw (Banglapedia, 2021b; Vikaspedia, 2020). 100% of the green gram grass can be included in the sheep ration without any adverse effects (Garg et al., 2004). The straw from green grams can be mixed with wheat and rice straw and used as goat and sheep feed. Green gram straw is palatable and has no deleterious outcomes in animal health. Green gram straw can be added to a goat’s complete feed block with the addition of yeast (Nehra et al., 2014).

Black gram is also a leguminous crop that is cultivated as a valuable legume in Bangladesh (Banglapedia, 2015). The straw and other by-products from black gram are full of nutritional qualities that make them a good resource for animal feeding (Table 8).

Table 8: Nutrient composition of black gram by-products (based on Dry matter).

| Nutrients         | Straw (%) | Chuni (%) | Husk (%) |
|-------------------|-----------|-----------|----------|
| Dry matter        | 90        | 93.1      | -        |
| Crude fiber       | 28.6      | 13.1      | 20.3     |
| Crude protein     | 8.9–17.2  | 20.7      | 18.2     |
| Ether extract     | 0.4–2.8   | 2.2       | 1.4      |
| ADF (Acid detergent fiber) | 31.9–36.4 | -         | 37.4     |
| NDF (Neutral detergent fiber) | 54.5–56.9 | -         | 48.2     |
| Ash               | 8.8–12.6  | 11.7      | 5.5      |
| Lignin            | 4.6       | 3.0       | 9.6      |
| Phosphorus        | 0.16      | -         | 0.26     |
| Calcium           | 1.74      | -         | 0.51     |

Source: Feedipedia, 2016

In Bangladesh, black gram or khesari can be cultivated as pasture with grass pea without any tillage system. The CP (crude protein) content of khesari straw is highly digestible than Leucaena leaves (Singh et al., 2002). The different ratios (318, 212, 106, and 0 g dry matter) of khesari with the supplementation of straw can increase the nutrient digestibility, the live-weight gain, and the feed intake of indigenous or deshi bull calves at the age of two to three years (Hossain et al., 2015). However, the use of khesari straw supported the growth of sheep as it made up 60% of the diet and gained an average of 60 to 62 grams of live weight daily (Jadhav and Deshmukh, 2001). The khesari foliage can be mixed with all or 50% wheat bran which improves milk production, fiber digestibility, and feed intake in hybrid milking cows (Dey et al., 2016). In the diet of buffalo bull, the addition of 40% khesari chuni in rice straw has a positive influence on the digestibility of the dietary fiber (Reddy et al., 2000).

Chickpea or gram is the most important legume. Chickpea is an annual legume crop known as gram or chola (Roorkiwal et al., 2020). Chickpea is a quick-growing plant that reached 20–60 cm in height. The stems of the gram are simple, hairy or branched, curved or straight. Rajshahi and Barishal are the top gram-producing areas in Bangladesh. There is a future hope that gram's by-products will be incorporated as livestock feed in Bangladesh. Chickpea is considered a legume with little labor and requires less input than other grains. It is considered an important legume crop, especially in mixed livestock-crop cultivation. Chickpeas are produced in particular as feed and fodder legumes, with the products simultaneously providing nutrition for livestock and humans. In mixed livestock-crop operations, the shortage of fodder is common and gram by-products can be a potential outcome for obtaining greater benefit to the livestock. The nutritional composition of chickpea or gram by-products is represented in Table 9.

Table 9: The nutrient composition of chickpea or gram by-products based on the dry matter.

| Nutrients         | Straw (%) | Pod husk (%) | Bran (%) |
|-------------------|-----------|--------------|---------|
| Dry matter        | 92–93.4   | 86.8–88.0    | 84.4–91.0 |
| Crude fiber       | 31.4–50.6 | 48.4         | 22.3–31.1|
| Crude protein     | 2.8–8.8   | 3.5–10.5     | 12.5–18.5|
| Ether extract     | 0.5–1.6   | 0.9–3.0      | 2.8–4.2 |
| ADF (Acid detergent fiber) | 33.0–59.6 | 46.9–65.2 | 35.3     |
| NDF (Neutral detergent fiber) | 46–78     | 56.7–76     | 43       |
| Ash               | 3.8–13.3  | 3.8–7.3      | 5.1–7.0 |
| Lignin            | 8.5–15.8  | 3.3–7.1      | -        |
| Phosphorus        | 0.05–0.44 | -            | 0.27–0.32|
| Calcium           | 0.34–1.36 | -            | 0.67–1.56|

Source: Feedipedia, 2016.

