Chapter XII: Innovative use of sweet sorghum juice and syrup in food industry

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I. Introduction

Sugar is one of the vital ingredients in all types of processed foods. Sugar is also extensively used in the pharmaceutical industry. The price of sugar has been rising during last five years. World trade in sugar is expected to decline by 5%, constrained by reduced export availabilities in several sugar producing countries. As a result, and given a strong global demand, international sugar prices may well remain relatively high and volatile in the coming years[1]. This is attributed to low cane availability and increased sugar intake in several emerging and developing countries. Hence, the need for suitable sugar alternatives. Sweet sorghum juice, obtained from low water consuming, drought resistant, short duration and seed propagated sweet sorghum, is thus a suitable source to obtain syrup. This syrup can replace sugar in food and pharmaceutical industry applications, thereby reducing its dependence on sugar.

Sweet sorghum is a plant with C_4 photosynthetic pathway, so its photosynthetic rate and dry matter production in g/m^2 per day per unit of inputs are more than those of other sugar producing crops like sugarcane and sugar beet. These characteristics make sweet sorghum an ideal crop for syrup and jaggery production. Sweet sorghum is a special purpose sorghum with a sugar-rich stalk like sugarcane. Besides having rapid growth, high sugar accumulation and biomass production potential, sweet sorghum has wider adaptability. The sugar content in the juice extracted from sweet sorghum varies from 16-23% Brix. It is a good source of energy, protein, vitamins and minerals. The syrup obtained from sweet sorghum contains biologically active substances and micronutrients. The sweet sorghum syrup is a rich source of calcium, potassium and iron. It is also a rich source of natural antioxidants (ascorbic acid and other carotenoids). Sweet sorghum syrup cannot be easily crystallized into sugar because of its relatively higher content of reducing

[1] FAO (2010). Sugar Market analysis, Food Outlook. November 2010; http://www.fao.org/docrep/013/al969e/al969e00.pdf (accessed on 06.01.2011)

sugars as compared to cane sugar. Thus, there is an opportunity for product developers to explore the use of sweet sorghum syrup in applications where crystallization is not an issue.

Sweet sorghum syrup can be used in the preparation of food products without compromising on their sensory quality. The syrup is thus a natural source for effective sugar replacement in bakery items, energy bars, breakfast cereals, sugar confectionery, fruit and vegetable based products etc. Beverages can also be formulated using sweet sorghum syrup. Sweet sorghum cultivation and further value addition through conversion of the juice to syrup and beverages and its use as sugar alternative, offers farmers an excellent opportunity to improve farm income and productivity in semi-arid tropics of the world.

II. Innovative use of sweet sorghum syrup in the food industry

1. Food grade sweet sorghum syrup production

The NutriPlus Knowledge (NPK) Program of the Agribusiness and Innovation Platform (AIP), ICRISAT, developed an innovative method of clarification and processing of the sweet sorghum juice in order to produce food grade quality syrup. It involves the following steps:

A) Clarification of sweet sorghum juice

The freshly harvested sweet sorghum stalks were crushed in roller mill to extract the juice from the stalks. The collected juice was pre-heated for about 20 min at 70°C. The juice was then cooled down to 40°C. Further, the cooled juice was clarified using vacuum filtration. Vacuum filtration was carried out on a uniform bed of Celite® (filter aid), prepared on filter cloth. A filter press may be used for filtration during scale up of the process. The clarified juice thus obtained, was either used directly for preparing beverages or it can be converted into shelf-stable sweet sorghum syrup for use in different food product formulations as detailed in Section 3.

B) Preparation of sweet sorghum syrup

Clarified sweet sorghum juice was used to prepare syrup. The juice was heated and evaporated slowly. Concentration was carried out under uniform

heating conditions with continuous stirring. As concentration increases, the boiling point also increases. It was thus important that heating is carried out under a low flame to avoid charring. During the concentration process frothing and scum formation occurs as a result of coagulation of remaining suspended particles, starch geletinization and protein denaturation. The scum was continuously removed.

