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The Benefits of Sugar Beet Pulp By-Products Used in Animal Feeding on Rumen Fermentation, Nutrient Utilization, Blood Components, Growth, And Milk Yield with Some Principal Considerations Prior to Introducing to The Animals

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Abstract: The process of making sugar from sugar beets results in a by-product known as sugar beet pulp. The beet pulp, which can be used as fresh, dried, or ensiled animal feed, is obtained by mashing sugar beet. The pulp from sugar beets is offered as either dry flakes or tightly packed pellets. Sugar beet pulp is a delicious food that is high in energy and low in sugar and other non-structural carbohydrates. Sugar beet pulp's highly digestible fiber is perfect for ruminants since it supports acetate production and maintains the health of the rumen. Users can add sugar beetroot pulp to the silage if they want to maintain the effluent's feed value because of its high liquid absorption ability. Cane molasses is a different by-product produced during the handling of raw sugar cane. After being dried, crushed, and sold as shreds or pellets, this is frequently mixed with sugar beet pulp and cane molasses to create molasses from sugar beet. The main component of the fiber in sugar beet remains cellulose, which is very easily digested. Therefore, sugar beet is a particularly well-suited diet for ruminants, aiding in the creation of ideal rumen circumstances and improving milk yield when provided with an appropriate quantity of degradable protein. After the sugar has been extracted, the sugar beet's fibrous portion is dried. Dried beet pulp shreds are routinely compressed into pellets or cubes for shipment due to their exceptionally low bulk density. Either pelleted or cubed beet pulp and beet pulp shreds are included in the animal feed. Beet pulp, which is made from the residual beet shreds after processing, is regularly added to or used in place of roughage in finishing diets for beef cattle.

Keywords: Sugar beets, animal nutrition, daily gain, milk composition, blood biochemical metabolites.

INTRODUCTION

The sugar beet plant (Beta vulgaris) is grown for its sucrose-rich roots, which are used to make sugar. Sugar beets were used to create 20 percent of the sugar produced globally (**FAO, 2009).** France, the United States, Germany, Russia, Ukraine, and Turkey were the top six nations producing sugar beetroot globally **(FAO, 2010**). On 1,004,600 acres, sugar beets were harvested in the US in 2008 (**United States Department of Agriculture, 2011**). The entire plant is composed of a rosette of leaves and a root. Sugar is created during the photosynthetic process in the leaves and is then stored in the root. Depending on the cultivar and growing circumstances, the real sugar levels might vary from 12 to 21% (**Agriculture Economic and Statistics Institute, 2009).** Beet root is mostly composed of water, with a small amount of sugar (20%) and pulp (5%). Sugar is the principal advantage of sugar beet as a commercial crop. The pulp, which is mostly composed of cellulose, hemicellulose, lignin, and pectin and is insoluble in water, is used to make animal feed. The byproducts of the sugar beet crop, such as pulp and molasses, increase the harvest's value by 10% (**FAO, 2009**). In 2011, 271.6 million metric tons of sugar beets were collected worldwide, according to data on sugar beet output. The largest producer in the world was Russia, which had a yield of 47.6 million metric tons. The average global output of sugar beet crops was 58.2 metric tons per hectare. Chile had the most prolific sugar beet fields in the world in 2010, with an average national production of 87.3 metric tons per hectare (**FAO, 2016**). Cattle and other livestock are given sugar beet pulp, a byproduct of sugar beet manufacturing, as a feed. It is sold as dry flakes or crushed pellets. A pulp dryer receives the pulp that will be marketed as dry shreds or pellets. In the pulp dryer, the pulp is dried to a moisture content of 10% or less. The pulp is pelletized after drying to make storage and distribution easier. The refining procedure results in the production of molasses. Although the volume of molasses generated varies, **Lardy & Schafer (2013**) report that it normally amounts to 4–5% of the weight of fresh sugar beets. The meal derived from sugar beet pulp is acceptability, high in energy (metabolizable energy equals 11 mg/kg dry matter), and includes highly digestible fiber that is good for ruminants because it keeps the rumen in good condition and encourages the production of acetate. As a silage supplement, it can be used to maintain the feed value of effluent due to its high liquid absorption capacity. The dark brown, sticky liquid known as cane molasses is an additional by-product of processing fresh sugar cane. This is often included when the sugar beet pulp is dried, crushed, and packed as shreds or pellets. The main component of the fiber in sugar beet remains cellulose, which is very easily digested. In order to sustain perfect rumen conditions and boost milk production, sugar beet is a very acceptable diet for ruminants when supplemented with a suitable quantity of degradable protein (**Habeeb *et al.*, 2017**). The fibrous component of the sugar beet is dried after the

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sugar has been extracted. Dried beet pulp shreds are routinely compressed into pellets or cubes for shipment due to their exceptionally low bulk density. Beet pulp is utilized in animal feed in two different forms: pelleted cubes and shreds. Beet pulp, which is made from the residual beet shreds after processing, is regularly added to or used in place of roughage in finishing diets for beef cattle. Molasses may occasionally be added to improve flavor. Several byproducts are created during the production and treatment of the sugar-beet crops that are used as animal feed. After the roots have been removed, the tops alone or the tops together with the crowns can offer ruminant animals as important source of feed. When sugar beet roots are processed, two more good feeds are produced, including sugar beet pulp and molasses. The process of fermentation may possibly be used to further process the molasses, yielding alcohol and water-soluble condensed molasses. These components can be used singly or in combination, dried or treated in a number of ways, to provide high-quality animal diets (**Mirzaei & Sis (2008**). The scarcity of feed needed to satisfy the population's needs for the nutrition of animals as it currently exists is one of the most critical issues with Egypt's animal industry. Additionally, attention to easily accessible and less expensive feed alternatives has increased as a result of the standard feeds' growing cost. In Egypt, sugar beetroot was grown on roughly 600,000 feddans in 2018–2019, yielding 715,600 tons of dry sugar beetroot pulp. The local nutrient supply benefits from the addition of 27,695 tons of DCP, 467,155 tons of TDN, and 644,038 tons of DM from dried sugar beetroot pulp (**USDA, 2021**). So, some byproducts and organic waste were allowed in order to lessen the shortage of animal feedstuffs. The high quickly fermentable fiber fraction of dried sugar beet pulp, which has 400 g/kg of neutral detergent fiber (NDF) per kg, is comparable to pasture NDF in content. As a consequence, sugar beet pulp provides ruminants with a respectable amount of fiber and is a great alternative to energy in diets based on maize (**Nikkhah, 2015**). The addition of sugar beet pulp to ruminant feed may help to resolve the direct competitive conflict that exists between livestock and human nutritional systems without sacrificing feed quality or animal productivity (**Abo-Zeid *et al.*, 2017).** The positive effects of employing sugar beet pulp byproducts in animal feeding on rumen fermentation, nutritional utilization, blood components, production, and economic efficiency were examined in this review of research by the author.