The main by-product of chickpea is straw, which is obtained after the grain has been threshed. Chickpea straw can be introduced as livestock feed. It contains 44–46% TDN (total digestible nutrients) and 4.5–6.5% CP based on dry matter compared to cereal straws. Chickpea straw has 7.7 MJ/kg metabolizable energy (ME) and is relatively higher than wheat straw (5.6 MJ/kg metabolizable energy). The rumen degradability and dry matter digestibility (DM) of the straw are 42% and 10% higher, respectively than other types of cereal straws. The metabolizable and digestible energy of its straw are 7.7 and 8.3 MJ/kg dry matter (DM), respectively, which suggests that the chickpea straw has great potential to be used as an alternative legume forage for the ruminant animals (Maheri-Sis et al., 2011).

The chickpea bran is also considered a valuable by-product collected after the processing of chickpea. The by-product contains the broken piece of husk and germ. It contains 13–
19% crude protein (CP) based on dry matter, an excellent protein content. The bran provides 164 kcal of energy per 100g of bran. It serves as a source of energy and protein for livestock animals. The bran has been shown to contain all the essential elements for ruminants for proper growth and milk production. It can be used in the diet of non-ruminants as a whole meal as it promotes meat growth and egg production (Royal Flour Mills, 2020).

The ADF and NDF content of Chickpea husk based on the dry matter are 65.2% and 76.0%, respectively. Tannin binds a small proportion of chickpea husk carbohydrates, which is conserved during fermentation but digested considerably in the small intestine. The husk of the chickpea has over 94% rumen digestible dry matter fraction. In wethers and lambs, at the age of 6–8-months, the husks of chickpea can be incorporated into 10–20% of the ration (dry matter basis), which can replace rice straw or rice bran, increasing the degradability of OM, DM, ADF and NDF (Ngwe et al., 2016b).

Grass pea is a legume crop, that is grown for human consumption, and as fodder for ruminant feeding (Heuzé et al., 2016b). Grass pea forage is a good source of protein containing 17% protein in mature leaves that can be used as fodder for animal feed (Lambein et al., 2019). Grass pea can be introduced in the marginal areas imparting an alternative to the hazardous animal protein source or imported soy as livestock feed. Grass pea forage is a valuable feed resource for livestock as shown in Table 10.

| Nutrients                        | %    |
|---------------------------------|------|
| Dry matter                      | 91.4 |
| Crude fiber                     | 28.5 |
| Crude protein                   | 19.1 |
| ADF                             | 32.7 |
| NDF                             | 43.4 |
| Ash                             | 9.9  |
| Ether extract                   | 2.9  |
| Gross energy                    | 18.6 MJ/kg dry matter |
| Phosphorus                      | 2.1 g/kg dry matter |
| Calcium                         | 13.3 g/kg dry matter |
| Energy digestibility in ruminants | 64.7% |
| Organic matter digestibility in ruminants | 68.3% |
| Metabolizable energy in ruminants | 9.5 MJ/kg dry matter |
| Digestible energy in ruminants  | 12.0 MJ/Kg dry matter |
| Nitrogen digestibility in ruminants | 71.7% |

Source: Feedipedia, 2014

Pea is an important crop that can be used as feed and fodder of animal (Heuzé et al., 2017). Although the production of peas is comparatively lower than other legumes, it has a great chance of being used as fodder during natural calamities. The mixture of pea and oat forage straw has the potential to be a great option as forage for dairy and other livestock farmers (Jim, 2018) as the nutritional value is listed in Table 11. The main reason for using peas by-products is the palatability and protein content that results in the ensiled forage (Jim, 2018).

