Production of Beet Sugar and Bio-ethanol from Sugar beet and it Bagasse: A Review

Ramesh Duraisam[1], Ketemaw Salelgn and Abiyu Kerebo Berekete

Department of Chemistry, College of Natural Science,
Arbaminch University, Arbaminch, Ethiopia

Abstract

*Sugar beet is one of the main sugar crops in the world which has outsized importance to fulfill the requirement of market for sugar supply scarcity. The developed countries found alternative crops over than sugarcane, and also had cultivation to the production of sugar from it, to accomplish public requirement and to improve the country economy by export. Further, sugar beet is one of the better choices for the production of sugar that it contains enough amounts (16 - 20%) of sucrose over than in sugarcane. In addition to the intended product, sugar beet sucrose gives by products like sugar beet pulp, and molasses that plays a vital role in filling energy gap, especially as an excellent alternative resource of green energy. In the search for sustainability and economic value, the complete utilization of the crop is necessary for maximum sugar yield, profitable plant operation and for efficient bio-fuel production like ethanol. Besides sugar yield and bio-fuel based energy generation, sugar beets can also provide many value-added co-products like human nutrition, plastics, animal feed, carbonized material used to remove heavy metals in water and wastewater treatment as eco-friendly manner and in pharmaceuticals. So, in this concern this review focus and suggests the sugar beet is an alternative crop for the production of sugar and regeneration bio-fuel like ethanol for our nation and leads to emphasis the research thematic area in near future for the researchers.***

Keywords: *Sugar beet, Sugar beet pulp, ethanol, sugar.*

I. Introduction

1.1 About Sugar

Sugar is one of the most widely traded products in international market. Sugar (called sucrose) is a carbohydrate that occurs naturally in most of the fruits and vegetables. It is a major product of photosynthesis, the process by which plants are transforms the sun light energy into food products like sugar [1]. The corresponding well known photochemical reaction takes place in plants are shown in reaction:

$$12\ CO_2 + 11\ H_2\ O \rightarrow C_{12}H_{22}O_{11} + 12O_2$$

Sucrose occurs in greater quantities in sugar cane and sugar beets from which it is separated and used as sweetener in domestic and also used as industrial raw material for the production of industrial chemicals like ethanol, acetone, acetaldehyde, etc. Sugar is the general term for a class of sweet-flavored substances used as food ingredients in food industries. As a natural nutrient, sugar also known as sucrose is a vital ingredient in our daily diet All sugars from whatever the sources, which are used almost entirely for food during our diet. Sugar mainly referred with sucrose and in certain extent referred as glucose and fructose [2].

Sugar is the substance whose demand can never be down and that has wide variety of application in human nutrition and also to chemical and biochemical transformations become other useful products. It is also ensures the significant portion of total energy income and ·is also widely used in foods produced in food industries or in workrooms for home consumption for the function of sugar ·as sweetener, flavoring agent, to enhance the preservation media, to increase of food volume and to improving the food texture substrate for fermentation. Only 5 % of sugar is used for producing non-food products under chemical or biochemical transformations of sucrose are biologically degradable and are not toxic. The possibilities of production coming out from sucrose fermentation into bio-ethanol use as a fuel or additives to fuel and classical fermentation products such as sprit, yeasts, organic solvents and acids (citric and lactic acids), vinegar and amino acids[3].Sugar was divided into cane sugar and beet sugar to incorporate unique characteristics in producing cane and beet sugar. In general, beet sugar production is more competitive than cane sugar. Cane sugar production is replaced with beet sugar in beet sugar cultivating regions and is allowed to increase their production and processing capacities. Beet sugar produced in sugar beet processing plants and cane sugar produced in refineries are perfect substitutes for each other, but the production processes are totally different. The production, transportation, processing, and delivery of sugar beets and sugarcane are kept separate in the model. Imported raw sugar is refined at domestic sugar refineries, and the refined sugar is delivered to consumption [4].

1.2 Sources of Sugar

Nearly three thousand years back the humankind started use to make sweetness of the food with the sugar (sucrose). On before 1750, sugar production was existed from sugar cane input, which grown in the tropics and subtropical regions and shipped around the world [5]. During 1880, a German chemist Andreas Marggraf extracted the sugar from beets (Beta Vulgaris) and sugar beet had replaced sugar cane as the main source of sugar in continental Europe [6]. Furthermore, sugar beet grown and cultivated primarily to use as animal fodder, and later discovered beet sugar from sugar beet was exactly the same as cane sugar [7]. Generally sugar is obtained in many countries on a large scale from two plants such as sugar cane (*Saccharumofficinarum*, shown in figure.1) and sugar beet (*Beta vulgaris*, shown in figure.2); the two plants compete and adapt different weather conditions [8, 9].

Fig. 1 Sugar beet cultivation in the field

Fig 2 Harvesting &transporting of sugar beet into Sugar Industries

Other sources for sucrose production may include date sugar is obtained from the sweet, fleshy fruit of the date palm (Algeria, Iraq), which contains up to 81% of sucrose in its solids, palm sugar originates from various palm species such as Palmyra, saga or Toddy palm, coconut and nipapalm growing in India, Sri Lanka, Malaysia and Philippines, etc., maple sugar is obtained from the maple tree (*Acer saccharum*) found solely in north America (USA and Canada) and Japan.

This source of sugar covers very low amount of sugar which is about 5% sucrose, minute amounts of raffinose and several other oligosaccharides of unknown structures. It is marketed in concentrated form either as maple syrup or as maple sugar. Aroma substances are important constituents of these products. The syrup also contains various acids, e.g., citric, malic, fumaric, glycolic and succinic acids. Wide range of sugar in the world is produced from sugarcane, palm, coconut, sugar beet and sugar cane, beet root and corn (only used for sweeteners) [9].

Sugar beet is generally considered as a temperate region crop but due to the development of new resistant varieties it has become a potential cash crop for tropics and subtropics too. Sugars are present in sugar beet as sufficient concentrations to be an efficient extraction of sugar. Sugar beets are very tolerant of different climates and soils and could be grown on marginal land. Plant breeding programs have selected for nutrition, sugar content, yield, and disease/pest resistance[10]. Sugar beet is a root crop (shown in figure.2) and is cultivated in cooler climates. Sugar as a substance is directly contained in sugar beet and is extracted in a watery solution by leaching, boiling or pressing and crystallizes in the process of boiling out the water content. Sucrose is the parameter that is mostly tested in food labs [9].