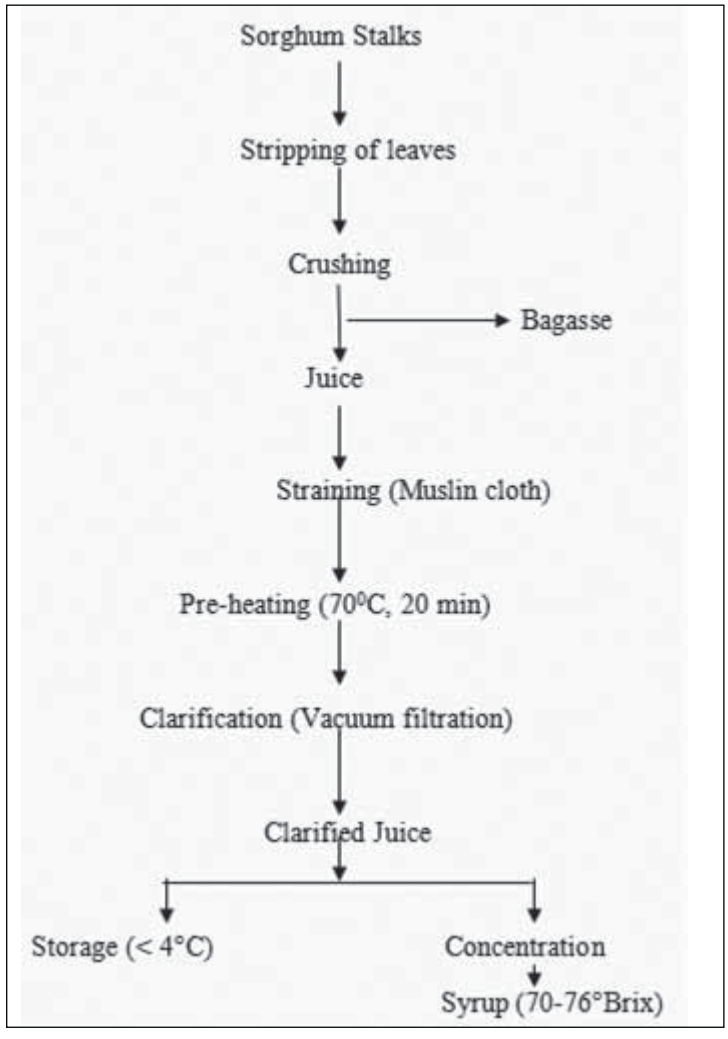

Fig. 1. Sweet sorghum juice extraction, clarification and concentration to syrup.

When the final Brix of concentrated juice (syrup) was 72 to 76% Brix, heating was completely stopped. The syrup was then cooled and stored in food grade containers under ambient conditions. The detailed steps involved in the sweet sorghum juice extraction, clarification and concentrating into syrup are presented in Fig. 1.

2. Shelf-life of sweet sorghum syrup

The physical and chemical composition of food helps determine the type of process required for its preservation. Factors that influence a choice of preservation method are the desired end product, type of packaging, cost and distribution methods. The two most important factors that affect how a food is preserved are water activity and acidity (pH).

Water content in any food sample includes moisture level, and what is even more important is the measurement of water activity. Water activity (a_w) refers to the level of available water in the food. Available water is water that is not bound chemically and is thus free for microorganisms to use. The water activity of pure water is 1.0 (or 100% relative humidity), a dry cracker has a water activity of about 0.2, and jam has a water activity of about 0.85. A low level a_w indicates less free water in the food and hence inhibits microbial growth. The sweet sorghum syrup produced in the range of 73 to 75% Brix had a_w varying between 0.60 to 0.75. Thus sweet sorghum syrup is an intermediate moisture food, similar to honey and can be stored at room temperature in air tight containers. Sweet sorghum juice has a_w of approximately 0.99 and hence susceptible to rapid microbiological spoilage.

The pH of food grade sweet sorghum syrup was in the typical range of 5.0-5.5. Thus given a combination of low a_w and acidic pH, it is possible to store sweet sorghum syrup under ambient conditions. However, it is important to ensure that no moisture ingress occurs into the product during storage.

3. Potential applications

Sweet sorghum syrup may partially substitute or completely replace sugar in the food and pharmaceutical industry. The sweet sorghum syrup can be used as an ingredient in the following food and pharmaceutical applications:

- Confectionary and ice-cream
- Fruit and vegetable products
- Beverages, syrup concentrates
- Bakery items
- Traditional sweets
- Extruded products and snacks
- Energy bars, energy drinks and sports drinks
- Nutraceutical formulations
- Medicated sweets
- Blended powders
- Syrups, elixirs
- Tablets, lozenges
- Capsules

4. Sweet sorghum-based food products developed by NutriPlus Knowledge Programme (NPK), ICRISAT

A number of food products were successfully formulated using the food grade sweet sorghum syrup (Fig. 2).

A) Ready-To-Serve (RTS) sweet sorghum-based beverage

A sweet sorghum-based, ready-to-serve (RTS) beverage was prepared using sweet sorghum syrup. Approximately, 6.0% of the syrup was used in formulating the product. Different flavored variants of the product were prepared (apple, peach, etc.). No artificial colors were added. The product is meant to be consumed directly as a refreshing drink and should be served chilled.