Oil seed

Mustard is the popular oilseed where the by-product of mustard, mustard cake is easy to find in Bangladesh and cheaper compared to peanut cake. Mustard seeds are a good source of protein and oil at 34-39% and 30-35%, respectively. The mustard cake is produced from the leftovers of a commercial mustard meal or oil production. It may replace expensive peanut cake and can be incorporated into growing lambs’ diet as a source of protein. It contains a comparatively large amount of methionine and balanced amino acids. It can be used in buffalo and cattle feeding (Kadegowda et al., 2002). Mustard oil cake supplements the protein that is degradeable in the rumen in a straw diet, which enhances the digestibility, absorption, and synthesis of microbial protein. It increases poor-quality feed (straw) utilization that may encourage the development of low-cost feeding systems in tropical areas (Khandaker et al., 2012). Bodyweight gain and milk production were higher while the cattle were fed mustard oil cake (Khare et al., 2014). It is a good source of energy for cattle because it contains 27% DCP, 74% TDN, 0.6% Ca, and 0.1% P, respectively. It may be introduced to cattle feed up to ten percent of the ration (Agritech, 2012).

The byproducts of soybean are a good source of nutrients, especially essential amino acids, and can be included in the dairy cattle ration as an excellent feed. The soybean's byproducts are suitable in any kind of forage-based feed formulation. It contains energy, fiber, fat, and high-quality protein as shown in Table 12 (Ishler and Varga, 2008). The meal generated after the production of soybean oil is an excellent source of protein for milking cows.
Table 11: The nutrient components in pea’s byproducts based on the dry matter.

| Nutrients                  | Straw % | Dried by-products (%) | Fresh by product (%) | Pod, silage (%) | Ensiled by product (%) |
|----------------------------|---------|-----------------------|----------------------|-----------------|------------------------|
| Dry matter                 | 88.8    | 90.4                  | 26.5                 | 27.5-95.1       | 28.2                   |
| Crude fiber                | 36.3    | 17.7                  | 22.6                 | 12.2-56.4       | 24.3                   |
| Crude protein              | 8.2     | 18.6                  | 17.8                 | 5.7-23.7        | 12.0                   |
| Ether extract              | 2.1     | 2.0                   | 2.1                  | 0.5-3.6         | 3.2                    |
| ADF (Acid detergent fiber) | 38.7    | -                     | 26.8                 | 9.3-45.1        | 40.5                   |
| NDF (Neutral detergent fiber) | 54.9   | 43.0                  | 43.1                 | 16.6-58.1       | 53.7                   |
| Ash                        | 9.8     | 15.2                  | 13.3                 | 3.3-11.4        | 18.7                   |
| Lignin                     | 7.2     | 8.0                   | 4.7                  | 0.4-12.9        | 9.3                    |
| Phosphorus                 | 0.11    | 1.24                  | -                    | 0.05-0.30       | -                      |
| Calcium                    | 2.37    | 1.27                  | -                    | 0.30-1.66       | -                      |

Source: Feedipedia, 2016

It is nutritious, palatable, and highly digestible. It provides energy and protein and is low in fiber compared to other oilseed meals. In addition, soybean hulls produced during the processing of soybean, contain a good amount of digestible fiber. They are low in lignin and high in energy. In different feeding systems, they can be added up to 10 percent (dry matter basis) in the diets of dairy cattle. They have the potential to be included in both dry and lactating cow diets. Researchers found that the hulls can replace forage fiber during mid and early lactation (Ishler and Varga, 2008). Moreover, the hulls of soybeans can replace a maximum of 50% maize in the concentrate mixture which has no adverse impact on the performance and health of the growing goats (Jadhao et al., 2020).