Sugar beet (*Beta vulgaris*) is an industrial crop grown commercially as hybrid, with sucrose refined from the root as the plant constituent of interest. In addition, the whole beet with its co-products of greens, molasses, and pulp residue could be utilized as an animal feed or a feedstock for alcohol production [11].

1.3 Processing of Sugar Beet

Beet harvesting equipment and transportation methods are well established, and delivery of the sugar beet to the sugar processing plant and follows the existing processes for the production of sugar [12].

Pretreatment: Washing and slicing of the sugar-beets into cosettes are the initial operations.

Extraction: The sugar is extracted by counter-current action from beet cosettes to obtain raw juice and beet pulp. The raw juice is thermally unstable at temperatures above 85°C. The beet pulp can be used for cattle feed or can be modified to obtain fibers for human feed.

Beet Juice Purification: Milk of lime and CO_2 are used for the juice purification. Coke and limestone are used for the production of CaO and CO_2. The lime usage of the conventional process is about 2% beet. Classical juice purification consists of liming, carbonation, sludge separation and sulphitation. However, this process removes only a part of non-sugars from the sugar juice (proteins, pectins, inorganic salts and coloring substances).

Beet Juice Concentration: By multi-effect evaporation the thin juice with a dry substance content of 14-16% is concentrated to thick juice with 60 - 75% of dry matter.

Crystallization: Further evaporation of water leads to crystallize and growth of crystals. Sugar crystals are separated by centrifugation from the syrup. The molasses is the by-product from which the crystallization is not possible [12]. The isolation of beet sugar will be described first because the processes used in material preparation and sugar separation have been developed to be perfection. The beet sugar production process is given in figure.ibn the following as:

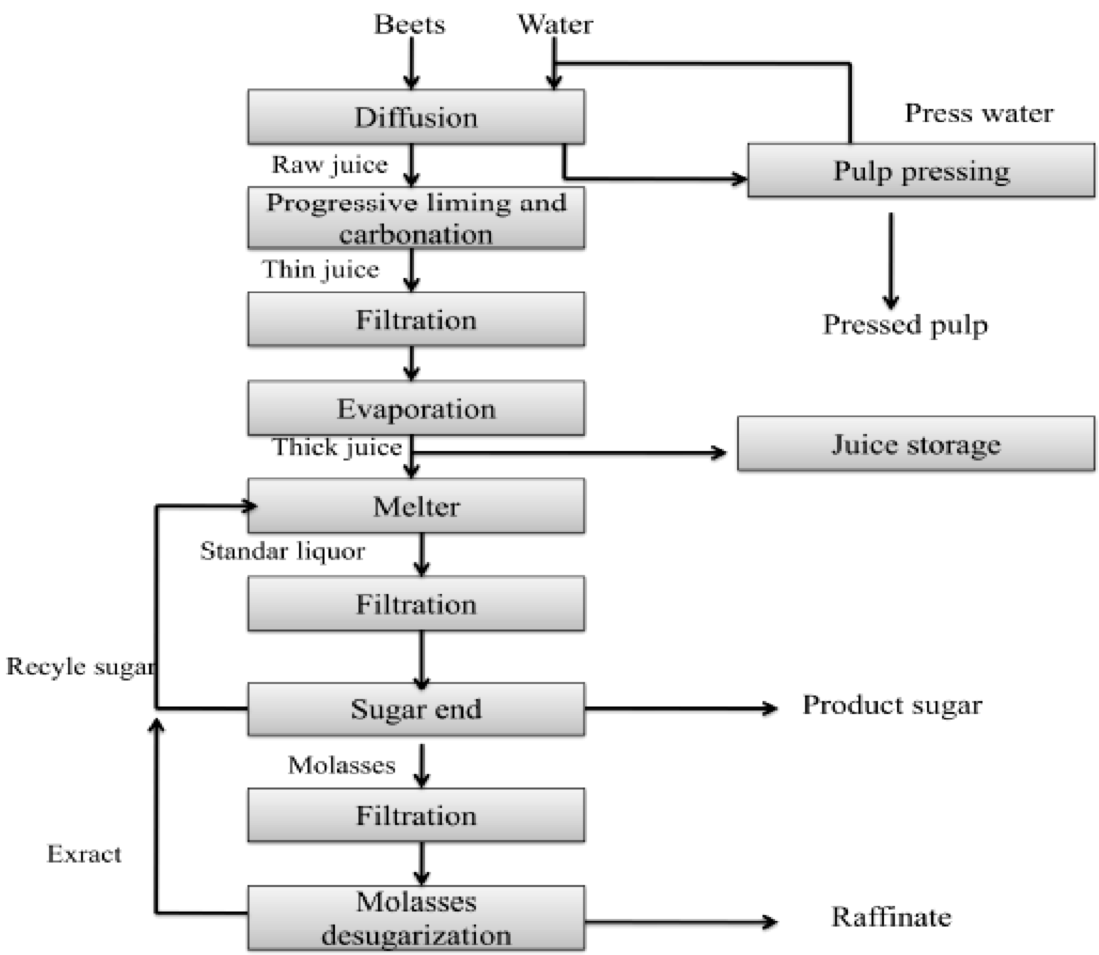

Figure.3. Beet sugar production process [13]

1.4 Beet Sugar Production and Its Co-products

Sugar (sucrose) is extracted from sugar beets using hot water in a multi-step process involves by extraction of the syrup and then concentration followed by cyclic washing and finally drying the Sugar. Production of beet sugar involves various types of process steps to obtain sugar crystal and isolated from its wastes and by products. Generally, standard sugar beets contain 16-20% sugar by weight. In order to extract the sugar and maximize the yield, the beets are cut into elongated slices (cossettes). In the diffuser the cossettes are flooded with hot water, and diffuse the sucrose from the beet cells [11]. The non-crystallized syrup called beet molasses consist 50% by weight of sugar. It is usually fermented into alcohol. The leftover molasses is rich in nitrogen and is used either as animal feed or as fertilizer. The remaining beet pulp pressed and dehydrated and is normally fed to animals. Sugar beet pulp (SBP) also contains a significant fraction of cell wall polysaccharides including pectin and dietary fiber. Utilization of the co-products reduces waste and adds value to the crop.