Importance of sugar beet pulp in Egypt

The industrial technique of sugar beet handling in sugar purifying manufacturing results in the by-product of sugar beet pulp, which is mostly employed as a component in final feedstuffs. However, sugar beet pulp is nowadays more readily presented as a by-product of sugar beet manufacturing. **Mirzaei & Sis (2008)** cleared the by-products from the processing of sugar beets as following in this diagram (Figure 1). In Egypt, around 600,000 feddans of sugar beet cultivation resulted in 715,600 tons of dried sugar beet pulp. The dried sugar beet pulp gives 644,038 tons of dry matter, 467,155 tons of total digestible nitrogen, and 27,695 tons of digestible crude protein to the native nutrient source **(USDA, 2021).** Fresh sugar beet pulp is pelletized after being dried using a pulp dryer until it contains only about 10 % humidity to make sugar beet pulp simpler to store and transport **(Münnich *et al.*, 2017).** Each year, sugar beet is produced on more than 135,623 feddans in Egypt, producing roughly 2,888,770 metric tons of tubers (Figure 2).

According to the **Agriculture Economic and Statistics Institute (2009)**, the dried sugar beet pulp, which is left over after sugar extraction, weighs about 173,326 metric tons and contributes 6,708 metric tons of digestible crude protein, 113,150 metric tons of total digestible nitrogen, and 1, 55993 metric tons of dry matter to the local nutrient supply. Sugar beet pulp shreds, a byproduct of sugar beet manufacturing, are a superior source of animal feed for many different species. Sugar beet pulp shreds (Figure 3) are the fibrous remnants of the sugar beet that are still present after the sugars have been extracted. The water content is mechanically squeezed and dried to a level of around 9%. Sugar beet pulp fiber, which is less dusty than hay, is highly absorbed (**Mustafa, 2011**)

Biochemical contents and nutritional values of sugar beet pulp

According to **Mohsen *et al.* (2021)**, the dried sugar beetroot pulp's chemical composition is as follows: 880.7, 953.5, 98.7, 246.7, 6.0, 602.1 and 46.5 g/kg for dry matter, organic matter, crude protein, crude fiber, ether extract, nitrogen-free extract, and ash, respectively. Sugar beet pulp is recognized as having a high soluble fiber content and a high dietary fiber concentration that is generally >75%, according to **Filipovic *et al.* (2007).** Dried sugar beet pulp can be substituted for maize grains up to 100%, resulting in a reduction in feeding costs of 27.4% with a diet containing 50% dried sugar beet pulp and 35.2% with a diet covering 100% dried sugar beet pulp. Due to soil contamination, various sugar beet pulp parts may contain significant amounts of ash. According to **Levigne *et al.* (2002),** the structure of beet compartment walls, and consequently sugar beet fiber, is described by a reasonably high pectin concentration and around 20% of each of galacturonic acid and arabinose. In sugar beet fiber, 20% glucose, largely of cellulosic origin, may also be present. Overall, sugars account for around 80% of the dehydrated mass, with xylose and mannose content being particularly low. In addition, there are a variety of non-sugar ingredients such as methanol, acetic acid, phenolic acids, proteins, lignin, and ash. A tiny proportion of polysaccharides, primarily of pectin origin, may also be removed by water from sugar beets in the sugar manufacturing process. Poor pectin extraction may be caused by the structure of beet cell walls or physical obstacles to the pectin polymers diffusing from the network of cell walls **(Fares, 2003).**

Animals can obtain a complete meal while experiencing less bloating and digestive upset thanks to sugar beet pulp. Sugar beet pulp, when soaked in water, increases succulence in food and cools show animals. Additionally, it enhances the coat's bloom for the best appearance. Sugar beet pulp not only offers variability in feed foods but also firm's stools for cleaner pens and increases feed intake. Sugar beet pulp may be a constituent of several cattle nutrition programs. About 9.1% crude protein, 31% acid detergent fiber (ADF), 0.72% calcium, and 0.20% phosphorus are all present in sugar beet pulp **(Mustafa *et al.*, 2009)**. A highly digestible source of fiber is sugar beet pulp. The dry substance is palatable, has a moisture content of around 10%, and may be fermented in the rumen. Highly digestible fiber found in sugar beet pulp is beneficial for ruminants since it helps to keep the rumen healthy and encourages the production of acetate. As a silage supplement, it can be used to maintain the feed value of effluent due to its high liquid absorption capacity. Sugar beet pulp can be used in beef cow's foods as a supplement to energy or as a way to start and conclude meals. Due to the low protein content of sugar beet pulp, extra protein is frequently required in most uses, particularly if subpar forages are offered. Shreds of sugar beet pulp may be weighted and put in storage with simplicity. To avoid rotting and shrinkage losses, wet sugar beet pulp should be used within two weeks of its arrival. In silage bags, it can be kept to extend storage and halt deterioration. The pulp of sugar beets has a high quantity of palatable energy that the rumen may ferment **(Mustafa, 2011).** According to Lardy & Schafer (2008), sugar beetroot pulp has highly digestible fiber that is beneficial to ruminants because it encourages the production of acetate and maintains the health of the rumen. Because of its quick rate of liquid absorption, scientists determined that it can be added to silage as a supplement to maintain crops' high feed charge. Beetroot pulp may also be a helpful supplement for cows that are pregnant or nursing, a replacement for roughage in finishing diets, and an addition to background feeds. The same authors also noted that although beetroot pulp has a high concentration of total digestible nitrogen (72%), it has very little crude protein. As a result, if beetroot pulp makes up more than 20% of a person's diet, their intake of dry matter will decrease. **Mahmoud & El-Bordeny (2016)** investigated the effects of substituting dried sugar beet pulp for yellow corn in Barki lambs' diets, either partially or entirely. The authors discovered that except for ether extract, corn substituted with sugar beet pulp at 75 and 100% levels significantly increased nutrient digestibility. Additionally, the 50 and 75% treatments had greater levels of total digestible nutrients, digestible energy, metabolizable energy, and digestible crude protein than the other treatments. The same authors demonstrated that sugar beet pulp had no significant impact on volatile fatty acids but that dry sugar beet pulp rations had a linearly negative influence on ruminal pH and ruminal ammonia levels when compared to animal-fed control rations.

