POTENTIAL OF SUGARBEET AS ALTERNATIVE ENERGY SOURCE FOR CATTLE IN INDIA

Abstract

With the advent of increased milk production and scarcity of energy rich feed and fodder mainly during lean period is one of the major constraints for sustainable dairy development in India. Beneficial and nutritional value of sugar beet in one side and the rising competitiveness of feed grains with human consumption, other side created a massive scope for sugar beet feeding worldwide. Sugar beet (Beta vulgaris L.) is a promising high yielding summer crop that can be grown well in the tropical and subtropical parts of India. It has several advantages over traditional fodder crops that it can tolerate the soil salinity up to 5 eCE, rich in stored carbohydrate in the form of sugar, all of its part contribute in animal feeding, can be conserved for longer period by making silage. Earlier, inspite of enriched quality, its higher sugar content than starch made it a burning topic of concern and least popular and acceptable among farmers due to the possibility of decrease in ruminal pH, hindrance in fiber digestibility and interference in microbial population but if little analytical value of sugar when rejected found to partially replace the feed grains and could support the production. Therefore, cultivation of sugarbeet with full package of practice and better utilization of its byproduct as cattle feed may help in overcoming the problem of shortage of feed and green fodder in summer season and could be a potential alternative energy source feed for cattle in India.

Keywords: Sugarbeet, digestibility, dairy cattle, milk yield, byproduct

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I. INTRODUCTION

Sugarbeet (Beta vulgaris L.) is a very old age crop originated in nineteen century from feral and fodder beets introduced to India along with other two crops like soybean and sunflower. These two crops suited well to our agroclimatic condition and been cultivated successfully throughout the country but sugarbeet as crop is still untapped. Although sugarbeet is generally a temperate region crop but can be well adapted to tropic and subtropic region of country. The crop is mainly produced in Europe and to a very lesser extent in Asia and North America. In India most of land are uncultivable and underutilized due to its high saline content (6.7 million hectare) but this crop being tolerant to saline condition can be utilized at its maximal in these land. Sugarbeet accounts for 16-20% of cultivable area of the world whereas production accounts for only 11-13% of the world. Till date the crop is chiefly exploited for sugar production. Near about 20% of sugar are obtained from sugarbeet other than sugar cane. But in addition to sugar it also provides valuable livestock feed and fodder like green beret tops and beet molasses. Indeed the residue or the pulp left after extraction of sugar can also be efficiently used as cattle feed. The molasses obtained after sugar purification also have potential benefit which could be further used in cattle feed or in pharmaceutical industry.

India is scarce in livestock feed and fodder with 61.1%, 21.9 % and 64% deficit in green, dry and concentrate respectively [25]. Only 5% of total cultivable land in country is being cultivated for fodder including both perinneal and annual. The search for alternative feed which is novel, high quality and cheap sources of protein and energy for ruminant feeding has been a principal endeavor of developing countries. Optimum usage of crop residues [45] is required for dairy sector. The fodder alternatives will not only decrease the feed cost but also solve economic and ecological problem of waste disposal [97]. Sugar beet has also been successfully grown as a fodder crop and used as a valuable source of green fodder in developed countries [68]. There is production of 272 million tonnes of sugar beet worldwide where 54.4 million tonnes of sugar beet comes from Russian federation alone which produces about 1.5 lakh tons of sugar beet pulp and 0.45 lakh tons utilized in production of dry molassed beet pulp [72], annually as a source of animal feed which reported to contain 12.5 MJ (2.986 Mcal) metabolisable energy and 79 g digestible crude protein per kilogram of dry matter (DM; Kelly [49]. Freshly harvested sugarbeet root contains water 70-75%, sugar 15-20%, non sugar 2.6% and pulp 4-6%. Processing of one ton of fresh sugarbeet roots yields 121 kg sugar, 38 kg molasses and 50 kg pulp. Due to its high energy content, its capacity to provide both cash from harvested root and livestock feed in form of above ground biomass (top) and root processing byproducts the fodder crop could offer a valuable alternative or supplementary high energy fodder crop in tropical countries like India. Apart from this the product is enriched in neutral detergent soluble fiber (NDF), mostly the pectins that help to buffer against acidosis thus optimise rumen fermentation, as well as support milk fat production. Hence sugarbeet could be an important sugar and fodder crop in India for supplementing sugarcane. Sugarbeet is a man made crop obtained by human selection from fodder beet for higher sugar content that made it more appropriate for cattle feeding. Thus the supplementation could be a boon to cattle feed during scarcity period of year when grass fodder is readily not available, may be used to replace grains as an energy source in the diet of dairy cows.