1.5 Composition and Uses of Sugar Beet and Its Bagasse

The sugar beet is one of the main sugar crops in the world. The sugar beet plant originates from the coastal areas in Mediterranean regions and extends in the Northern coastal area, where it has always been considered as a very stable and productive crop. Sugar beet bagasse also known as sugar beet pulp (SBP) is the main by product of beet sugar industry. SBP consists of desugared beet cossettes, which are usually dried and processed as animal feed. The dried pulp is valuable cattle feed because it supplies carbohydrates, proteins, and minerals which is also important for fermentation that generates energy [6, 7]. Approximately 20% of the pulp is rich in cellulose and also the major polysaccharide is pectin,galacturonic acid, rhaminose, arabinose, galactose, methanol and acetic acid. Pectin is recognized for its potential to give health effects in the body, such as lowering blood cholesterol and leveling out the blood-glucose curve. These effects are likely to depend on the ability of pectin to form viscous solutions [14]. Furthermore, sugar beets consists about 75% water, 18% sugar, 5% cell walls and others are 2%. After the sugar is extracted, remaining cell wall material called SBP is used to produce the sugar beet fiber which is a natural dietary fibre with high fibre content. The high dietary fibre content in sugar beet fibre in combination with water absorption leads to low energy density, thus reducing the energy content of a meal. The fibres provide increased bulk which promotes digestive health, contributes to safety and can prevent or reduce obesity [15].

Sugar beet bagasse has numbers of benefits for domestic and industrial activities which includes animal feed for production of fibres products mainly pulp and paper, for activated carbon synthesis which is used environmental waste treatment and fuel generation like bio-ethanol. The residual cellulose can be used as a high quality fermentation feedstock, as inhibitory compounds [16-19]. Industrial processing wastes from SBP were identified by manufactures such as a dry-matter content of 23% w/w after sugar extraction, and are mainly converted into a low value animal feed to deserving significant drying and transportation costs.SBP has very high carbohydrate content (~80% w/w) predominantly made up of glucose (26% of the total w/w) in the form of cellulose together with arabinose (23%) and galacturonic acid (15%) in the form of sugar beet pectin. Unlike many waste lignocelluloses materials that contains very low in lignin (~1-2%), making it relatively easy to process and the mild conditions under which sucrose extraction is carried out (60°C, with 75 wt% of water) and make SBP as a potential raw material for saccharification and subsequent conversion of sugars to value-added products[20, 34]. Sugar beet pulp is an abundant by-product of the beet sugar industry, which is mainly used in cattle feeding. It's composition suggests that it could be used to produce several value added products [17].

Table.1 Fermentable Sugars in SBP [18]

Component	Dry weight (%)
Carbohydrates	68
Glucose	22
Arabinose	18
Uronic acids	18
Galactose	5
Rhamnose	2
Xylose	2
Mannose	1
Saccharose (residual)	4
Ester-linked substituents of polysaccharides	0.5
Ferulic acid	1.6
Acetic acid	0.4
Methanol	8.0

1.6 Comparison of Sugar Beet and Sugarcane

Beet and cane are slightly different in sugar content (beet typically contains 18% and cane about 13%), but are dissimilar in the amount of non-sugars (beet juice contains about 2.5% and cane juice about 5%) and in the case of fiber (beet contains about 5% and cane about 10%). The composition differences require different methods to produce sugar from beet or cane. The differences in farming, composition, and processing of these crops are sufficient to justify two separate industries. The beet-sugar industry plays an important role in the economy of beet-sugar-producing countries, which employ large numbers of people to grow sugar beet, to produce sugar, and to support sugar-related areas such as sales, service, and research [19].

1.6.1 Cultivation Conditions

Sugar beets flourish in temperate climates where the soil is rich in fertility and the growing season is about five months long. In the issue of cultivation the key advantages of sugar beet in comparison with sugar cane are well known: a shorter growing cycle (around 5 months), a lower water requirement (about 1/3 to 1/2 of the water needed to grow than sugar cane) & yield slightly higher sugar and ethanol than sugarcane [7,8].

1.6.2 Yields and Sugar Content

Yield potential of sugar beet (*Beta vulgaris* L.) depends upon several factors. Intensity of solar radiation intercepted by the canopy, temperatures at critical stages of growth, and distribution of precipitation are the main limiting growth factors. It is well documented that nitrogen is the nutrient limiting the most sugar beet productivity. The application of too little nitrogen results in reduced root yield and cause to productivity of sugar beet [20].

The sugar content in sugar beet can vary from 16 - 20% but in cane sugar is 13-16%. It is the sugar that gives value to the sugar beet crop. The by-products of the sugar beet, such as pulp and molasses, give an added value up to 10% of the value sugar. The sugar extraction rate depends on the sugar content of the sugar beet at the moment of its arrival in the processing plant. The standard sugar beet should have a sugar content of 16%, which would yield 130 kg of sugar per 1 ton of standard sugar beet processed at a sugar plant, and the ideal efficiency is 82.5% [1, 21 & 22].

1.6.3 Extraction Rate

Whatever the resources for production of sugar is used, the sucrose is stored in/as plant products naturally by photosynthesis and the only activities is to be done in sugar factory is separation of the sugar from the non-sugar matter. During extraction the cost of operation from sugar cane is high because of recycling and refining of product and desugaring of byproducts, but in case of sugar beet maximum extraction can attained without further processing. The process of separating sugar from the sugar cane plant is accomplished in two steps: at sugar mills and at sugar refineries. Beet sugar processing is similar to cane sugar processing, but it is done in one continuous process without the raw sugar stage. The comparison of beet sugar processing with cane refining is reported [1]. Beet sugar produced in sugar beet processing plants and cane sugar produced in refineries are perfect substitutes for each other, but the production processes are totally different. The production, transportation, processing, and delivery of sugar beets and sugarcane are kept separate in the model [23]. It is shown as follows:

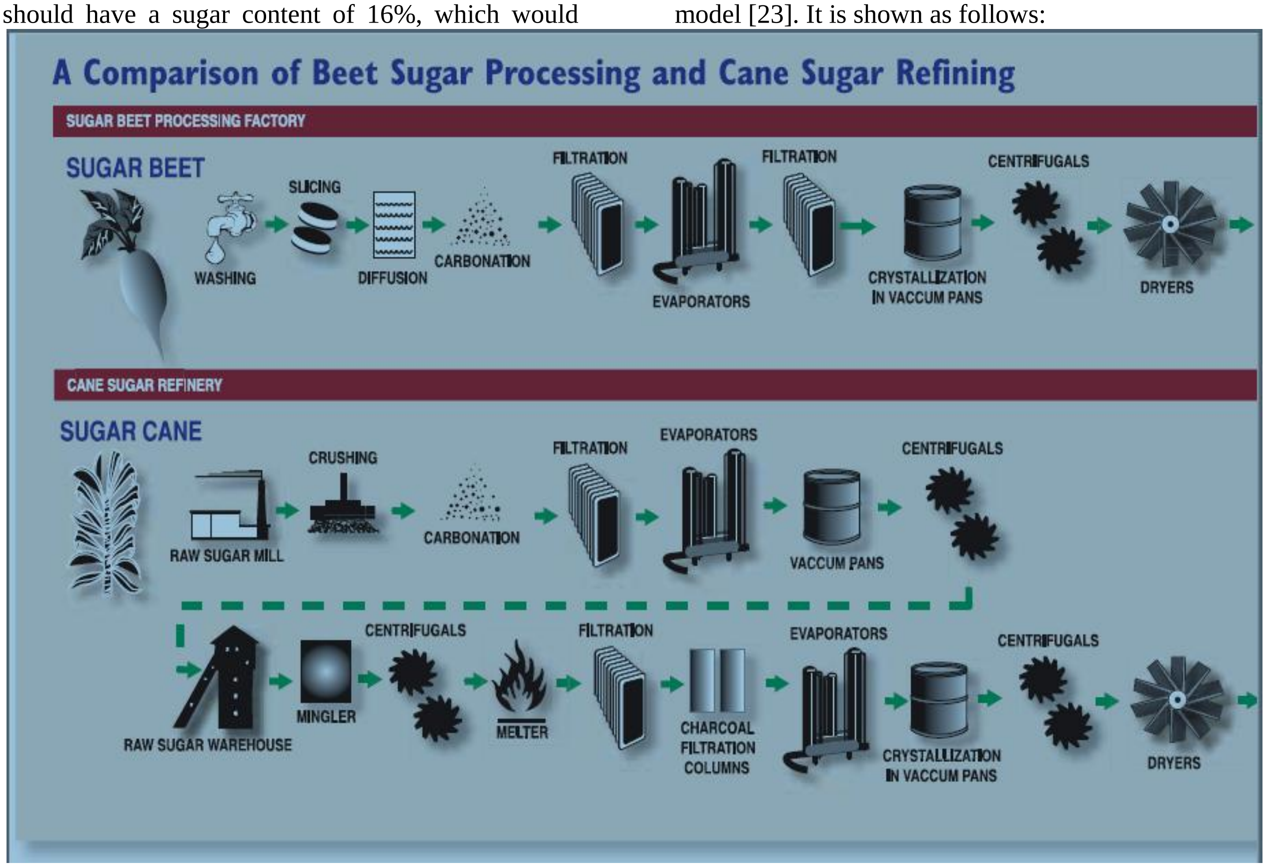

Figure.4 Comparison of Beet Sugar Processing and Cane Sugar Refining
Source: Sugar association, Washington, DC 2005 [1]

1.6.4 By-products of Sugar Beet

1.6.4.1 Sugar Beet Pulp (SBP)

It is an abundant residue from sugar manufacturing industry that has high hemicelluloses and cellulose content and low lignin content [19]. Sugar beet pulp combined with a biobased polymer, polylacetic acid, to form polymer composites that had similar tensile properties to commodity plastics. The SBP could be plasticized and used as a co-polymer rather than as filler in both PLA and poly (butylene adipate-co-terepthalate. Pectin, extracted from SBP, is also used in plastic packaging materials. In some cases, pectin can be used to protect active ingredients from thermal shock during processing into thin films for food packaging [24]. Sugar beets are harvested from their roots. After sugar and molasses are extracted from roots, the remaining pulp is processed into a cattle feed. Sugar beets are highly sensitive to insects, diseases, and weeds and therefore require continuous monitoring and management for control of these problems. Sugar beets tend to be grown with other crops in 3 - 5 year rotations. The rotation results in improved soil fertility, fewer problems with diseases, and improved yields and quality of beets [19].

1.6.4.2 Carbon Materials for Removal of Contaminants

Contamination of water sources by toxic substances is an ongoing environmental and health concern. In green chemical approach, using agro materials have some advantage over conventional including low cost, regeneration of bio sorbents, and potential recovery of heavy metals[25]. The binding capacity of SBP is an ion-exchanger can be improved and making it more valuable material in the market. In this concern, biochar is produced at high temperatures to burn biomass leaving only carbon (carbonization).Biochar has been shown to enhance soil fertility and water holding capability and sequesters carbon. Biochar also has potential as a low-cost absorbent as it shows high affinity for heavy metals. While any biomass can be carbonized, economics suggest that agricultural wastes would be more suitable. Using slow pyrolysis (600^0C), sugar beet residue could be carbonized and is shown to be capture phosphates reported was prepared activated carbon at high temperature pyrolysis (500 - 700^0C) using $ZnCl_2$-activated sugar beet bagasse, and it was successful at removing nitrates from water. An alternate, low-energy technique used to converts lingocelluloses to carbon by sulfuric acid dehydration method and has been shown to absorb heavy metals especially Cr (VI). Sugar beet pulp can be carbonized and used to decolorize sugar syrups [26].

1.6.4.3 Molasses

Non-crystallized syrup, produced upwards of 50 % by weight of sugar during processing of sugar beet. It is one of the raw materials used for production of alcohol by fermentation. Molasses referred specifically to the final byproduct obtained in the preparation of sucrose by repeated evaporation, crystallization and centrifugation of juices from sugar cane and from sugar beets. Cane molasses is a by-product of the manufacture or refining of sucrose from sugar cane. It must not contain less than 46% total sugars expressed as invert. Beet molasses is a by-product of the manufacture of sucrose from sugar beets. It contains not less than 48% total sugars [3].

1.6 Energy Perspective

One of the differences between a beet sugar industries and its cane sugar counterpart is with respect to energy of consumption and energy of generation is from perspective byproducts. The relatively short period, during which sugar beets are harvested and available for processing, a beet sugar industry operates in average only 90 days a year. But, cane sugar industry operates longer since after raw sugar is produced during approximately 5 months, refining process can take place in the same plant for some more months. The production costs of beet sugar are significantly lower than that of cane sugar and process of value addition of the byproducts like molasses, pulp, and particulate matter of sugar beet are easy to isolate [21].

1.7.1 Fuel Capacity and Fuel Analysis of Sugar Beet

Sugar crops, including sugar and sugar cane (*Saccharumofficinarum*), sugar and it beets (*Beta vulgaris*), and sweet sorghum (*Sorghum bicolor* L. Moench), are existing excellent renewable biomass feed stocks because of their availability, their being amongst the plants that give the highest yields of carbohydrates per hectare, and high sugar contents [27].