Nutrients of dried sugar beet pulp

Dried sugar beet pulp contains 89.52% dry matter, 10.71% crude protein, 21.54% crude fiber, and 0.64% ether extract, as well as 3.25% ash, 63.86% nitrogen free extract, 2.83% lignin, 0.29% reducing sugars, 2.99% sucrose, undetectable starch, 8.21% true protein, 0.77% calcium, 0.09% phosphorus, 0.3% magnesium, and 0.03% iron. Each kilogram of dried sugar beet pulp contains 0.21 mg of beta-carotene as well. Furthermore, 85% of the crude protein was actual protein, and the total energy content was roughly 4164 Kcal/kg. The amount of actual protein in dried sugar beet pulp varies from 54 to 77% of the total nitrogen, whereas the amount of crude protein is relatively low but has a high bioavailability (**Castle, (1972).** Dried sugar beet pulp was found to contain a range of nutrients, including 83.8 to 92.5% for dry matter, 9.3 to 10.7% for crude protein, 0.1-2.4% for ether extract, 18.4 to 22% for crude fiber, 59.3 to 65.7% for nitrogen free-extract, and 3.2 to 6.7 for ash. According to **Mandebvu & Galbraith (1999),** the total digestible nitrogen value of dried sugar beet pulp ranged from 68 to 74%, and the metabolizable energy value was about 2.99 Mcal/kg, or 12.52 MJ/kg DM. From a different perspective, **Mustafa *et al.* (2003)** determined the total oxalate content to be 4.90, 0.366, and 0.237 mg/100 g DM in sugar beet leaf, root, and pulp of sugar beet pulp, respectively. Sugar beet tops had a total oxalate concentration that ranged from 3.3 to 4.89% on a dry matter basis, according to **Bendary *et al.* (1992).** Because calcium is insoluble, oxalic acid can reduce calcium absorption. **Saleh *et al.* (2001)** found that high oxalic acid levels were associated with a reduction in appetite, indications of stress, and other biochemical, clinical, and histological outcomes. Despite having low crude protein content (6.8–8.0%) and a high energy content (75-81% total digestible nitrogen, TDN), whole beets may be given to cattle with success. Whole beets are a strong source of energy and may be fed to ruminants like cattle and sheep because of their high sugar content and easily digestible fiber. Due to their comparable calorie content but somewhat lower protein content, sugar beets and oatmeal can be compared in terms of feeding value (**Ministry of Agriculture & Food, 2008).** According to **Maareck (1997),** sugar beet pulp may be an adequate energy source when used in diets for growing and fattening ruminants. When concluding lamb dinners in **1998, Mahmoud *et al.*** showed that dried sugar beet pulp may replace up to 50% of the energy sources. According to **Gaivoronskii (1980),** dried sugar beet pulp, like maize, provides up to 73% of the energy needed by lactating cows in well-balanced dairy concentrate feeds. Despite having a theoretically lower TDN concentration than maize or barley, beetroot pulp's 20% highly digestible fiber content maximizes the amount of dietary energy that may be obtained from the meal. Due to its by-product origin and low price, beet pulp is also a preferred component in cow feed **(Habeeb *et al.*, 2017).**

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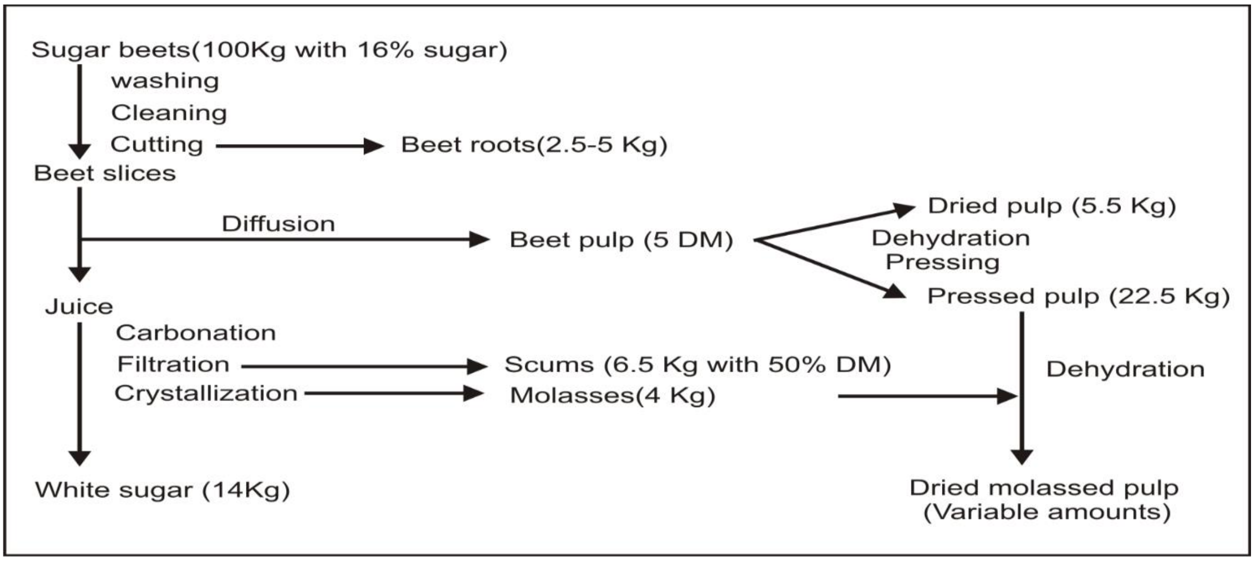

Figure 1: By-products from the processing of sugar beets (Mirzaei and Sis, 2008).