The concept of feeding sugar beets for livestock in our country needs patience, it will be accepted only when the beneficial effects of sugarbeet and its byproducts are focused and highlighted. The left-overpulp after sugar extraction from beet is rich in nutrients for use as animal feed. The unique property of high digestibility and degradability of sugar beet than the roughages (cellulose and hemicellulose) [75] are due to the presence of small particle size, fermentable NDF rich in pectin and high functional specific gravity [9].The above-mentioned properties make the beat pulp a good source of non-fiber carbohydrates which could replace a part of grain and tends to maintain the normal rumen pH as they regulate the fermentation rate and pattern towards more of acetate production as compared to starch in rumen [35]. Owing to its bulkiness and palatability they can be used in wet/dry/pelleted forms and depending on chemical composition, nature and physical characteristics of ration they could be used as an alternative for various feed sources. Various studies conducted abroad on sugarbeet, sugarbeet pulp and molasses feeding in dairy animals have indicated that feeding of whole sugarbeet or its by-products offers a great potential to be used as livestock feed in developing countries including India. Thus considering the important aspects of the sugarbeet as feed the demand supply gap of both green fodder and feed can be abridged by judicious use of sugarbeet and its byproduct for livestock feed and may prove to be an economically viable option for dairy farmers and industry.

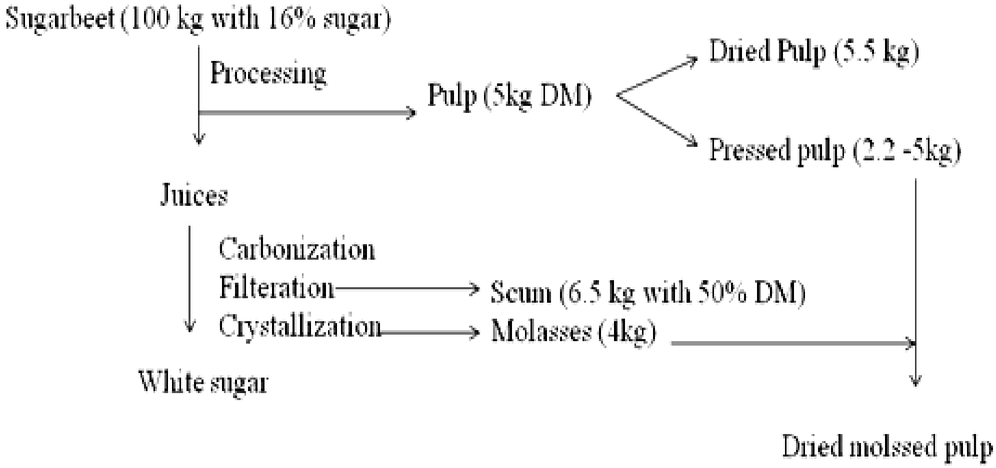
II. SUGAR BEET POTENTIAL, IMPORTANT CHARACTERISTICS AND UTILITY IN VARIOUS ASPECTS

In India fodder beet has potential to produce fodder (125 million tonne/ha) of excellent quality for the dairy animals during fodder scarcity period of summer months (March to June) in a short duration of 4 months. The average and dry matter yield/ha of sugar beet (62.5 MT/ha) surpasses that of corn (9.64 MT/ha) and other grains usually used in farm animals feed [28]. The deep penetration of root makes it tolerant for both drought and salinity as they resist changes in osmotic pressure [48], depth of root also make this crop high water efficient as 28-30 kg green biomass can be obtained by cubic meter utilization of water. Roots being the edible part and less prone to environmental changes possess several advantages over the other energy grains used for feeding cattle. The crops of sugar beet can be grown to a wide range of soil with a pH of 6.0–8.0 [58]. However for higher production loamy soils are best but being halophyte can also be grown successfully in salt affected soils too.

Like other fodder crops sugar beet can also be utilized as a fodder crop to feed producing animals in different forms. In normal climatic conditions sugar beet can be stored for a period of about 6 months as such without considerable loss in sugar content. Sugar beet can be stored in form of silage either alone or ensiled with other crops like barley, alfalfa, dry rolled corn grain, wheat straw, wheat middlings. Silage could be prepared either of whole crop beets, or beet tops or only of beet. The silage prepared by mixing chopped sugar beet and barley straw result in formation of product very similar to whole-crop barley silage [5]. Various trial on different parts (leaf lamina, leaf petiole and root) of sugar beet proved that contents of CP, ADF, NDF and ash content were higher in leaf lamina. The root were superior in DM, in vitro dry matter digestibility (IVDMD) and sucrose content. Whereas de-sugared cossettes can provide a good alternate fodder being low in nitrate-N and high in IVDMD [34].

III. PROCESSING OF SUGAR BEET

After extraction of sugar from sugarbeet the beet pulp is left which is a valuable feed material for livestock. The pulp can be used as such, with a DM content of 10-12% or processed further to 20- 25% or dried to 88-90% DM. About 5 kg beet pulp DM is obtained per 100 kg sugar beets (Figure 1). The extracted juice is then purified and crystallized to obtain sugar leaving behind scums and molasses. Scums are used as soil fertilizer while molasses are used in animal nutrition either as such or after mixing with pulp before drying [10].