Sugar beet provides an abundance of sucrose, which is easily fermented by many microbes and is also one of the most efficient sources of ethanol; however storage of harvested roots is problematic. Bioethanol from sugar beet reduces green house gas (GHG) emission comparably or superiorly to maize or sugarcane. There are also other bio-fuels from fermentation, including biomethanol, biobutanol, biomethane and biohydrogen, many of which are more energy dense than ethanol [10]. Energy production from renewable resources is increasingly in demand. In this concern, sugar beets are used as the feedstock, the main target for bio-fuel production especially for ethanol. Once sucrose is extracted, and it can be directly fermented into ethanol using any number of traditional or industrial scale methods. In contrast, starchy crops need additional processing steps to obtain fermentable sugars.

Advances in lignocelluloses bioconversion will allow the use of the beet tops and SBP for bio-energy production. For example, ethanol production was demonstrated using SBP and a mixed enzymatic culture to solubilize pectin and cellulose and then the sugars were converted via fungal enzymes. Recently, ethanol may be driving bio-fuel technology right now, but second generation of bio-fuels are being studied such as hydrogen, methane, methanol and butanol and the best source for each type is sugar beet and its byproducts separated in plants.. In one way in another way, value added products and by products of sugar beet plays a vital role in the area of renewable energy. The value added co-products of sugar beet are generalized in the following block diagram [7, 8].

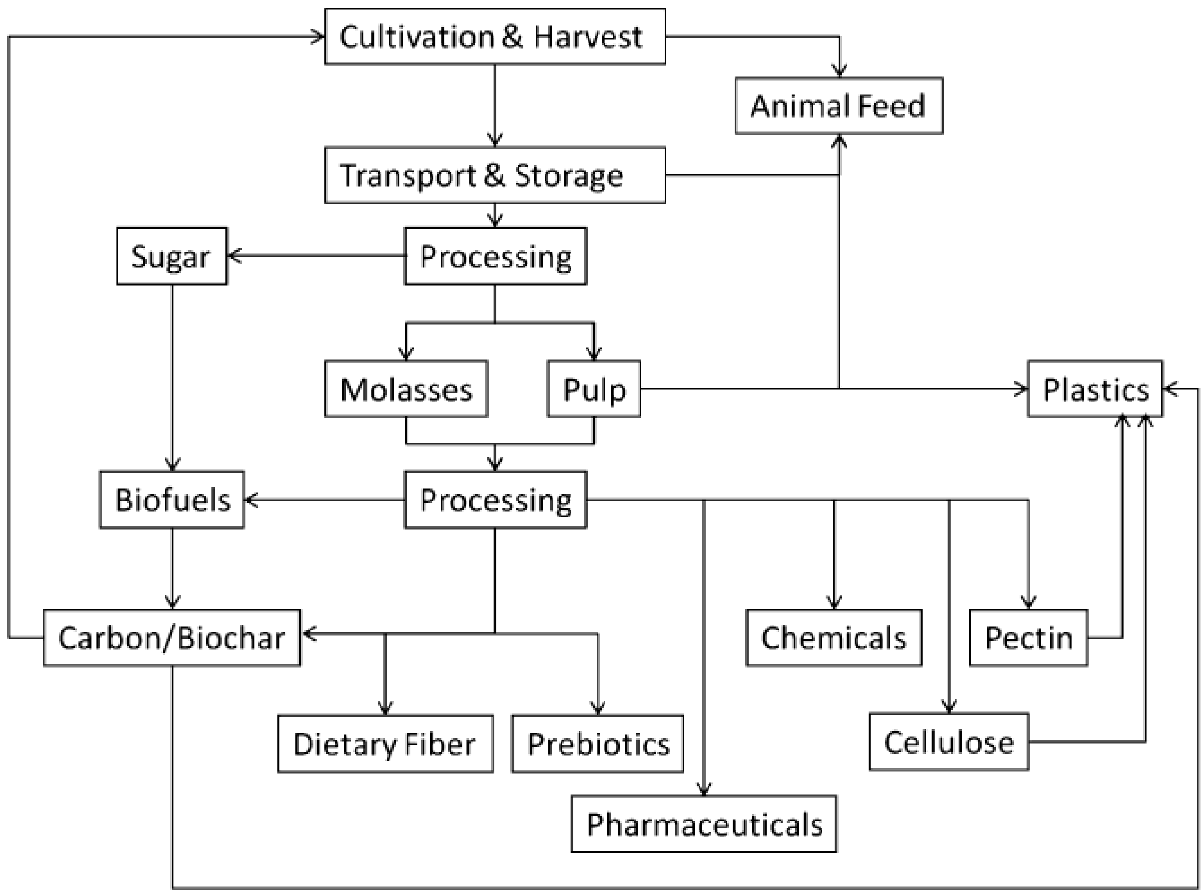

Figure.5 Schematic Diagram of Utilization of Sugar Beet into Value Added Products [7].

1.8 Significance of this Review

The significance of this study is to examine the contribution that will provide the usefulness of sugar beet and its co-products emphasize the different strategies for sugar and biofuel generation. So this deal will travel much to introduce the sugar beet as primary and better input than other possible resources of sugar production. This review further focuses the scope to enhance the research theme upon identifying method of cultivation, suitable weather condition, soil type, and ways of utilization of the final output and its byproducts after harvesting. Finally this review will come up with a cumulative clue in order to introduce the multi useful product of sugar beet into the nation in the aspects of focusing the alternative sugar production crop in addition with sugarcane for developing countries like Ethiopia. This study stimulates agricultural sectors, agricultural and food security related nongovernmental organizations and research institutes in order to conduct further deals and investigations on this area and finally enables to solve energy and food security related problems from the source in Ethiopia. Furthermore, this study will open researcher eyes to design sugar beet cultivation using suitable conditions, which has wide farm land; excellent water supply, cheap labor and also this regional soil contain good enough fertility. Parallel to this it helps for creating job opportunity for the nation and generates some useful value added by-products to the community of developing countries.

II. Review of Literature

2.1 Sucrose from Sugar Beet

Sugar beet (Beta vulgaris L.) is the world's most cultivated crop for the production of sucrose for human consumption after sugarcane (Saccharumofficinarum L.). The sugar beet contains a high level of sucrose, which varies between 16% and 20% on the fresh weight (FW) basis, mainly depending on cultivation and growing condition. Sucrose, soluble solids, moisture content and mechanical property are important parameters in evaluating the suitability of newly developed sugar beet varieties. In general speaking, the post-harvest mechanical properties (e.g., maximum force, force/displacement area and slope under compression) of sugar beet are important in the design and adoption of handling, cleaning, packaging, storing, and processing and transportation equipment [20].