Figure 2: Sugar beet pulps in the field

Figure 3: Shreds, pellets and crumbles of sugar beet pulp

The effect of dried sugar beet pulp on rumen digestion and nutritional uptake

According to **Habeeb *et al.* (2017),** dried sugar beet pulp has a 20% readily assimilated crude fiber content that gives rumen ingest specific physical and chemical characteristics to prevent digestive problems, acidosis, and decreased appetite. Same authors found no appreciable difference in the digestibility each of dry matter, nitrogen free extract, and crude protein between the three meals that included 0, 17.13, and 34.25% dried sugar beet pulp. **Masude *et al.* (1999)** discovered that feeding goats Italian ryegrass hay with 10% dried sugar beet pulp significantly improved the degradability of dry matter, neutral detergent fiber (NDF), acid detergent fiber (ADF), and hemicelluloses. In addition to finding that the digestibility of ether extract was significantly lower when the diet contained dried sugar beet pulp than the control, **Mohsen *et al.* (1999)** also discovered that the use of dietary nitrogen had enhanced in sheep and goats fed diets inclosing 50% dried sugar beet pulp. These findings were corroborated by the fact that the utilization of dietary nitrogen had also improved. According to **Ali *et al.* (2000),** the crude fiber of beet pulp was highly digestible, and diet digestibility improved with each increase in the dietary quantity of beet pulp. In other studies, substituting dried sugar beet pulp for concentrated ration raised the quantity of crude fiber, ADF, and NDF in the daily ration for summer and winter diets **(El-Ashry *et al.*, 2000).** When yellow corn was substituted with either 50% or 100% of the dried sugar beet pulp, **Saleh *et al.* (2001)** showed that the digestibility coefficients of dry matter and nitrogen-free extract were unaffected, despite the fact that the crude fiber digestibility increased significantly and the ether extract digestibility decreased significantly. On the other hand, crude protein digestibility decreased as the amount of dried sugar beet pulp rose. As a result of enhanced bacterial protein synthesis in the rumen, **Kammtali *et al.* (1992)** demonstrated that total nitrogen and amino acids in duodenal digesta increased when dried sugar beet pulp was added to the diets of non-gestational Friesian heifers. The same authors also discovered that adding dried sugar beet pulp to the diet increased butyric acid in rumen fluid and decreased ammonia concentration. Additionally, dairy cows given dried sugar beet pulp showed an increase in rumen bacteria, according to **Haaksma (1993).** Additionally**, Mohsen *et al.* (1999)** found that the level of total VFA significantly increased as the amount of dried sugar beet pulp in the diet climbed. Although **Ali *et al.* (2000)** found no discernible differences in the rumen pH levels among rams intake feeds, the amount of total VFAs and NH3-nitrogen significantly increased in feeds enclosing various percentages of dried sugar beet pulp (0, 25, and 50%) in place of concentrate feed mixture. The amount of total or proportionate VFAs did not change when the source of the diet's carbohydrates was changed from dried sugar beet pulp to starch grains, according to **Saleh *et al.* (2001),** who also found that while ruminal pH values and NH_3-nitrogen levels remained unchanged, total VFA levels increased significantly when the amount of dietary dry sugar beet pulp in the diet increased. **EL-Badaw & EL-Kady (2006)** evaluated the effects of feeding rations with 50% ureated feed sugar beet pulp to replace the concentrate feed combination on developing Egyptian sheep. The authors demonstrated that whereas crude fiber digestibility was much greater than that of the concentrate feed combination, crude protein and ether extract digestibility were both reduced with 50% ureated dry sugar beet pulp. Total digestible nutrient was increased in the feed combination made from concentrate and 50% ureated dry sugar beet pulp. For lambs given 50% ureated dry sugar beet pulp, the utilization efficiency of metabolizable energy for net energy gain was much greater. The later authors came to the conclusion that adding 3% ureated sugar beet pulp to rations for growing sheep is advised because it could offer a safe source of carbohydrates with a longer time of passage rate and, as a result, a better utilization of dietary energy. According to **Boguhn *et al.* (2010),** replacing 20% of the corn silage in the diet with beet pulp silage significantly improved the organic matter's ability to be digested. **Mousa (2011)** studied the impact of substituting fodder beet roots for concentrate feed combinations on nutritional value and economic effectiveness in ewes and dairy goats. The author discovered that no level of replacement significantly affected the digestibility coefficients of dry matter, organic matter, ether extract, and nitrogen-free extract, whereas the digestibility of crude protein and crude fiber significantly decreased as the amount of beet roots in the diets increased and all animals also had positive N-balance levels. **Münnich *et al.* (2017)** confirmed that the adding of beet pulp silage to dairy calves had a detrimental impact on calorie intake due to increased fiber consumption, even if it had no significant impact on the quantity of dry matter intake. As sugar beet pulp substituted corn in the diet of developing Egyptian male buffalo calves**, Abo-Zeid *et al.* (2017)** discovered that the acetate: propionate ratio and total protozoa were linearly considerably higher, while the ruminal NH3-nitrogen level was significantly higher. The authors came to the conclusion that feeding sugar beet pulp in place of maize grains improved ruminal fermentation and rumen fermentation components in developing Egyptian male buffalo calves. The effect of partial substitution (0, 25, and 50%) of beet pulp as dry matter base in place of barley grain during the pre-partum phase on ruminal fermentation in multiparous Holstein cows was examined by **Shahmoradi *et al.* (2015).** In comparison to cows fed the 0% beet pulp diet, the authors discovered that cows on the 50% beet pulp diet had a substantially higher rumen pH, a higher molar percentage of butyrate, and lower acetate: propionate ratio. According to this study, beet pulp may substitute barley grain up to 25% of the time throughout the pre- and post-partum period without negatively impacting the production of early lactation cows. **Aziz (2020)** examined the impact of substituting dried sugar beet pulp for 40% of the yellow corns in concentrate feed mixture on rumen fermentations and bacteria, nutrient digestibility, nutritional value, and rate of transit in the rumen of ewes. The rumen fermentations were markedly enhanced when dried sugar beet pulp, which made up 40% of the concentrate feed mixture replaced a portion of the yellow maize. **Mohsen *et al.