Adapted from [85]

IV. NUTRITIONAL VALUE OF SUGAR BEET AND ITS BYPRODUCT

Sugar beet pulp, sugar industry-based byproduct mainly contains pectins, a heterogeneous molecule consisting of homogalacturonan and rhamnogalacturonan I. The side chains of rhamnogalacturonan I contains α-1,5-linked arabinan along with some α-1,4-linked galactan [81]. The byproducts of the sugar beet crop, such as pulp and molasses adds another 10% to the value of the harvest. Sugar beets are also called as “feed beets” when used for feeding the animals and differ with the fodder beets. In many parts of country sugar beet is in feeding practice to ruminants as a source of energy with no anti nutritional factor. Sugar beet is very similar to fodder beet in nutritional content with minute difference in DM and sugar content. The nutrient composition of fodder beets and sugar beets are compared in Table 1.

Sugar beets generally contains more calcium but lower phosphorus on dry matter basis as compared to other grains such as barley or corn [28]. After processing the sugar beet residue yield variety of byproducts like beet pulp, molasses and dried molasses etc. which may be extensively used in feeding of animals. The nutrient composition of different sugar beet byproducts in mentioned in table 2.

Table 1: Nutrient Composition of Beet Roots (g/kg dry matter)

	Beet root	
Nutrient	**Fodder**	**Sugar**
Dry Matter (DM), g/kg	169	236
Crude protein (CP)	71	61
Neutral detergent fiber (NDF)	124	125
Acid detergent fiber (ADF)	59	61
Ether extract	4	9
Ash	53	44
Calcium (Ca)	11	2.5
Phosphorus (P)	3.7	2.3
Potassium	30	15.2
Sodium	4.1	2.5
Magnesium	1.8	2
Starch	1	-
Sugar	725	760
ME, ruminants, MJ/kg dry matter	11.6	11.9
N digestibility ruminants, g/100 N	61.3	56.7

Adapted from [29].

Beet pulp is the fibrous residue of sugar beet after sugar extraction which is rich in NDF (approximately 40%). The pulp is insoluble in water, mainly composed of cellulose, hemicellulose, lignin, and pectin, is used in animal feed. This pectin (250 gm/kg DM) rich NDF possess the ability to participate in cation exchange capacity which maintains pH stable for rumen environment. Further, lower lignin content in beet pulp NDF [69] may increase their overall digestibility than other similar feed/fodder. [33] observed beet pulp NDF digestibility as 76 g/100 g NDF with an overall DM digestibility of 90 g/100 g. Beet pulp further processed and can be fortified to form pellets, evaluated to be an important energy source [102].

Sugar beet molasses is a byproduct brown colored thick liquid obtained after sugar extraction and crystallization [58]. Molasses due to presence of fermentable sugar residue which ranges from approximately 48 to 53% is highly energetic feedstuffs for both types of molasses (Sugar cane and sugar beet). Moreover, they are enriched with various minerals with higher bioavailability. In economic preview because of lower cost of final product; they are considered as potential and popular substitute for cereals for feed formulations of many livestock feed [63]. Sugar beet molasses have many similarities with cane molasses such as energetic value, density and acidic pH (5-5.8) [58,104], but they possess some differences in terms of type of sugar conformation, nitrogenous portion and mineral composition. For example, the sucrose content of beet molasses is 60.9% as compared to 48.8% in sugarcane molasses on DM basis [43]. The amount of non-fermentable reducing sugars is approximately 0.5 to 1.5% in beet molasses. It also reported to contain higher Nitrogen (8.7%) than cane molasses (3.7%). The main component of protein in molasses consists of nitrates, free amino acids (chiefly, glutamic acid, aspartic acid, leucine, tyrosine, arginine and histidine) and bases of nitrogen such as betaine, guanine, and xanthine [103]. It has been determined that the sugar beet molasses is poor source of fat-soluble vitamins [77]. In respect of water-soluble vitamin, sugar beet reported to contain lower concentration of thiamine and pantothenic acid as compared to sugar cane molasses. As regards to the mineral fraction present in the beet molasses it constitutes 8–9% with higher content of sodium and potassium ions and lower proportion of calcium and phosphorus ions.

Table 2: Nutrient Composition of Various Sugar Beet by Products.

Feedstuff	DM	CP	TDN	NEm	NEg	ADF	Ca	P
Sugar beet tops	17	15.1	58	0.59	0.27	14	1.01	0.22
Sugar beet top silage	21	11.9-12.7	51-53	0.45-0.55	0.2	18	1.56	0.2
Sugar beet Tailings	18.4	8.9	65	0.67	0.4	34	2.35	0.27
Sugar beet Tailings silage	20	10	65	0.66	0.4	NG	2.5	0.2
Sugar beet Pulp, Dried	90	9.1	72	0.77	0.49	31	0.72	0.2
Sugar beet Pulp, Wet	25	9.1	72	0.77	0.49	31	0.72	0.2
Sugar beets (Whole)	20	6.8	81	0.9	0.6	NG	0.24	0.24
Sugar beet Molasses	77	10	75	0.77	0.5	0	0.12	0.03
Concentrated Separator Byproduct	66	20	67	0.75	0.42	0	0.05	0.03

Abbreviations: TDN = Total Digestible Nutrients; NEm = Net Energy for Maintenance; NEg = Net Energy for Gain; NG=Not Given. Adapted from Greg Lardy, Review on "Feeding Sugar Beet Products feeding to cattle".