Table 12: The nutrient components in soybean byproducts based on dry matter.

| Nutrients   | Soybean meal (%) | Soybean hull (%) |
|-------------|------------------|------------------|
| DM          | 88.0             | 90.0             |
| NDF         | 14.0             | 67.0             |
| ADF         | 10.0             | 50.0             |
| CP          | 50.0             | 12.0             |
| Ash         | 7.3              | 5.1              |
| Fat         | 1.4              | 2.3              |
| p           | 0.68             | 0.21             |
| Ca          | 0.30             | 0.59             |

Source: Ishler and Varga, 2008

Linseed is the third oil-producing seed in Bangladesh. The byproduct of linseed, linseed meal, whole or ground, is a good feed resource in cattle, swine, and poultry because it contains energy, oil, and protein. It provides 70-85 percent TDN (total digestible nutrients) and 32-37 percent CP (crude protein). It can mostly be fed to young calves and horses. The meal is a rich source of omega-3 (Ω-3) fatty acids and researchers have observed that feeding the linseed meal to animals increases Ω-3 fatty acids in meat and milk (Dairy Knowledge Portal, 2014).

CONCLUSIONS AND RECOMMENDATIONS

Currently, most of the commercial animal production systems in Bangladesh can be characterized as intensive in nature. Due to the high conversion of pasture or agricultural lands into residential areas or industries, the semi-intensive and extensive production systems with the development of fodder plots and pasture areas are quite costly and troublesome. Commercial farmers are therefore directly dependent on concentrate feed and always compensate for the shortages of animal feeds and forages by supplementing high-priced imported feed. On the other hand, the small and marginal farmers restrain their livestock from feeding concentrate feeds as imported feedstuffs such as concentrates are highly expensive. They always prefer roadside grasses or plant leaves as animal feeds and are not capable of feeding their animals according to their requirements. In addition, the competition between animal feed and human food is a common barrier to animal production and profitability. These key constraining factors are currently under consideration to be solved. To address these issues, shifting to utilizing high quality home-grown crop by-products can be an efficient solution.

To improve the productivity of animals in a systematic and coordinated scheme under the mentioned scenario, it is, therefore, necessary that all stakeholders, for example, agricultural extension departments, non-government organizations, and research associations, should engage in planning, implementation, and development of sustainable livestock production. They can arrange seminars, workshops, and field meetings that can create an awareness to the commercial and marginal crop producers, feed
manufacturers, and animal farmers who are particularly involved in the unconsciousness of the values of major crop's by-products. The proper scheme in the utilization of major crop by-products is shown in Figure 1.

![Figure 1: The operational scheme in the utilization of major crop byproducts as animal feed.](image)

This review article has provided sufficient knowledge of the nutritional properties and feeding strategy of key crop's by-products, so that the objectives of reducing feed waste and imports can be successfully implemented and environmentally friendly livestock production can be gradually accomplished.

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NOVELTY STATEMENT

The current scenario of major crop production in Bangladesh and the ability to use these by-products as animal feed were mentioned. The nutritional quality and feeding strategy of each by-product were also highlighted. The information will be helpful for researchers to conduct the researches and find out the outcomes.

AUTHOR’S CONTRIBUTION

All authors contributed equally.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