The composition, especially sucrose, of sugar beet as a basis of food is a key consideration to the breeder, producer and processor. Beets with high moisture content are normally accompanied with lower sucrose content; as a result, they increase the cost of transportation. In beet breeding, sucrose and moisture content are usually tested from representative roots harvested at the end of a growing season. Polarimetry and refractometry are the best methods to determine the moisture and sucrose content of sugar beet. Polarimetry is the most commonly used method for sucrose analysis by the beet industry. Refractometry, on the other hand, it is commonly used for the determination of soluble solids content of extracted juice [28]. Sucrose is the most economically significant sugar and is produced industrially in the largest quantity. Only a few of the sugars occurring in nature are used extensively as sweeteners. Besides sucrose (saccharose), other important sugars are: glucose (starch sugar or starch syrup); invert sugar (equimolar mixture of glucose and fructose); maltose; lactose; and fructose. Some are used commonly in food and pharmaceutical industries, while applications for others are being developed [8].

Sucrose is commonly distributed in nature in most of the green plants, leaves and stalks (sugar cane 12-26%; sweet corn 12-17%; sugar millet 7-15%; palm sap 3-6%); in fruits and seeds (stone fruits, such as peaches; core fruits, such as sweet apples; pumpkins; carobs or St. John's bread; pineapples, coconuts; walnuts; chestnuts); and in roots and rhizomes (sweet potatoes 2-3%; peanuts 4-12%; onions 10-11%; beet roots and selected breeding forms 3-20%, sugar beet 16-26%). The two most important sources for sucrose production are sugar cane *(Saccharumofficinarum)* and sugar beet *(Beta vulgaris ssp. vulgaris varaltissima)*[8].

The extraction and production of beet sugar that separates from natural sugar stored in the root of sugar beet plant. Extracting beet sugar normally involves in a continuous process. The sugar beets are washed, sliced and soaked in hot water and extracting a sugary juice. A series of steps involves similar to sugar cane processing such as purification, filtration, concentration, and drying, packing and completes the procedure by shipping into the market. Sugar beet industries could be operated efficiently, if the quality of the beet received and it is suitable for further processing. Cultivation techniques and material inputs must therefore be an important to be adapted to the climate and soil types of the region [29]. The isolation of beet sugar will started by preparation and sugar separation from the developed and enough matured to raw material sugar beet. These processes that begin from preparation of the raw material will later transferred to the production of purified sugar from the clear juice after concentration stage. The beet sugar extract contains about 17% sucrose, 0.5% inorganic and 1.4% organic non sucrose matter. Invert sugar and raffinose content is 0.1% (in molasses this may be as high as 2%).The pulp contains residual sugar of approx. 0.2% of the beet dry weight.The pulp is pressed, dried on band dryers, and pelleted. It serves as cattle feed. Before drying, 2-3% of molasses and, for nitrogen enrichment, urea is sometimes added [30].

2.2 Concept of Sugar Beet in Bioethanol Co-production

Energy shortages, elevated prices for petroleum and climate change have enhances research and development on alternative energy resources to keep up economic and population growth. Ethanol is one renewable biofuel made from various biomass materials that can be used as a sole fuel source or partial substitute for fossil fuels and Sugar beet pulp (SBP), a major by-product of the sugar refining industry, is a potential feedstock for biofuels. It contains 20–25% cellulose, 25–36% hemicelluloses, 20–25% pectin, 10–15% protein, and 1–2% lignin content on a dry weight basis [31].

The European sugar industry is undergoing a period of change and innovation, largely influenced by European sugar production reform. They are considering shifting some of the mass flow of sugar beet into renewable energy mainly bioethanol production, and then apply for the energy grant. The production of bioethanol from sugar beet seems to be an attractive option due to declining fossil fuel sources, and the increasing dependency of the EU on imported crude oil. Industrial facilities already designed for sugar and bioethanol co-production have a spatial advantage, because key co-products or even wastes from one industrial process (i.e. molasses or sugar juice in sugar production), are available onsite for use as raw materials for the additional bioethanol production. The production of bioethanol from beet is technically feasible at most beet sugar plants with appropriate plant and equipment modifications, and additions. The additional processes and equipment required for bioethanol production from sugar beet alone include fermentation, distillation, dehydration, storage, instrumentation, quality control, and loading [31].

Ethanol is mostly known as biofuel energy input and the basic alternative energy source which can be produced either from biomass and agricultural products. In the world, ethanol is produced primarily from sugar cane, sugar beet, corn and starch. Sugar industry promotes currently alternative solutions for high yield and no waste process for ethanol production from sugar beet as well as from intermediates and byproducts like molasses. This can be very profitable for distilleries located near the sugar factories since it would minimize high transportation costs and allow a complex treatment of the substrate. A very important problem in the usefulness of sugar beet for energy purposes is to obtain the highest performance that is correlated with the size of the sugar beet yield [30, 32]

Sugar beet is among the plants that give one of the highest carbohydrates yield per hectare. For this reason, it is ideal raw material for the production of ethanol which can be used as green energy. Sugar beet provides Molasses and sugar beet pulp or sugar beet bagasse as a by-product of sugar processing in its industry and from early days it has been used as raw material for ethanol, baker's yeast and citric acid production. Environmentally friendly technologies are becoming more and more popular because of increased environmental pollution. One of them is the ethanol production process using the fermentation of sugar beet pulp. In sugar beet processing, molasses is a by-product obtained at the end of the process and the cost of its production is much higher than that of production cost of sugar beet pulp. In addition, composition of molasses and intermediates of sugar beet processing depends on number of factors, beet quality and technological process of sugar refining. Hence the optimization of ethanol production from intermediates and byproducts of sugar beet processing in domestic factories is important step toward mass production of ethanol in Serbian factories. Due to the reduction of the economic support for refined sugar efforts have been made to find new ways of using sugar beet outside food industry [32].

Bioethanol is a high octane number biofuel which is produced from fermentation of corn, potatoes, grain (wheat, barley and rye), sugar beet, sugar cane and vegetable residues. Bioethanol is usually used in the transport sector by mixing with gasoline at the specific rate or octane increaser (ethyl tertiary butyl ether (ETBE)). Methyl tertiary butyl ether (MTBE), which is used for increase in octane number, was prohibited in the USA and Canada because of cancerous emissions increasing the demand for bioethanol. ETBE (from 45% bioethanol and 55% isobutylene) is starting to be used in many countries instead of MTBE [29].