V. SCOPE OF SUGAR BEET AND ITS BYPRODUCT AS CATTLE FEED

1. **Whole Sugarbeet:** Sugarbeet is nutritious, palatable and energy (75-81% TDN) rich cattle feed but deficient in Ca, P and protein (6.8%) with high moisture content (80%). It is primarily used as a green fodder for ruminants and pigs [109] and can be fed successfully to cattle. Sugarbeet is higher in energy than most concentrate feeds and could be treated as a "wet concentrate". Beet can be fed either as such after chopping or it can be spread on the fodder fields and make the cattle to graze on these fields. They could also be chopped and ensiled for making silage since they are rich in sugar and may be used for feeding animals and longer period storage. But prior to making silage they must be properly wilted to bring the moisture content between 60-65%. Grains hull, husks, various straws and some agricultural byproducts may be used as solid substrate for successful ensiling as they reduce the moisture content of beet.

   It is reported that sugarbeet supplementation resulted in better nutrient utilization. it causes increased DM and ME intake. It has recommendation that the ration of the cattle must contain a minimum of 50% dry matter to maintain a healthier dry matter intake (DMI) [69]. Feeding of sugar beet silage alone may not be beneficial for lactating animals because of higher moisture which tends to decrease the DMI.

   Sugar beet supplementation has positive effect on milk production due to higher hydrolysable sugar content which favours the production of propionic acid. Replacement of 50% hybrid Napier fodder with sugar beet tubers can be done without any adverse effect on animal production performance and milk composition [99, 86]. Further, in line of this [6] demonstrated that feeding of mixed silage of sugar beet (100 g/kg DM) and maize top (180 g/kg DM) tends to enhance milk yield, along with higher milk fat and protein as compared to the other groups of animals fed with either sugar beet top or maize top silage alone. Moreover, an increase in milk production was recorded after supplementing maize green fodder (15.8 kg), with sugar beet pulp and top (17.5 kg) than with forage alone however, this increase was found to be less than with that of corn (19.1 kg) or concentrate (19.6 kg) [80].Thus it is clear that to get optimum production mixed silage must be fed than the corn silage alone.

On the other hand, [26] found unaltered milk yield when concentrate mixture consisting of 80:20 mix of sugar beets and barley on DM basis fed to dairy cow when compared to the concentrate mixture containing 80:20 mix of raw potatoes pulp with barley. However, the DMI was improved when beet mixed with barley i.e.,390 g/kg as compared to beet mixed with raw potatoes (280 g/kg). It was also observed that sugar beet fodder has got limitation for enhancing milk production after sole supplementation but the same will capable of augmenting the milk production when they are supplemented with some high protein as an additive [30]. This observation was supported by the fact that beet root fodder contains about 13% CP which leads to low production when fed alone.

Moreover, it has been attributed that sugar beet fodder exerts synbiotic effect on fibre digesting microbes and thus enhancing rumen fiber digestion. Approximately double fold increase in ruminal protein synthesis was recorded after replacing normal fodder-based silage with both the sugar beet fodder and pulp. Incorporation of beets in diet also helps in increasing total purine derivatives, indicating enhanced microbial output. Inspite of these effects' inclusion of beet in the diet of ruminants has been found to increase the ruminal methane production consequently reducing the energy efficiency [67]. This increase in methane production could be attributed to the fact that beet pulp fodder tends to increase acetate and lowers propionate: acetate ratio in the rumen.

Further, feeding beet root have disadvantage in winter as it may reduce animal welfare by causing a chemical imbalance leading to hypophosphatemia, hypocalcemia, hypomagnesemia, ketosis, and hepatic lipidosis, in addition to ruminal acidosis. There should be proper balance between the addition of beet top with other feed sources to maintain the balance of rumen and cater the benefits of sugar beet and benefiting the animals [38].

2. **Sugar Beet pulp (SBP):** Sugar beet pulp is the major industrial byproduct of sugarbeet processing unit for sugar. Beet pulp is relatively low in protein (8 percent) but relatively high in TDN (72 percent). The dry matter content of the dried pulp found to be in the range of 84 to 95% if it is stored properly in suitable dry place. The high DMI and better digestibility of SBP fiber may be due to the presence of ample quantity of water soluble carbohydrate or non-fibrous carbohydrate (NFC) [49]. It is reported to be included in animal feed but higher rate could also impair feed intake to comprise the production of animal. Various feed trials are performed at different age group of dairy and beef animals. It was observed that after feeding young beef bulls with pelleted dried sugar beet pulp at an increasing rate (50, 60 or 70%) and decreasing concentrate level 50, 40 or 30% respectively resulted in improved feed efficiency and mean growth rate [11] with slight depression in digestibility which may be due to laxative effect of beet pulp. The digestibility coefficient of CP, organic matter (OM) and crude fiber (CF) in SBP reported to be 59%, 87% and 88%, respectively [108]. Nutritive profile especially CP (around

15%) and its digestibility (approximately 55%) of SBP top is comparable to alfalfa fodder owing to which it may be alternatively used for feeding cattle and sheep. It has been observed that the performance of gestating cow and ADG in their growing calf was not affected after substitution of corn with sugar beet pulp in their diets however, the performance and carcass characteristics got reduced when SBP forage was used as maize forage substitute in steers and mature animals' diet [107]. The low performance may be linked with the lesser dry matter present in the SBP forage as compared to maize.