* (2021)** studied the effects of replacing dry sugar beet pulp with 25 and 50 percent of yellow maize grain digestibility qualities on multiparous nursing Holstein cows during their peak lactation phase. The authors discovered that in the dry sugar beet pulp groups, the amounts of dry matter, organic matter, ether extract, nitrogen free-extract, and fiber carbohydrate tended to decrease, whereas crude protein, crude fiber, ash, and fiber components tended to rise. In the dry sugar beet pulp rations, the only significant improvement in digestibility was for crude fiber. **Aziz & Kholif (2015)** looked into the effects of adding sugar beet pulp that has been treated with urea to the diet of female goats to substitute about 30% of the concentrate feed combination on milk supply and conformation, birth weight, and weaning weight. The obtained results showed that when sugar beet pulp treated with urea replaced 30% of the concentrate feed mixture in the diet, the contents of dry matter, organic matter, ether extract, nitrogen free-extract, and crude protein significantly increased and the contents of ash, crude fiber, NDF, ADF, acid detergent lignin (ADL), cellulose, and hemicellulose significantly decreased when related to animals fed concentrate feed mixture without or with untreated sugar beet pulp. The authors came to the conclusion that treating sugar beet pulp at a level of 4% urea improved milk yield and composition, as well as the digestibility coefficients of all nutrients, fiber fractions, nitrogen balance, and rumen parameters, particularly microbial protein concentration. **Kargar *et al.* (2021)** giving shredded sugar beet pulp to newborn female Holstein dairy calves dramatically boosted their consumption of beginning diet dry matter as well as their overall intake of dry matter, total crude protein, and NDF. The authors discovered that giving newborn female Holstein dairy calves steam-flaked maize instead of 25% shredded sugar beet pulp reduced their intake of total ether extract and starch while having no discernible impact on their intake of total metabolizable energy. The same researchers discovered that substituting steam-flaked maize for shredded sugar beet pulp improved meal length and proportions, dramatically amplified ruminating occurrence and extent, but significantly reduced the intervals between rumination. According to the same authors, calves given 25% shredded sugar beet pulp spent more time eating, reflecting, and standing, while less time was spent laying down and engaging in non-nutritive oral behaviors. With increasing inclusion rates of 0, 15, or 30% of beet pulp, dry matter, organic matter (from 79.7 to 75.6%), CP (75.7 to 70.1%), and starch (97.1 to 93.1%) digestion coefficients dropped linearly considerably. While the digestion coefficients of NDF (from 47.1 to 52.7%) and ADF (44.1 to 53.0%) are rose linearly considerably with increasing beet pulp inclusion rates. These findings imply that beet pulp may be a more advantageous substitute for maize in calf starter concentrates **(Dennis *et al.*, 2018). Mohsen *et al.* (2021)** studied the effects of replacing dry sugar beet pulp with 25 and 50 percent of yellow maize grain digestibility qualities in multiparous nursing Holstein cows during their peak lactation phase. The level of total volatile fatty acids augmented in the dry sugar beet pulp groups, but the pH value and ammonia nitrogen concentration in the rumen declined. The authors came to the conclusion that dairy cows' digestion and rumen activity significantly improved when dried sugar beet pulp was substituted in part for yellow maize grain in their meals. The effects of feeding dairy Holstein cows maize silage with increasing concentrations of shredded beet pulp instead on nutrient intake, sorting index, nutritional intakes of particle size, and other factors were examined by **Naderi *et al.* (2019**). With increasing quantities of shredded beet pulp in the meals, the authors saw a decrease in the extent of sorting against long particles and medium particles, but not for tiny particles. The number of feeding bouts per day was found to be 8.2% lower in cows fed shredded beet pulp diets than in cows fed maize silage, according to the same authors, and to decrease in eating time per day through treatments. **Maktabi *et al.* (2016)** investigated the effects of substituting alfalfa hay or beet pulp for grain barley on rumen parameters and eating activity in pre- and post-weaning male Holstein calves. The researchers discovered that giving beet pulp fiber to male Holstein calves at the pre-weaning stage had no influence on chewing activity but tended to increase chewing time, rumen acetate, and rumen pH. Compared to Ossimi lambs fed a concentrate feed combination mostly made up of grains, **Hamed *et al.* (2013)** found that adding dried sugar beet pulp to the feed mixture at 90% greatly enhanced crude fiber digestibility but dramatically lowered ether extract digestibility. The same researchers discovered that feeding dried sugar beet pulp at a rate of 90% to lambs dramatically improved nitrogen balance as measured by nitrogen-intake, or digestible nitrogen, and decreased urinary nitrogen loss. Dried sugar beet pulp was also added, which had a substantial impact on the levels of total volatile fatty acids and nitrogen ammonia. In a 2011 study**, Mojtahedi & Mesgaran** examined how Holstein steers' chewing behavior, ruminal fermentation, and nutrient digestibility changed when different amounts of dried molasses sugar beet pulp were substituted for barley grain in little-forage foods. The researchers discovered that adding dry molassed sugar beet pulp to the meal considerably increased eating, ruminating, and total chewing duration, as well as ruminal pH linearly. The mean ruminal ammonia concentration, which was greatest in Holstein steers given barley grain in low-forage diets, however, dramatically decreased linearly and quadratically. Additionally, adding dried molasses-sweetened sugar beet pulp to the diet resulted in considerably increased acetate and butyrate and decreased the amounts of propionate as well as total volatile fatty acids in the rumen fluid. The apparent digestibility of DM and NDF appeared to be improved by the quantity of sugar beetroot pulp in the meal, even though the apparent digestibility of CP and ADF was the same in all treatments. The findings of this study imply that dried molasses sugar beet pulp, when used in low-forage diets in place of barley, maybe a source of physiologically beneficial fiber that encourages prolonged chewing. The lowered ammonia-nitrogen content and increased rumen pH were signs of the positive effects sugar beet pulp inclusion, especially, at lesser addition amounts, had on rumen synchronizing. Additionally, the inclusion of sugar beet pulp improved the apparent digestibility of DM and NDF in the experimental diets. As dry sugar beetroot pulp (25 and 50%) was substituted for yellow corn grains in the rations of lactating multiparous Holstein cows, the contents of DM, OM, ether extract, nitrogen-free extract, and fiber carbohydrate tended to decrease; however, crude protein, crude fiber, ash, and fiber fractions tended to increase in the replacement groups **(Mohsen *et al.*, 2021).** The effects of substituting whole-plant corn silage with a mixture of rice straw and sugar beetroot pulp with inoculation in high-production dairy cows are examined by **Wang *et al.* (2021).** The researchers discovered that the content of propionate and total VFAS increased linearly with the amount of sugar beetroot pulp and rice straw mixed silage added. When the percentage of rice straw mixed silage and sugar beetroot pulp climbed to 45%, the DMI and digestibility values of NDF and ADF increased linearly.