REFERENCES

• Agritech (2012). Feeding Management of Cattle and Buffalo. [link] (Accessed 7, April 2021).
• Alamgir MdS (2019). Increasing rice production eliminating the vicious chain of food gap: The review of long-term outlook of rice sector in Bangladesh. Int. J. Environ. Sci. Nat. Res. 20(1): 556028. [link] (Accessed 10.19080/IJESNR.2019.20.556028)
• All about feed (2015). Maize cobs meal suitable as livestock feed. [link] (Accessed 12, April 2021).
• Banglapedia (2014a). Wheat. National Encyclopedia of Bangladesh. [link] (Accessed 12, April 2021).
• Banglapedia (2014b). Pulse. National Encyclopedia of Bangladesh. [link] (Accessed 12, April 2021).
• Banglapedia (2015). Black Gram. National Encyclopedia of Bangladesh. [link] (Accessed 15, April 2021).
• Banglapedia (2021a). Farming Systems. National Encyclopedia of Bangladesh. [link] (Accessed 19, June 2021).
• Banglapedia (2021b). Mung bean. National encyclopedia of Bangladesh. [link] (Accessed 18, May 2021).
• BBS (2020a). National accounts statistics. Bangladesh bureau of statistics. [link] (Accessed 10, May 2021).
• BBS (2020b). Yearbook of Agricultural Statistics-2019. Statistics Division, Ministry of Planning, The Government of peoples Republic of Bangladesh. [link] (Accessed 15, May 2021).
• Beef Cattle (2019). Can wheat straw be used in beef cattle rations? [link] (Accessed 15, May 2021).
• Benjamin R (2016). Stabilized rice bran for poultry feeding. Feed Strategy. [link] (Accessed 18, May 2021).
• Bodie AR, Micciche AC, Atungulu GG, Rothrock Jr MJ, Ricke SC (2019). Current trends of rice milling byproducts for agricultural applications and alternative food production systems. Front. Sustain. Food Syst., 3: 47. [link] (Accessed 10.3389/fsufs.2019.00047)
• Bunge (2021). Wheat Germ for Animal Consumption. [link] (Accessed 21, May 2021).
Calles T, Xipsiti M, del Castello R (2019). Legacy of the David B (2011). Wheat straw can be part of cattle rations. Farm progress https://www.farmprogress.com/livestock/wheat-straw-can-be-part-cattle-rations (Accessed 12, May 2021).

Dei HK (2017). Assessment of maize (Zea mays) as feed resource for poultry. Poul. Sci., pp. 1-32. https://doi.org/10.5772/65363

Dey A, De PS, Gangopadhyay PK (2016). Mungo bean (Vigna mungo L.) foliage supplementation to crossbred cows: Effects on feed intake, nutrient digestibility and milk production. Asian-australas. J. Anim. Sci., 30(2): 187–191. https://doi.org/10.5713/aasj.16.0286

DHaka Tribune (2019). Record maize production likely in Rangpur. https://www.dhakatribune.com/business/2019/03/18/record-maize-production-likely-in-rangpur (Accessed 15, May 2021).

DHaka Tribune (2020). Amazing maize success. https://www.dhakatribune.com/bangladesh/agriculture/2020/11/14/amazing-maize-success (Accessed 15, May 2021).

El-Tarabany AA, Teama FEI (2013). Importance of adding wheat germ in diets of growing goats to improve some components of blood and growth performance. Isot. Radiat. Res., 45(1): 79-89.

Ertl PQ, Zebeli W, Zollitsch, Knaus W (2016). Feeding of wheat germ in diets of growing goats to improve some components of blood and growth performance. Isot. Radiat. Res., 45(1): 79-89.

FAO (1994). Fodder crops and products. http://www.fao.org/es/taoed/taoed11e.htm (Accessed 23, May 2021).

Feedipedia (2013a). Lentil screenings. https://www.feedipedia.org/node/12249 (Accessed 7, May 2021).

Feedipedia (2013b). Lentil bran. https://www.feedipedia.org/node/12246 (Accessed 7, May 2021).

Feedipedia (2014). Grass pea (Lathyrus sativus), hay. https://www.feedipedia.org/node/11969 (Accessed 16, May 2021).

Feedipedia (2016). Animal feed resources information system. INRA/CIRAD/AFZ/FAO. https://www.feedipedia.org/node/285. (Accessed 10, April 2021).