Inclusion of beet pulp on milk production variables were independent of the dietary concentrate level as well as the replacement aim. In dairy cows the ruminal pH increased but only when the level raised to be more than 200 g/kg of diet DM [66]. But there is no limitation or specification upto which the wet beet pulp is to be incorporated in diet of beef cattle. Considering the scientific and practical approach in view SBP may not be added more than 50% of the ration on DM basis to better nutrient digestibility and feed efficiency. Inspite of limitation of high moisture content they are rich in fiber which help them to maintain healthy rumen environment and able to prevent many digestive disorders like acidosis, SARA.

- **Beet pulp for milk production:** Earlier it was assumed that betaine present in the sugar beet pulp reacts with the molasses present in the diet and got converted to trimethylamine oxide that produces fishy taint in the milk after reacting with the unsaturated fatty acid in milk. Later on it was proposed that feeding 4.1 kg beet pulp twice daily after milking may eliminate the taint flavor from milk which was further supported by [14] when it was fed 3.6 kg/day beet pulp.

  Beet pulp (BP) considered to be lipogenic source which is rich in NFC and non-forage fibre [84, 93] improving their digestibility and provide more energy than other forage and produces higher molar acetate than grains. Inconsistency in DMI has been reported as several works some have reported an increase in DMI [19, 70, 81], some have reported a decrease in DMI [57,88]. Metanalysis data revealed positive correlation between DMI with sugar beet pulp addition on efficiency of milk production in dairy animals [66]. Finally, they summarized that beet pulp affected the feed efficiency by affecting the DMI and may be used as a partial replacement for grains in rations of dairy animals.

  SBP like other energy rich feed source high in NFC can support milk yield, with inconsistent result in various studies [53, 90, 100]. Beet pulp when compared with whole beet and silage ration resulted in higher milk yield than both diet while milk fat content was lowest [98]. SBP inclusion in the concentrate mixture diet of high milk yielding cows improved DMI, feed efficiency but does not produce any change in body weight and fat corrected milk (FCM) [7]. No difference in milk yield or FCM was reported after adding different levels of beet pulp alone in the diet or after feeding corn grain with SBP in TMR [88, 19, 100] and barley [55]. On the other hand, an increase in milk yield and FCM was reported after substituting SBP upto 25% for barley grain [81]. However, supplementing beet pulp 50% with 4% fat as tallow resulted in 5.8% increase in FCM [42]. Later on many workers have reported similar findings and inferred that SBP is responsible for an increase in milk fat when replaced with grain [101, 60, 96, 55, 81]. This lipogenic effect of beet pulp feeding was observed only after medium level (101–200 g/kg DM) of beet pulp supplementation/replacement in the diet of lactating animals [66]. The reason for this increase in milk fat is credited to increased ruminal acetate and butyrate production which acts as precursor for de novo milk fat synthesis [2, 47]. The mechanism for SBP effect on milk fat percentage and rumen behavior have been explained in figure no 2.

Studies related to effect of beet pulp effect on the milk protein is still very indefinite, some studies reported an increased [37] some reported decreased [57, 81] while some reported to have no effect [102, 92] on milk protein. The SBP reported to cause minimal effect on nitrogen metabolism and protein synthesis inside the rumen. The effect of decrease in milk protein may be due to shift in fermentation pattern and reduction in propionate production. Moreover, some studies have indicated that SBP could reduce milk lactose [76, 93]. Nevertheless, some studies observed little or no change in milk lactose level after SBP inclusion in the diet [1, 20, 95, 81]. The milk quantity and quality remains unaffected even after addition of fresh sugar beet pulp at the levels of 0, 80, 160 or 240 g/kg on DM basis of the total ration as compared to control group animals feed with corn and barley-based concentrate mixture ration [29].

Effect of beet pulp on milk production is independent of concentrate proportion but upto an extent dependent upon replacement aim. Dietary grains when replaced with SBP upto 50% resulted in enhancement of DMI and energy balance which lowers the risk of animals for metabolic disorders [24, 79, 39] however, when the substitution is increased beyond 50% it results in adverse effect on DMI, milk yield and metabolic status [81, 66]. Type of replacement also judges the production performance. [4] demonstrated that, inclusion of dried sugar beet pulp and dried olive cake upto a level of 70% concentrate feed mixture results in improved nutrients digestibility, nitrogen balance, and microbial protein synthesis. This combination also increases the number of ruminal protozoa and bacteria leading to improvement in performance of sheep.