Impact of sugar beet pulp on blood biochemical components

In their 2016 study, **Mahmoud & El-Bordeny** looked at the effects of replacing some or all of the yellow corn in the diets of growing Barki lambs with dried sugar beet pulp on blood biochemical components and discovered that all blood metabolites were in within the normal ranges**. Abo-Zeid *et al.* (2017)** found that with increasing the dietary sugar beet pulp levels in the diet of growing Egyptian male buffalo calves, the blood urea-nitrogen, cortisol and thyroxin levels were increased significantly while significantly decreases in creatinine, and cholesterol levels. The serum total protein, albumin, glucose, and thyroid hormones levels of Egyptian male buffalo calves did not change as the amount of sugar beet pulp in their diet increased, but the levels of serum creatinine and cholesterol decreased linearly and significantly. In addition, the mean blood levels of urea-nitrogen, lipids, cortisol, and thyroid hormone all increased as sugar beet pulp intake increased. Effect of partial replacement 0, 25 and 50% beet pulp as dry matter basis substituted for barley grain during the pre-partum period on plasma level of metabolites of multiparous Holstein cows (**Shahmoradi *et al.* 2015).** The results showed that cows fed the beet pulp diets had greater significantly plasma beta-hydroxybutyrate and lower concentrations of plasma glucose and blood urinary nitrogen than cows fed the barley grain diets. The authors concluded that replacing beet pulp for barley grain at 50% had adverse effects on metabolic status, as showed by main blood metabolite levels. **Aziz (2020)** investigated the impacts of replacing dried sugar beet pulp for 40% of the yellow corn in a concentrate feed combination on the biochemical components of the blood in Barki ewes. The quantities of blood serum glucose, total proteins, albumin, and creatinine were noticeably raised when dried sugar beet pulp (40%) was substituted for a portion of the yellow maize in the concentrate feed combination. However, impact of replaced dry sugar beet pulp of 25 and 50% of yellow corn grain digestibility traits, of multiparous lactating Holstein cows during their peak period was conducted by **Mohsen *et al.* (2021)**. The authors found that the levels of blood plasma total protein and globulin were higher significantly in dry sugar beet pulp groups than in yellow corn grain. Moreover, plasma albumin level, liver enzyme activities were lesser significantly in dry sugar beet pulp groups (50%) than in yellow corn grain. The authors concluded that partial substitute of yellow corn grain with dry sugar beet pulp in the rations of dairy cows led to significant plasma biochemical parameters. **Kargar *et al.* (2021)** reported that **c**irculating levels of glucose, total protein, and albumin were not affected by partial substitute of shredded sugar beet pulp with steam-flaked corn. The authors found significantly higher concentrations of blood urea-N and a lower significantly albumin to globulin ratio were detected in shredded sugar beet pulp vs. steam-flaked corn-fed calves. Effect of increasing beet pulp at the expense of barley grain on blood metabolites of late lactating pregnancy Holstein cows was examined by Mahjoubi ***et al.*** (2009). The authors found that plasma glucose and cholesterol declined as beet pulp replaced for barley grain. According to **Hamed *et al.* (2013),** Ossimi lambs fed a concentrate feed combination made primarily of grains saw a considerably lower blood plasma level of triglycerides, cholesterol, urea, and uric acid when dried sugar beet pulp was added to the feed mixture. When barley grain in low-forage diets was substituted with various amounts of dried molasses and sugar beet pulp, **Mojtahedi & Mesgaran (2011)** found that introduction of sugar beet pulp caused a linearly significant drop in plasma urea nitrogen levels before the morning meal. Other blood biochemical parameters were unaffected by the treatment.

Impact of sugar beet pulp on feed intake and daily body weight gain:

In comparison to sheep fed simply beet pulp or beet pulp plus corn, sheep fed ground rations including corn saw considerably lower average daily gains. According to **Ali *et al.* (2000)**, the average body weight growth increased but the feed conversion decreased when the amount of dry sugar beet pulp was increased from 0.0% in the control ration to 25 or 50% in the other experimental ration. However**, Eweedah (2001) reported that by** boosting the amount of dried sugar beet pulp in the diet, feed consumption rose significantly. **El-Baddawi *et al.* (2001)** found that sheep given 3% untreated sugar beet pulp at 50% substitute had the highest average daily gain increase, while sheep fed