Hossain A, Teixeira da Silva JA (2013). Wheat production in Bangladesh: Its future in the light of global warming. AoaB Plants, pp. 5. https://doi.org/10.1039/a0bplab0042

Hossain MS, Miah MY, Khandaker ZH, Islam F (2015). Effect of different levels of matikai (Vigna mungo) hay supplementation to straw-based diets on feed intake, digestibility and growth rate of indigenous cattle. Livest. Res. Rural Dev., 27(2). http://www.lrrd.org/lrrd27/2/hoss27021.html

Hu Y, He Y, Gao S, Liao Z, Lai T, Zhou H, Chen Q, Li L, Gao H, Lu W (2020). The effect of a diet based on rice straw co-fermented with probiotics and enzymes versus a fresh corn Stover-based diet on the rumen bacterial community and metabolites of beef cattle. Sci. Rep., 10(1): 10721. https://doi.org/10.1038/s41598-020-67716-w

Huque KS, Sarker NR (2014). Feeds and feeding of livestock in Bangladesh: performance, constraints and options forward. Bangladesh J. Anim. Sci., 43(1): 1-10. https://doi.org/10.3329/bjas.v43i1.19378

Ishler V, Varga G (2008). Soybeans and soybean byproducts for dairy cattle. Dairy Anim. Sci., 1: 13.

Jadhao AB, Bhalerao SM, Khanvilkar AV, Patodkar VR, Doiphode AY, Jadhav SN, Rangnekar MN (2020). Replacement of maize with soybean hulls in concentrate mixture on nutrient digestibility and haemato-biochemical parameters of growing goats. Haryana Vet., 59(1): 135-136. https://www.luvas.edu.in/haryana-veterinarian/download/harve2020-june/36.pdf

Jadhav SE, Deshmukh SV (2001). Evaluation of complete rations containing mung bean straw and wheat straw in sheep. Indian J. Anim. Nutr., 18(2): 190–193.

Jim Isleib (2018). Oat and pea forage combinations. Michigan State University Extension. https://www.canr.msu.edu/
news/oat_and_pea_forage_combinations. (Accessed 15, May 2021).

• Kadegowda A, Panwar V, Yadav K, Sihag S (2002). Mustard cake as a source of dietary protein for growing lambs. Small Rumin. Res., 44: 47–51. https://doi.org/10.1016/S0921-4488(02)00034-2

• Kanengoni AT, Chimonyo M, Ndomba BK, Dzama K (2015). Potential of using maize cobs in pig diets. A review. Asian Austral. J. Anim. Sci., 28(12): 1669. https://doi.org/10.5713/ajas.15.0053

• Kazi AAF (2017). Market insight: Bangladesh feed industry. Light castle partners. https://www.lightcastlebd.com/insights/2017/06/market-insight-bangladesh-feed-industry. (Accessed 7, May 2021).

• Khan J (2008). Best practices in animal feed production and management in SAARC countries. http://www.sac.org.bd/archives/publications/best_practices.pdf. (Accessed 5, May 2021).

• Khandaker ZH, Uddin MM, Sultana MN, Peters KJ (2012). Effect of supplementation of mustard oil cake on intake, digestibility and microbial protein synthesis of cattle in a straw-based diet in Bangladesh. Trop. Anim. Hlth. Prod., 44(4): 791-800. https://doi.org/10.1007/s11250-011-9969-0

• Khare A, Baghel RPS, Gupta RS, Nayak S, Khare V, Patil A, Sharma R, Tomar R Singh VP (2014). Milk production of indigenous cattle fed supplements of mustard oil cake or azolla meal (Azolla filiculoides). Livest. Res. Rural. Dev., 26(4):65. http://www.lrd.org/lrd26/4/khar26065.html

• Knoema (2020). Bangladesh- Maize production quantity. https://knoema.com/atlas/Bangladesh/topics/Agriculture/Crops-Production-Quantity-ton/Maize-production. (Accessed 13, May 2021)

• Kumar, R., Sudarshan S.T., Mahesh MS (2016). Rice gluten nutraceutical or just plain food? Planta, 250(3): 821-838.