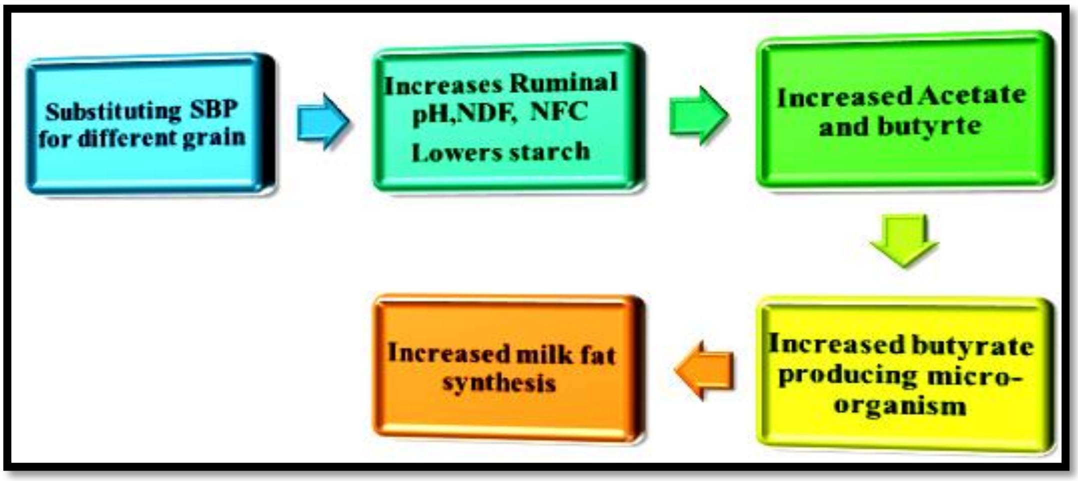


Figure 2: Mechanism for Improvement in Milk Fat Synthesis by Substitution of Barley Grain with SBP

- **Beet pulp for beef production:** Similar to dairy production beet pulp aids in improving quality of beef production. The body weight remains intact in groups of growing and fattening cattle which were fed SBP in replacement for barley as the energy profile remains the same for both. The VFA production and proportion remains the same in fattening steers in which SBP was replaced [8]. Combinational supplementation reported to benefit greater, as when sugar beet combined fed with FOS and garlic residues reported to increase lamb weight gain, encourage growth of beneficial Operational Taxonomic Units (OTUs) in GIT, such as Bifidobacterium, Lactobacillus and Veillonella in the pre weaning period [78] . These may exert prebiotic effect in agreement of previous studies as reviewed by [83] that prebiotics may confer many other beneficial effects in neonatal life of calves. Supplementing urea to dried beet pulp tends to increase weight gains. Level of 0.6 to 1% urea supplementation in dried beet pulp reported to employ the best effect and increase the crude protein to 12.2 -13%. Urea-supplemented beet pulp diet reported to increase daily weight gain by 12% increase and DMI by 8% in Friesian steers [32], as inclusion of 3.0 or 7.8% urea contributed significant increase in dry matter intake and crude fiber digestibility. In other species SBP fed with urea led to improvement in body weight as [50] demonstrated that goats fed with 4% urea treated SBP showed maximum weight gain and improvement in growth and nitrogen utilization in sheep fed with sugar beet pulp treated with Trichoderma reesei and urea [73]. Similarly the SBP fed together with urea could help in augmentation of body weight in beef cattle.

3. **Beet tailings:** Small beets, spoiled/broken beets, soil and other foreign materials which become unsuitable for sugar production are collectively known as beet tailing. The product is variable in nutrient content and has high moisture 75-85%. If the soil contamination or foreign material is nullified the feeding value of tailings is slightly greater than corn silage on DM basis as the foreign material and soil contamination reduce the energy content of beet tailings upto limit. For storage purpose beet tailings can also be ensiled but before ensiling it should be mixed with dry feedstuffs that prevent effluent losses from stored silage. This can be obtained by adding chopped forages, grain screenings and other byproducts feed. There is a huge scope for feeding beet tailings when properly chopped or sliced to prevent choking. Due to its similar nutrient content as sugar beet helps in augmentation of production both in dairy and beef cattle.

4. **Sugar beet molasses:** Beet molasses a thick brown colored viscous fluid obtained after processing of beet for sugar which may be included in animal feed and could be a viable option to improve profitability of dairy industry and farming. Apart from a good source of energy (75% TDN) they can be used in rations to improve palatability of feed, reduce dust, acts as binder for blocks & pellets and carrier for urea or other non-nitrogen protein sources, vitamins and minerals. Molasses could be incorporated in feed upto 15% maximum, however in various studies reported to have negative effect of molasses incorporation in feed if its limit exceeds greater than 10% DM of daily ration (6.75% of diet DM) [21]. Optimum dose of molasses may be added i.e. 1 kg/head/day for beef cattle and 0.5, 1, 1.5 kg/head/day in heifers, dry and lactating cows, respectively [74], to modify ruminal fermentation for improved microbial activity and lowering ruminal ammonia production [13] which leads to reduction in blood and milk urea concentration [12]. Molasses when added to the poor quality forage tends to increase their digestibility and intake as they reported to enhance digestive activity of ruminal microbes [105]. Further

molasses provides a better way for utilization of ruminal nitrogen thus minimizes the wastage of nitrogen through cattle excretion [44, 12].