100% untreated sugar beet pulp ration had the lowest average daily gain increase because animals consumed less feed. According to the same authors, replacing frequently fed combinations with untreated sugar beetroot pulp at a level of 50% considerably enhances sheep body weight by about 30% in comparison to the control ration. The feed conversion ratio (either as dry matter/kg or TDN/kg gain) was significantly superior with the diet enclosing 50% untreated sugar beet pulp than in the control diet. According to research by **Mostafa *et al.* (2003),** lambs fed a diet of dried sugar beet pulp gained more weight than those who received the standard control diets. The authors noted that the sugar beet pulp-fed groups saw larger average body weight gains and that the lambs' finishing-stage growth rates for the control, 50%, and 100% dry sugar beet pulp diets were 189.4, 226.5, and 216.2 g/head/day, respectively. The same author concluded that diets containing 1:1 corn and dried sugar beet pulp produced better growth rates than those containing only corn or dried sugar. The latter authors concluded that replacing dietary corn as an energy source partially (50%) or entirely (100%) with dried sugar beet pulp had a significant improved effect on lambs' daily progress rates. According to **EL-Badaw & EL-Kady (2006),** the addition of ureated dry sugar beet pulp boosted average daily gain by over 30%, and, as a result, feed conversion ratio (kg DM or TDN per kg gain) was much superior for the group fed 50%. The authors came to the conclusion that it is acceptable to propose using 3% ureated sugar beet pulp in diets for developing sheep in place of a 50% concentrate feed combination. According to **Bauer *et al.* (2007),** wet beet pulp has been employed as roughage feed and has a higher calorie value than corn silage. In background diets, it can make up to 40% of the diet as dry matter, but at inclusion levels higher than 20% of the diet, dry matter intake will be decreased. **Gad *et al.*** (2008) examined the effects of various sugar beet pulp concentrations on body weight in Friesian calves. The author discovered a substantial increase in average daily body gain as a result of substituting 20% sugar beet pulp for the concentrate feed combination. **Mousa (2011)** investigated the effects of feeding fodder beet roots to dairy goats and ewes at rates of 35, 50, and 65% of a concentrate feed mixture and found that the ration containing 65% had the highest feeding value and had the most replacement without having any negative impacts. Additionally, due to the enhanced rate of starch digestion with the fiber component of sugar beet pulp, the apparent digestibility of dry matter increased in the diet of Ossimi sheep (**Omer *et al.*, 2012).** In the **Omer *et al.* (2013)** study, replacing concentrate feed for the diets of developing sheep with sugar beet pulp coupled with 10% soybean meal showed no adverse impact on the animals' performance. Additionally, the later authors discovered that using sugar beet pulp to create economical sheep rations might reduce the cost of feeding the sheep and that each ensiling technique should follow appropriate silage-making principles. Beet pulp can be used successfully as addition for milking or pregnant cows, as a part of background foods, or as constitute for roughage in finishing rations, according to the findings of **Lardy and Schafer (2013).** According to **Hamed *et al.* (2013)**, adding dried sugar beetroot pulp to Ossimi lambs' diet at a rate of 90% had no discernible impact on final body weight, total body weight increase, or average daily gain, but it dramatically enhanced feed conversion ratio (kg intake of DM, TDN, and digestible crude protein/kg gain). According to the same authors, lambs fed the concentrate feed combination made primarily of grains had considerably lower daily feed consumption expressed as a percentage of body weight, TDN intake, or digestible crude protein intake. The later authors came to the conclusion that substituting dried sugar beet pulp for concentrate feed combination resulted in a reduction in total daily feeding costs of 45.03% when compared to the control diet. In the meantime, daily profit over feeding costs increased by 18.4% and feed cost Egyptian Pound/kg gain was improved by 38.07% compared to control ration. In order to determine how beet pulp replaced for barley grain during the pre-partum phase affected Holstein cows' intake of dry matter, **Shahmoradi *et al.* (2015)** indicated that dry matter intake and calorie intake were higher considerably in cows given the beet pulp diet during the postpartum period compared to cows fed the barley grain diet, with the maximum amount for the 25% and lowest amount for the 50%. The authors came to the conclusion that while using beet pulp instead of barley grain increased dry matter intake, but net energy balance was not significantly impacted**. Mahmoud & El-Bordeny (2016)** looked at the impact of replacing the dried sugar beet pulp for yellow corn in Barki lambs' diets, either partially or completely. The kg DM/kg gain was not substantially different among the experimental diets; however, TDN and digestible crude protein per kg gain were significantly greater for the animals fed solely maize, as shown by the average daily gain, which suggested that 75 and 100% tended to have comparable values to control and feed conversion. The authors came to the conclusion that yellow maize may be replaced with dried sugar beet pulp as a partial or whole replacement with no negative effects on the performance of growing Barki lambs. **Maktabi *et al.* (2016)** investigated the effects of substituting alfalfa hay or beet pulp for grain barley on intake and growth in male Holstein calves before and after weaning. The researchers discovered that the post-weaning phase or increasing the amount of beet pulp in the meal had no effect on growth or feed intake. **Abo-Zeid *et al.* (2017)** reported that increasing the amount of sugar beet pulp caused a quadratic rise in the average daily gain and a linear propensity for a substantial increase in dietary dry matter consumption. The feed conversion ratio drastically dropped as sugar beet pulp levels rose. **Abo-Zeid *et al.* (2017)** added that increasing the dietary sugar beet pulp level considerably increased the daily intake of organic matter, NDF, and ADF while dramatically decreasing the daily intake and digestibility of EE. The authors discovered that feeding costs based on body weight gain were linearly decreased greatly by 25%, leading to a much higher total profit ($/head/d). The collected findings show that adding up to 667 g of sugar beetroot pulp per kg of food in place of maize grains produced the maximum profit of 21%, improved nutrient digestibility and average daily growth, and decreased feed conversation ratio. Therefore, without affecting the health or performance of the animals, this study may be economically practical for use in fattening diets for growing Egyptian buffalo calves. The cost of feed was greatly reduced when maize was replaced with sugar beet pulp, going from 0.35 to 0.29 $/kg DM and from 2.92 to 2.52 $/head/day, respectively. According to **Abo-Zeid *et al.* (2017),** sugar beet pulp, which was the only source of energy employed in this investigation, may successfully improve nutrient digestibility and cause significant changes in ruminal fermentation to boost daily gain and reduce feed conversion without endangering animal health. Additionally, **Munnich *et al.* (2017)** discovered that adding sugar beet pulp to sheep diets at a rate of 200 g/kg DM had a favorable impact on ruminal pH. In their 2018 study, Dennis ***et al.*** examined the growth performance of young male Holstein calves (59 days old) fed diets containing 0, 15, or 30% beet pulp. They discovered that as the amount of beetroot pulp in the diet increased, the average daily gain of the calves reduced linearly considerably from 1.09 to 1.04 kg/day. **Aziz (2020)** investigated the impacts of replacing dried sugar beet pulp for 40% of the yellow corn in the concentrate feed mixture on the consumption of feed and lamb performance in Barki ewes. The results showed that compared to the untreated group, the concentrate feed mixture with sugar beet pulp treated with some microorganisms had significantly higher feed intake and water utilization and the opposite effect on lamb performance, which increased body weight, average daily gain, feed efficiency, and economic efficiency comparing to concentrate feed mixture contained untreated dried sugar beet pulp. **Kargar *et al.* (2021)** found that average daily gain, feed efficiency, ultimate weight, and skeletal development did not alter much, according to the authors. The outcomes also showed that switching from steam-flaked corn to shredded sugar beet pulp considerably boosted and lowered consumption of NDF and starch from particles retained on all sieve fractions, respectively. In the first two months of lactation, **Benbati *et al.* (2022)** evaluated the impact of feeding nursing ewe's beet pulp silage on weight fluctuations and lamb development. The findings demonstrated that the weight of the ewes at 10, 30, and 60 days of lactation was unaffected by the addition of beet pulp silage. However, there was a considerable impact on the lambs' weight at 10 days and an average daily increase from 0 to 10 day. The diet had no effect on the lambs' weight at 30 and 60 days or on their average daily gains of 10 to 30, 30 to 60, or 0 to 60. The findings demonstrated that the addition of beet pulp silage reduced feed expenditures, which are expected to have decreased by 17.5%.

Impact of sugar beet pulp on milk yield and composition:

El-Ashry *et al.* (2000) found that while the 4% fat-corrected milk yield (kg/d) tended to increase, the mean daily milk output tended to decrease when the amount of dry sugar beet pulp in buffalo meals increase. When buffalo were fed dry sugar beet pulp, their total milk solids increased; however, this was due to higher fat and protein percentages rather than solids, which only slightly increased with dry sugar beet pulp diets. **El-Badawi *et al.* (2001)** found that cows given concentrate feed mixtures containing 25 and 40% dry sugar beet pulp had significantly greater daily milk production and milk fat content than cows given the control diet. The latter authors stated that the average daily output of 4% fat-corrected milk increased on average by 7.15 and 11.90%, while the feed cost per ton reduced on average by 13.4 and 16.9%, respectively. **El-Fouly *et al.* (2004)** discovered that ewes given concentrate mixtures containing 27 and 54% dry sugar beet pulp had noticeably greater daily milk production and milk fat content than those given the control ration. Compared to the control, dairy goats and ewes given beet roots produced around 12.09 and 24.38% more milk, respectively. **Mahjoubi *et al.* (2009)** investigated the impact of increasing beet pulp at the expense of barley grain on the milk production and composition of late lactation Holstein cows. The findings confirmed that substituting barley grain with beet pulp did not influence the yield of milk protein and lactose, but that doing so raised milk fat content and milk energy output. The authors came to the conclusion that adding more beet pulp to the diet enhanced milk energy output while also boosting milk fat levels when barley grain was replaced with beet pulp. According to **Mousa (2011),** feeding fodder beet roots in place of up to 50% of the concentrate feed combination in the diets of dairy goats and ewes increased milk yield, growth performance, and economic efficiency, declined feed costs, and may help address the issue of a feed shortage in North Sinai. Effect of replacing beet pulp as dry mater basis replaced for barley grain to varying degrees (0, 25, and 50%) during the pre-partum phase on milk output of multiparous Holstein cows was studied by **Shahmoradi *et al.* (2015).** The findings indicated that milk output was considerably lower for the 50% beet pulp diet than for the 0% and 25% treatments. The authors came to the conclusion that the milk production of multiparous Holstein cows was negatively impacted by the 50% substitution of barley grain with beet pulp. **Mohsen *et al.* (2021)** examined the effects of substituted dry sugar beet pulp at 25 and 50 percent yellow maize grain on the characteristics of multiparous lactating Holstein cows during their peak lactation stage. The researchers discovered that dry sugar beet pulp groups outperformed yellow corn grain substantially in terms of milk output and yield of 4% fat-corrected milk. For feeding diets including dried sugar beet pulp, the amounts of milk's fat, protein, solids-not-fat, and total solids greatly increased. Dry sugar beet pulp decreased the cost of feeding while increasing milk production. The authors came to the conclusion that addition of dry sugar beet pulp to the diets of dairy cows resulted in substantial changes in milk output, milk composition, feed usage, and milk yield. Adding extra dry sugar beet pulp to the diet also increased milk output and growth and reduced feed costs. Therefore, it is advised to substitute dry sugar beet pulp for other feed ingredients to feed dairy Holstein cows inexpensive feed without having to sacrifice their health or output. In conclusion, Holstein dairy cows' productivity significantly increased after receiving dry sugar beet pulp in their diets. **El-Badawi *et al.* (2001)** observed that calves given concentrate mixes containing 25 and 40% dry sugar beetroot pulp, respectively, had increases in average daily yields of 4% FCM of 7.15% and 11.90%. In the diets of multiparous lactating Sugar beetroot pulp may have an impact on particle size, palatability, nutritional digestibility, and nitrogen utilization efficiency since it has been shown to boost feed intake and milk protein output in dairy cows **(Kahyani *et al.*, 2019).** Holstein cows, partial substitution of yellow corn grains with dry sugar beetroot pulp (25% and 50%) resulted in notable enhancements in the areas of digestion, rumen activity, plasma biochemical parameters, milk production, milk composition, feed utilization, and milk yield. Moreover, when the amount of dry sugar beetroot pulp in the diet increased, the improvement in milk output and the decrease in feed costs improved (**Mohsen *et al.*, 2021**). When comparing dried sugar beetroot pulp (25% and 50%) to yellow corn grains, milk output rose by 1.55 and 3.05 kg/day, or 5.06 and 9.95% and 4% FCM yield increased by 5.70 and 10.98 kg/day, or by 19.73 and 38.27% when substituting yellow corn grains with dry sugar beetroot pulp by 25 and 50%, respectively. In high-production dairy cows, **Wang *et al.* (2021)** examine the inclusion effects of rice straw combination silage and sugar beetroot pulp with inoculation in place of whole-plant corn silage. According to the scientists, the amount of sugar beetroot pulp and rice straw mixed silage that was produced after inoculation improved milk output in a linear fashion. The synthesis of milk protein increased linearly as a result of the rising, causing a drop in the concentrations of milk urea nitrogen and ammonia nitrogen. The authors came to the conclusion that feeding high-production dairy cows diets consisting of rice straw mixture silage with up to 45% inoculation instead of whole-plant corn silage improved their performance in terms of production, suggesting that this technique might be a suitable use for rice and sugar beetroot pulp.

Some principal considerations prior to introducing to the animals

The following factors should be taken into consideration while feeding sugar beets in animal nutrition, agreeing to the Ministry of Agriculture and Food (2008) are:

1. Whole beets can be difficult to store due to their high levels of moisture (about 80%) and relatively high sugar content.
2. Processed sugar beets can be ensiled with a dry material to reach an ultimate humidity content of 35–40 %, and the mound must be compacted and covered to keep oxygen out.
3. To reduce the risk of environmental pollution and unpleasant odours, temporary storage pile locations should be carefully studied. Keep an eye out for possible runoff and take steps to stop it from entering outward liquid forms.
4. To reduce the risk of environmental pollution and unpleasant odors, temporary storage pile locations should be carefully studied. Keep an eye out for possible runoff and take steps to stop it from entering surface water bodies, including streams, ditches, and ponds.
5. It has been demonstrated that an efficient ensiling combination consists of four or five processed sugar beets per straw.
6. Beet sugar is a great source of fermentable carbohydrates, which are essential for fermentation success.
7. Whole beets can be managed in a number of ways, such as by being driven over, being placed through an industrial wood chipper, being fed through a forage harvester, being ground in a tub, being stirred for a long time in a total mixed ration mixer, etc.
8. For beef cows, the recommended inclusion rates for foods are present up to 50% of the dry matter intake and up to 20% for growing or back grounding animals.

CONCLUSION

Sugar beets are used to produce sugar and result in sugar beet pulp by-products, which can be used as feed for livestock, either as dried flakes or as compressed pellets. Fresh sugar beet pulp is dried using pulp dryer until it possesses approximately 10% moisture, and then it is pelleted to facilitate storage and transportation. Dry sugar beet pulp could be used as a partial replacement of grains in the rations of dairy cows. The inclusion of dry sugar beet pulp led to significant improvements in feed intake, nutrient digestion, rumen fermentation, plasma biochemical parameters, milk yield and composition, feed conversion, and economic efficiency and increased with increasing dry sugar beet pulp in the ration.

HIGHLIGHTS

1. The processing of sugar beet roots results in the production of two more valuable feeds: sugar beet pulp and molasses.
2. These products may be used separately or combined, and they may be dried or otherwise processed in a variety of ways to produce a range of high-quality animal feeds.
3. In Egypt, there is a serious shortage of dietary energy ingredients needed for ruminant feeding. The animal

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nutrition system depends mainly on the imported grains. However, increasing quantities of sugar beet pulp are now available as a byproduct of the sugar beet industry.
4. Sugar beet pulp is a highly digestible fiber source. It is sold in both wet and dry forms. The dry product contains approximately 10% moisture and has high energy in a palatable form in rumen fermentable.
5. Similar in energy levels to barley but low in protein. Contains highly digestible fiber, which is suited to ruminants as it maintains rumen condition and encourages acetate production.
6. It has a high liquid absorbency and can, therefore, be used as a silage additive to retain the feed value from effluent.
7. Sugar beet pulp can be used as a source of supplemental energy in beef cow diets or as an ingredient in back-grounding and finishing rations.

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