• Lambein F, Travella S, Kuo YH, Van Montagu M, Heijde D, White C, Poore MH, Johns JT, Burris WR (2002). Soybean hulls, wheat middlings, and corn gluten feed as supplements for cattle on forage-based diets. Vet. Clin. North Am. Food Anim. Pract. 18(2): 213–231. https://doi.org/10.1016/S0749-0720(02)00021-X

• Mahmoud Y, Ebrahimnezhad Y, Ghalehkandi JG, Asaadi-Dizaji, A, Hashemi M, Ramezani M (2017). Chickpea (Cicer arietinum) Straw in ruminants. J. Anim. Sci. and Technol., 14(2): 321-328. https://doi.org/10.5958/0974-181X.2014.01331.6

• Ngwe T, Nukui Y, Oyaiuiz S, Takamoto G, Koike S, Ueda K, Nakatsuiji H, Kondo S, Kobayashi Y (2012). Bean hukas as a supplemental fibre for ruminants: Potential use for activation of fibrolytic rumen bacteria to improve main forage digestion. Anim. Nutr. Feed Technol., 14(2): 321-328. https://doi.org/10.10111/j.1740-0929.2011.09916.x

• Ontario (2021). Wheat crop feed. ministry of agriculture, food and rural affairs. http://www.omafra.gov.on.ca/english/livestock/beef/facts/wheat.htm. (Accessed 5, May 2021).

• Pandey PR, Koirala KB (2017). Best practices of maize production technologies in South Asia. SAARC Agriculture Centre, Dhaka, pp. 122.

• Poore MJH, Johns JT, Burris WR (2002). Soybean hulks, wheat middlings, and corn gluten feed as supplements for cattle on forage-based diets. Vet. Clin. North Am. Food Anim. Pract. 18(2): 213–231. https://doi.org/10.1016/S0749-0720(02)00021-X

• Rahman M (2017). Role of agriculture in Bangladesh economy: Uncovering the problems and challenges. Int. J. Bus. Manag. Invent., 6(7): 36–46. https://ssrn.com/abstract=3697022

• Reddy KS, Rao DS, Rao ZP, Prasad JR (2000). Effect of inclusion of varying levels of urad (Phaseolus mungo) chuni in concentrate mixtures on the nutrient utilization in native male buffaloes. Buffalo Bull., 19(2): 43–47.

• Ren H, Feng Y, Liu T, Li J, Wang Z, Fu S, Zheng Y, Peng Z (2020). Effects of different simulated seasonal temperatures on the fermentation characteristics and microbial community diversities of the maize straw and cabbage waste co-ensiling system. Sci. Total Environ., 708: 135113. https://doi.org/10.1016/j.scitotenv.2019.135113

• Riverina (2015). Wheat bran. https://www.riverina.com.au/products/wheat-bran/. (Accessed 7, June 2021).

• Roorikwal M, Bharadwaj C, Barmuki R, Dixit GP, Thudi M, Gaur PM, Chaturvedi SK, Fikre A, Hamwich A, Kumar S, Sachdeva S (2020). Integrating genomics for chickpea improvement: Achievements and opportunities. Theor. Appl. Genet., 133(5): 1703–1720. https://doi.org/10.1007/s00122-020-03584-2

• Royal Flour Mills (2020). Chick peas bran (battana). https://royalfournmills.com/our-products/chick-peas-bran/. (Accessed 15, June 2021).

• Rungcharoen P, Amornthewaphat N, Ruangpanit Y, Attamangkune S, Ratanatabtimthong S (2010). The utilisation of mung bean bran in nursery pig diets. Proceedings of the 48th Kasetsart University Annual Conference, Kasetsart, 3–5 March, 2010.

• Sarkar N (2019). Feeds and fodder trend-in Bangladesh -AHCCAB-2017. (Accessed 9, June 2021). https://www.banglajol.info/index.php/BJAS/article/view/36317/24456

• Singh KK, Das MM, Samanta AK, Kundu SS, Sharma SD (2002). Evaluation of certain feed resources for carbohydrate and protein fractions and in situ digestion characteristics.
Indian J. Anim. Res., 72(9): 794–797.