Dietary sugars in form of beet molasses be likely to increase ruminal butyrate concentrations and could be used as viable substitute for starch obtained from cereal grain [74, 22, 23, 18, 71] Enhanced butyrate production tends to increase milk production as it promotes efficiency of energy utilization, stabilizes rumen pH, fasten absorption of all VFAs in the rumen thereby increasing the overall nutrient utilization efficiency [56]. Moreover, this elevated butyrate level also promote the growth of Butyrivibrio fibrisolvens leading to increase in milk fat synthesis [87].In dairy animals' inclusion of molasses in diet helps to abridge the negative energy balance during transitional and heat stress condition and aids to prevent many metabolic and reproductive disorders.

The sugar beet molasses likely to increase the average daily gain and feed conversion rate in growing steers as molasses tends to increase DMI and digestibility of feed [64] with no remarkable change in carcass quality [3, 65]. It is demonstrated that sugar beet molasses aids in palatability and act as a binding agent for making sugar beet molasses urea blocks (SBMUB) causing slow release of urea in the rumen [63]. Licking these blocks may fulfill the nutrient requirement, and tends to improve feed efficiency by enhancing fiber utilization and stabilizing rumen pH in both dairy and beef cattle.

5. **Dried Molasses Beet pulp (DMBP):** DMBP is obtained by adding molasses (18-22% of DM) to beet pulp rich in energy (12.5 MJ) and moderate in protein (7.9% DCP) may be used as valuable ruminant feed. The protein fraction of beet pulp represents true protein as the associated amides got removed during the sugar extraction process. DMBP substitution for cereals improves roughage digestibility and contains the occurrence acidosis, while they are deficient in phosphorus [16, 40]. DMBP feeding was beneficial as they increase milk fat content along with decrease in plasma urea nitrogen (PUN) and mean ruminal ammonia concentration in rumen [62] .

DMBP reported to increase water consumption by 18% without conferring any adverse effects on health of animals which eliminates practice of soaking DMBP prior to feeding as long as fresh water is easily available [15]. It was also concluded that DMBP could be replaced for barley at low (11% DM) and moderate (22% DM) level in dairy cow fed with silage [17] which shift the fermentation pattern towards higher production of acetate and butyrate at the same time decreasing propionate along with total volatile fatty acids (VFA) in the rumen. Feeding DMBP to cows reported to increase milk production by about 10% and improves its quality in terms of fat content in mid of their lactation [59] which may be attributed to higher content and digestibility of CF, NDF, ADF, cellulose, and hemicellulose in DSBP [102]. It was recorded that the ruminal pH, ruminal NH_3-N lower after replacing 25% and 50 % corn by DSBP in the ration of cow, although the ruminal TVFAs level found to be increased [61]. Moreover, they also demonstrated that the plasma total protein and globulin along with milk quality in terms of fat, protein, SNF, and TS improves after replacing corn with DSBP. They concluded that the overall economic efficiency of dairy rearing improved considerably.

In contrast various studies reported that inclusion of DMBP does not exert any positive effect on milk yield [47, 57, 88, 19]. They explained that lower starch content of sugar beet (2.1%) as compared corn grain (36%) could be the reason for no response of DMBP for milk production. Additionally, the fibrous components are low in lignin but high in pectin causing their high rate of degradation inside rumen.

To further enhance the nutritive value and mineral content of DMBP it can be fortified with phosphorous and magnesium to form triple nuts and magnesium nuts respectively.

6. **Fortified beet pulp products:** Two commercial fortified beet pulps available in the market : Magnesium nuts and triple nuts.

   - **Magnesium nuts:** Addition of 1.5% magnesium in the form of calcined magnesite (MgO) to the DMBP to produce this commercial fortified product that may be used extensively in animal feeding. They are fed at rate of 1.8 kg/day to cattle which could be a potent source of Mg and at the same time may provide all the benefits of DMBP.

   - **Triple nuts:** As the names suggest they contains three component urea, high phosphorus (P) mineral and vitamin added to DMBP. P is added in the form of 4% dicalcium PO4 to which other minerals and vitamins may be added in DMBP to form triple nuts as per need and recommendation for animals. DMBP considered as ideal binding material for urea because of richness of pectin and physical consistency which ensures slow breakdown and release inside the rumen. These products also ensure better utilization of urea since the sugar of SBP is utilized rapidly by rumen microbes.

     Effect of triple nuts on milk production in dairy cows was substantiated by [41] who reported enhancement in milk production from 25 to 30 L/day after feeding 10.9 kg of triple nuts to milking cows without affecting blood ammonia level. Gradual introduction of triple nut based DMBP upto 5.4 kg can be always recommended because they degrade slowly and maintain the equilibrium blood ammonia level below 600ug/100ml thus preventing the risk of ammonia toxicity. Therefore, fortified DMBP could offer an enriched cattle feed providing better utilization of minerals and released urea for efficient production of microbial protein and enhancement of milk. Moreover, the consumption of straw decreases when the stall-fed cow was given triple nuts as compared to barley and urea cube [32]. After calving feeding of this also causes deterioration in body condition and body weight although no change in calf performance was found, which could be due to low protein intake by triple nut diet. Fortified beet pulp also has effect on reproductive performance of animals the reports of extended calving interval, and fertility were recorded but this could be attributed to insufficient energy intake rather than adversity of beet pulp.