Ethanol is also used to mix with gasoline at the rates of 5%, 10% and 85%. A total of 85% ethanol can only be used in specific engines, while mixing 5% and 10% can be used without any engine modifications. Ethanol is produced from agricultural raw materials including sugar and starch by fermentation. The prices of the feedstock used in ethanol production, production capacity and yield in sugar beet and its byproducts are higher than some other alternative inputs [33], shown in table.2.

Table.2 Ethanol yield of some agricultural crops

	Sugar beet	Wheat	Triticale	Rye	Corn	Potatoes
Total production (million ton)	27.8	21.4	4.1	4.1	3.3	13.1
Average yield (ton ha^{-1})	61.7	7.2	5.6	4.9	9.2	43

Ethanol yield (m^3ha^{-1})	6.62	2.76	2.23	2.03	3.52	3.55
Ethanol yield (lkg^{-1})	0.11	0.38	0.40	0.41	0.38	0.08
Energy consumption ($MJha^{-1}$)	19,806	25,142	15,554	15, 554	21,184	34,403
Energy yield (MJ ha^{-1})	155,570	64,840	52,405	47,705	82,720	83,425

Note: A, B and C quota price of sugar beet; Source**:** ErkanIcoza, et.al. Turkish Sugar Factories Corporation [32]

There are many advantages for using ethanol as fuel [34, 35] .The advantages of using biofuels or mixtures of them are:

- Enhances the rural economy,
- Provides higher added value by producing10–15% more sugar beet than that at present,
- Provide benefits to other sectors using by-products,
- Economical benefits of agricultural and the other inputs trading
- Decreasing of foreign dependency on imports as producing renewable fuels locally,
- Reduces atmospheric emissions.

Fibrous bagasse is the most important by-product and it is the primary source of fuel for the generation of fuel and energy to operate sugar industries. Wet and dry beet pulp as well as pressed pulp silage, with or without added molasses are sources of animal feed. Molasses is a valuable by-product of sugar manufacture and exists in a range of grades: edible molasses, cane and beet molasses, and refinery molasses. It is used as an animal feed additive in the industrial production of rum and other beverage alcohols, bakers' yeast, citric acid, and other fermentation processes. The pulp contains residual sugar of approx. 0.2% of the beet dry weight. The pulp is pressed, dried on band dryers, and pelleted. It serves as cattle feed. Before drying 2–3% of molasses and, for nitrogen enrichment, urea is sometimes added [10].

The bagasse also currently used as vigorous initiatives for developing renewable and potentially carbon neutral, solid, liquid and gaseous biofuels as alternative energy resources as well as bio-based alternatives to petroleum-derived chemicals and materials. A unique advantage SBP has over grain and cellulosic crops, are that they require less processing as their juice sugars are directly fermentable. Sugar beet industries, furthermore, have well-established agricultural production systems with a well-developed logistics and processing structure and at present, fuel ethanol production is already from sugar crops mostly the fermentation of either sugar beet juice or molasses and sugar beet pulp [27]. High sugar content in sugar beet molasses enables its use for fermentations while SBP represents an interesting cheap raw material source for enzyme production [36]. The recent unrest in Northern Africa and the Middle East countries has contributed to the increase in prices of petroleum. Alternative fuels can be used to reduce our dependence on foreign oil. Bioethanol could be a substitute for fossil fuel. Presently, most of the bioethanol produced in the developed countries like United States of America is derived from corn. However, corn is a valuable source of food for humans and animals of our nation. In order not to disturb the food security and for ethanol production from lignocellulosic material is advantageous because this material is abundantly available with minimum cost.

Hence, Sugar beet pulp is an attractive feedstock for ethanol production, because it is a co-product from the table sugar industry [37, 38]. Bio-ethanol production, sugar-beet used as raw materials and hopes to provide a new way for producing bio-energy. Fuel alcohol can be obtained after a multi-tower pressure distillation and products are isolated from sugar-beet bagasse and can be used as feed or degradable materials as well. Economic benefits of ethanol plants primarily depend on materials, energy and resources, labor cost and investment [35, 39].

Conclusion

Sugar beets are used primarily for the production of sucrose, a highly energy pure food and which is the principal use for production of sugar in sugar manufacturing industries. Sugar beets contain 13-20% sucrose that is the maximum sucrose content among the already known alternative resources of sugar. High fiber sugar beet pulp does used for the manufacturing of bio-fuels. In addition to SBP, and molasses are obtained as processing by-products that is widely used as feed supplements for livestock food, energy generation, bio-fuel production, environmental and for pharmaceutical inputs. Sugar beets have adapted to a very wide range of climatic conditions and different soil types. Cultivating and adaptation of sugar beet enhances not only in sugar manufacturing industry but also supports the whole society in the area through; creating job opportunity, useful animal feed providing, renewable energy supply, and overall productivity. Generally sugar beet is a number one highly efficient input for sugar industries than some other raw material inputs. So that introducing, cultivating and using sugar beet in Ethiopia is step up of the economic development to the national in multi directions.

Scope of the future work

The composition and uses of sugar beet could attract the researcher's very much for the production of sugar. So, the researchers have the scope to make a thematic area in processing of sugar beet into sugar, finding of renewable energy resource and also effluent treatment in sugar industrial outlet. In this concern, this review gives the idea to develop and to design research themes in this field of study. Also this review may be spark many fold idea of new researches in this field in order to initiate and do the contribution for the home land to fulfill the requirement of sugar scarcity and in economic progress.