• Slominski BA, Boros D, Campbell LD, Guenter W, Jones O (2004). Wheat by-products in poultry nutrition. Part I. Chemical and nutritive composition of wheat screenings, bakery by-products and wheat mill run. Can. J. Anim. Sci., 84(3): 421-428. https://doi.org/10.4141/A03-112

• Shrivastava B, Jain KK, Kalra A, Kuhad RC (2014). Bioprocessing of wheat straw into nutritionally rich and digested cattle feed. Sci. Rep., 4(1): 1-9. https://doi.org/10.1038/srep06360

• Stanford K, Wallins GL, Lees BM, Mundel HH (1999). Use of lentil screenings in the diets of early weaned lambs and ewes in the second trimester of pregnancy. Anim. Feed. Sci. Tech., 81(3–4): 249–264. https://doi.org/10.1016/S0377-8401(99)00092-9

• Sun Z, Li X, Liu L (2018). Effect of steam explosion on solid-state fermentation of maize stalk by Penicillium decumbens and Phanerochaete chrysosporium for animal feed production. J. Anim. Physiol. Anim. Nutr., (Berl.), 102(2): 596-599. https://doi.org/10.1111/jpn.12782

• Timsina, Gulipart (2013). Description of cropping systems, climate, and soils in Bangladesh. Yield gap. https://www.yieldgap.org/bangladesh. (Accessed 7, June 2021).

• Uddin J, Sarker A, Podder R, Afzal A, Rashid H, Siddique KH (2013). Development of new lentil varieties in Bangladesh. Res. Gate, pp. 1–5. http://www.regional.org.au/au/as3a/2008/poster/farmer-focussed-research/5654_uddinj.htm

• Vahdani N, Moravej H, Rezayazdi K, Dehghan M (2014). Evaluation of nutritive value of grass pea hay in sheep nutrition and its palatability as compared with alfalfa. J. Agric. Sci. Technol., 16: 537-550. https://www.sid.ir/en/Journal/ViewPaper.aspx?id=373583

• Venkidasamy B, Selvaraj D, Nile AS, Ramalingam S, Kai G, Nile SH (2019). Indian pulses: A review on nutritional, functional and biochemical properties with future perspectives. Trends Food Sci. Technol., 88: 228-242. https://doi.org/10.1016/j.tifs.2019.03.012

• Vikaspedia (2020). Grazing and feed management. https://vikaspedia.in/agriculture/livestock/cattle-buffalo/grazing-and-feed-management. (Accessed 18, May 2021).

• Vinh NT, Tuan BQ, Hang NM (2013). The use of Mung bean (Phaseolus aureus) hulls in diets of laying hens. Livest. Res. Rural. Dev. 25(1). http://www.lrrd.cipav.org.co/lrrd25/1/vinh25014.htm

• Wachirapakorn, Chalong, Krung P, Metha W, Pawadee P, Anusorn C (2016). Effect of ground corn cobs as a fiber source in total mixed ration on feed intake, milk yield and milk composition in tropical lactating crossbred Holstein cows. Anim. Nutr., 2(4): 334-338. https://doi.org/10.1016/j.aninu.2016.08.007

• Zayed MS (2018). Enhancement the feeding value of rice straw as animal fodder through microbial inoculants and physical treatments. Int. J. Recycl. Org. Waste Agric., 7(2): 117-124. https://doi.org/10.1007/s40093-018-0197-7

• Zhang W, Wu S, Cai L, Liu X, Wu H, Xin F, Zhang M, Jiang M (2018). Improved treatment and utilization of rice straw by Coprinopsis cinerea. Appl. Biochem. Biotechnol., 184(2): 616-629. https://doi.org/10.1007/s12010-017-2579-0

• Zhao X, Wang F, Fang Y, Zhou D, Wang S, Wu D, Wang L, Zhong R (2020). High-potency white-rot fungal strains and duration of fermentation to optimize corn straw as ruminant feed. Bioresour. Technol., 312: 123512. https://doi.org/10.1016/j.biortech.2020.123512