7. **Desugared Molasses/Concentrated Separator Byproduct (CSB):** CSB is extracted molasses from sugar beet during sugar processing conventionally practiced as a core ingredients in formulation of molasses block [36] to supplement cattle exposed to poor or low quality forage as a rich source of energy and protein. It was proposed that removal of sugar from sugar beet molasses by further processing and refinement yield CSB, having lower energy (67% TDN) in comparison to SBM but higher in C.P (20%) and potassium [91]. The responsiveness by animals to CSB is different when mixed with forage as it has

lower level of sucrose (23 vs 50% DM basis) and greater DM content (29 vs 11.3% DM basis) when compared with beet molasses [106, 69]. Their supplementation in the dose rate of 5-15% leads to improved DMI without affecting any physiological and metabolic parameters. In beef steers inclusion of 10% CSB at different dietary level along with medium quality forage indicated minimal intake and digestion responses [89], helps to enhance nitrogen intake, increases intestinal protein supply by increasing microbial nitrogen production and total VFA fermentation [82]. It was reported that including CSB at 5% of DMI increased intake and attained body weight gain in newly received feedlot steers [54]. Feeding CSB 10% mixed forage resulted in similar N balance compared with urea added forage [52]. It tends to improve DMI, total tract DM and OM digestion , however no difference reported in apparent total tract NDF or ADF. Thus CSB fed separately or mixed with forage could offer a valuable source of supplemental dietary nitrogen for medium and lower-quality forage diets.

VI. FUTURE PROSPECTS OF SUGARBEET AS CATTLE FEED

Sugarbeet as experimentally studied is agriculturally feasible under Indian condition. It is well suited to agroclimatic condition of country which allow us to be self reliant on sugar beet production. It has high yielding potential comparable to sugarcane. It yields double than half time of sugarcane with water saving of 30-40%. Hence it is considered to be dual purpose crop i.e, both sugar and energy producing.

For popularization of the crop in country a business model should be provided for successful cultivation in countries like Morocco, Egypt, Iran, Pakistan European Union and North America which have wide variation in agroclimatic condition. In the country like India a model of contract farming needs to be established where various stakeholders have committed with their specific task in entire venture. A very good example of such practice is in Shriganganagar of Rajasthan, India where a joint venture runs among farmers, factory and seed companies for sugarbeet production.

Apart from this an integrative approach, cultivating sugarbeet with existing crop pattern and also intercropping with sugarcane to increase sugar and byproduct per unit time and area could be other viable option for extending and increasing its production. The role of extension agencies like Krishi Vigyan Kendra (KVKs) in introducing a new crop like sugarbeet as fodder crop to the farmers thus becomes of paramount importance.

Future research inculcates, a release of such varieties which are more adaptive to saline and alkaline soil . Best promotion and utilization of sugarbeet and its byproduct as nutritious cattle feed. The sugarbeet as fodder can be cultivated in rotation with other crop like Sorghum, fodder maize, sorghum/maize plus cowpea, pearl millet/cluster bean for higher fodder yield. It can be ensiled with other fodder crops such as maize, oats, sorghum and pearl millet to produce excellent quality of silage and can thus one can sustain the production from dairy cattle even during lean period of year. SBP and its other related product can be used for enhancing livestock production efficiency and can be used as viable option for conventional feeds in providing nutrient requirement of cattle keeping in consideration the economy, rumen health and animal welfare, at the same time lowering the competition with human edible products for sustainable dairy and beef production [27]. It could be a good substitute of cereal grains being fed to cattle because of the similar nutrient profile and richness in easily digestible fibre component as compared to other feed being used in ruminant feeding which helps to balance the rumen pH and minimizing risk of sub-acute rumen acidosis [110]. With increasing demand of fodder for sustainability of dairy production and shrinkage in fodder cultivable area will again broaden the scope of feeding sugar beet and its byproduct a very good alternative as cattle feed in future. Dose optimization and fortification with different additives like probiotics, phytobiotics may need to be studied in detail for opening new avenues for exploiting its maximal benefit and establishment in near future.

VII. CONCLUSION

To summaries sugar beet and its byproducts discerned to be a feasible option in augmenting sustainability of production both for dairy and beef cattle by substituting a dietary grain portion. The exclusive property of easily degradability and digestibility due to its small particle size, high NDF ferment ability made it a unique feed to partial replace the conventional concentrate feed for cattle. Being halophyte and well suited to Indian agroclimatic condition it can be cultivated in larger area to can overcome the problem of fodder scarcity. Future research demands a release of such varieties which are more adaptive to saline and alkaline soil for better adaptability. Thus the important aspects of the sugarbeet and its byproduct can be exploited as feed to bridge the gap of demand and supply of feed and fodder in country and may prove to be an economically viable option for dairy farmers and industry.

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