References

1. Sugar association; how well do you know sugar? Washington, DC 2005, **website:** http://www.sugar.org.
2. Mettler Toledo, Sugar Guide: Food and Beverage analysis, **website:**http://us.mt.com/dam/LabDiv/Campaigns/food 2012,
3. Oscar J.etal. (2013) "Trends in biotechnological production of fuel ethanol from different feedstocks: Review", Vol.13 (6) pp.334-339.
4. Robin Limb, (2004) "UK sugar industry", Vol.6 (1 & 2) pp.1-4.
5. Gulistan Erdal, etal. (2007) "Energy use and economical analysis of sugar beet production in Tokat province of Turkey", Vol.32 (1) pp.35-41.
6. Steven Cosyn, etal.(2011) "Sugar beet: A complement to sugar cane for sugar and ethanol production in tropical and subtropical areas", International Sugar Journal, 113, p.653-658.
7. Victoria L. et al. (2013) "A review on the complete utilization of the sugar beet, sugar technology",Vol.16 (4) pp.339-346.
8. Yi Zheng, et al. (2013) "Dilute acid pretreatment and fermentation of sugar beet pulp to ethanol", Applied Energy, Vol.105, pp.1-7.
9. H.D. Belitz, et al.(2014) "Food Chemistry", 4th revised and extended edition, Springer.
10. Luc saulineir etal (1999) "Ferulic acid and diferulic acids as components of sugar beet pectins and maizbran",Journal of the Science of Food and Agriculture, Vol.79(3)p.396-402,
11. E.Bonnina, et al. (2012) "Enzymic release of cellobiose from sugar beet pulp, and its use to favour vanillin production in Pycnoporuscinnabarinusfrom vanillic acid", Carbohydrate Polymers, Vol.41 (2000) pp.143-151.
12. H. Řezbováetal. (2015) "Sugar beet production in the European Union and their future trends, Agris On-line Papers in Economics and Informatics, Vol.5 (4) pp.165-178.
13. Rafik et al., (2015) "Membrane separation in the sugar Industry", Journal of Chemical and Pharmaceutical Research, Vol.7(9) pp.653-658.
14. Nordic Sugar member group,Guide book for Sugar Beet Fibre-Physiological effects & Clinical studies, 2014.
15. Y.O.Nal et al., (2007) "Textural development of sugar beet bagasse activated with $ZnCl_2$", Journal of Hazardous Materials, Vol.142, pp.138-143.
16. G.Vaccariaet.al., (2005) "Overview of the environmental problems in beet sugar processing: Possible solutions, Journal of Cleaner Production Vol.13, pp.499-507.
17. R.Chamy,et.al, (1994) "Acid hydrolysis of sugar beet pulps as pretreatment for fermentation", Bioresource Technology, Vol.50, pp.149-152.
18. KuhnelStefan et al. (2011) "Aiming for the complete utilization of sugar-beet pulp: Examination of the effects of mild acid and hydrothermal pretreatment followed by digestion", Biotechnology for Biofuels, Vol.4, pp.1-14.
19. Dr. Leo V. Curtin, "Molasses - General considerations", National Feed Ingredients Associations, West Des Moines, Lowa, 1983.
20. Koo, Won W. Taylor, Richard D "Competitiveness of regional sugar production under alternative production conditions and policies", Agricultural Economics Report 1995, North Dakota State University, pages.50.
21. Koo, Won W, "Competitiveness of regional sugar production under alternative production conditions and policies", Agricultural Economics Report 2012, North Dakota State University.
22. M.I. Masri1 et al.(2015) "Effect of water stress and fertilization on yield and quality of sugar beet under drip and sprinkler irrigation systems in sandy soil", International Journal of Agricultural Sciences, Vol.5 (3) pp.414-425.
23. Gillian Eggleston et al. (2015)"Review: Sustainability Issues and Opportunities in the Sugar and Sugar-BioproductIndustries", Sustainability, Vol.7, pp.12209-12235.
24. NurlanOngdas (2015) "Comparative Assessment of metal removal and neutralization capacities of Biochar and Charcoal in treating Acid Mine Drainage", Trinity College, Dublin, The undergraduate Awards Library, http://www.undergraduatelibrary.org07/05/2016 1:37
25. R. Sagardoy et al.(2009) "Effects of zinc toxicity on sugar beet (Beta vulgaris L.) plants grown in hydroponics botanical society", Plant Biology (Stuttg), Vol.11 (3) pp.339-50.
26. Leiqing Pan et al. (2015) "Measurement of moisture, soluble solids, sucrose content and mechanical properties in sugar beet using portable visible and near-infrared spectroscopy", Postharvest Biology and Technology, Vol.102, pp.42-50.
27. Katarina Mihajlovski et al. (2016)"Improved-amylase production on molasses and sugar beet pulp by anovel strain Paenibacilluschitinolyticus CKS1", Industrial Crops and Products, Vol.80, pp.115-122.
28. W.Grosch, et al. (2013) "Food chemistry", 4th revised and extended edition, Springer.
29. Steven Cosyn, etal. (2011) "Sugar beet: A complement to sugar cane for sugar and ethanol production in tropical and subtropical areas", International Sugar Journal, Vol.113, pp.653-658.
30. MałgorzataGumienna et al. (2016) "The impact of sugar beet varieties and cultivation conditions onethanol productivity", Biomass and Bioenergy,Vol.85, pp.228-234.
31. JovanaGrahovac, et al. (2012) "Future trends of bioethanol co-production in Serbian sugar plants", Renewable and Sustainable Energy Reviews Vol.16 (5) pp.3270-3274
32. ErkanIcoz et al. (2009) "Review: Research on ethanol production and use from sugar beet in Turkey", Biomass and Bioenergy, Vol.33, pp.1-7.
33. P. Barlog,et al. (2013) "Sugar beet response to balanced nitrogen fertilization with phosphorus and potassium",

Bulgarian Journal of Agricultural Science, Vol.19 (No 6) pp.1311-1318
34. Guang-Qi Zhou, etal. (2011) "A new method of producing bio-energy by using sugarbeets", EnergyProcedia, Vol.12, pp.873-877.
35. DamjanKrajnc, Peter Glavic (2009)"Assessment of different strategies for the co-production ofbioethanol and beet sugar", Chemical Engineering Research and Design, Vol.87 (9) pp.1217-1231.
36. E.Donkoh, (2012) "Optimization of enzymatic hydrolysis of dilute acid pretreated sugar beet pulp using response surface design", Journal of Sugar Beet Research,Vol.49,(1& 2),pp.26-37..
37. Hansen et al. (2012) "Enzymatic depolymerization of sugar beet pulp: Production and characterization of pectin and pectic-oligosaccharides as a potential source for functional carbohydrates", The Chemical Engineering Journal, Vol.192, pp.29-36.
38. Hamley-Bennetta,C. Lye G.J. Leak D.J. (2016 "Selective fractionation of Sugar Beet Pulp for release of fermentation and chemical feed stocks; Optimizations of thermo-chemical pre-treatment", Bioresource Technology, Vol.209, pp.259-64.
39. Lee Panella, (2010) "Sugar Beet as an Energy Crop: Review Article", Sugar Tech, Vol.12(3–4) pp.288-293.