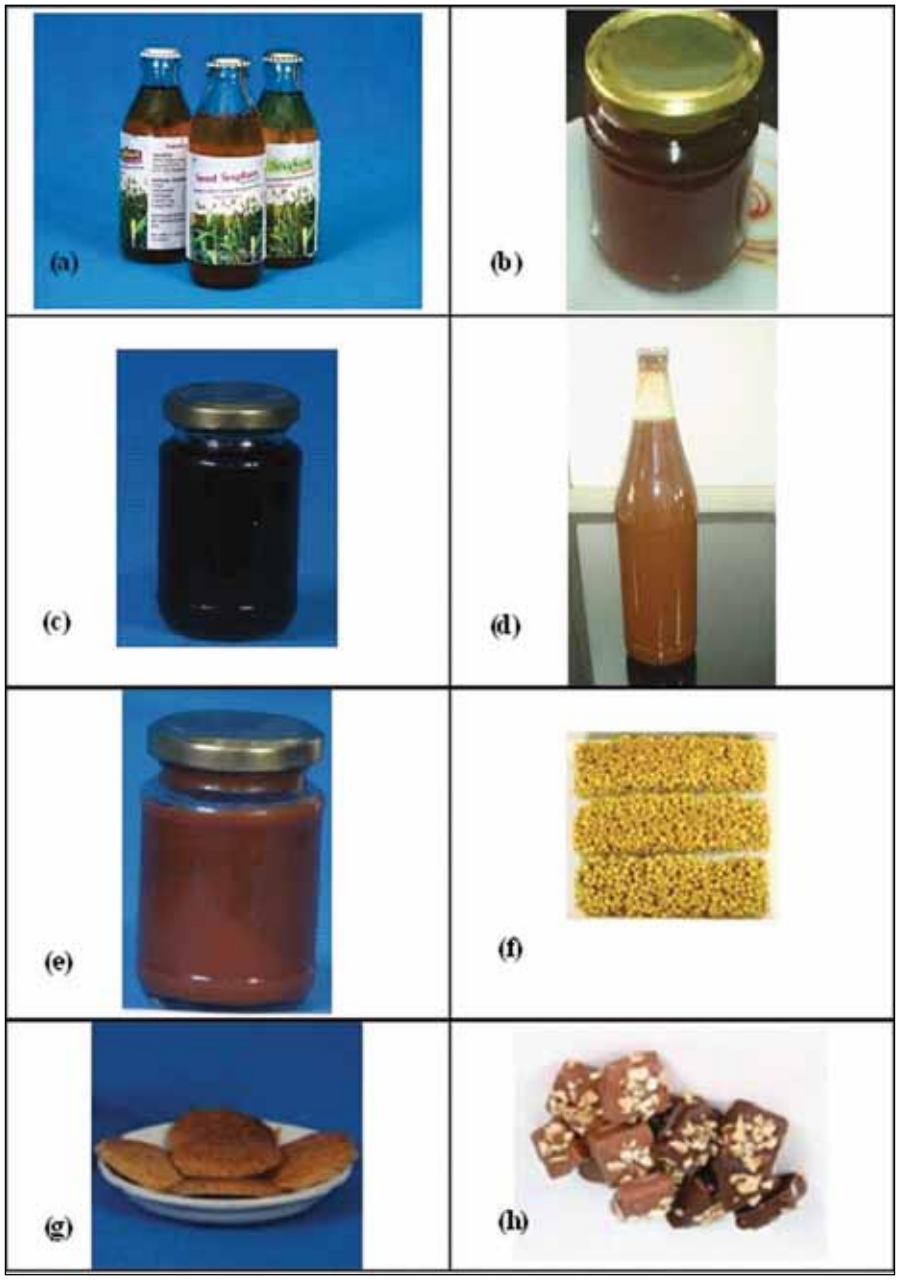

Fig. 2. Sweet sorghum-based food products: (a) Ready-To-Serve (RTS) Sweet sorghum-based beverage (b) Sweet sorghum-based mixed fruit jam (c) Sweet sorghum-based waffle syrup (d) Tamarind - Sweet Sorghum Sauce (e) Sweet sorghum-based tomato sauce (f) Sweet sorghum-based energy bar (g) Multi-grain cookies with sweet sorghum syrup (h) Sweet sorghum-based toffee.

B) Sweet sorghum-based mixed fruit jam

Sweet sorghum-based mixed fruit jam was prepared using a combination of sweet sorghum syrup and mixed fruit pulp (apple, banana, guava, papaya, grapes etc.). Approximately 18.0% of the syrup was used in the product formulation. The product can be consumed with bread, cakes, biscuits etc.

C) Sweet sorghum-based waffle syrup

Sweet sorghum-based waffle syrup was prepared using a combination of sweet sorghum syrup and apple extract. Approximately 15% of the syrup was used in the product formulation. The product can be consumed as a topping along with waffles. It can also be used as toppings in cakes, desserts, ice creams etc.

D) Tamarind–sweet sorghum sauce

Tamarind–sweet sorghum sauce was prepared using a combination of tamarind pulp and sweet sorghum syrup. The sweet sorghum syrup in the product also acts as an alternative sweetener and hence no sugar was required. Approximately 33% of the syrup was used in formulating the product. The product can be consumed as a tangy sauce along with different snack and savory products (samosa, sandwich, burgers etc.).

E) Sweet sorghum-based tomato sauce

Sweet sorghum-based tomato sauce was prepared using a combination of tomato pulp and sweet sorghum syrup. Approximately 8% of the syrup was used in the product formulation. The product can be consumed as a sauce along with different snack and savory products (samosa, sandwich, pizza, noodles, pasta, burgers etc.).

F) Sweet sorghum-based energy bar

A sweet sorghum based energy bar was prepared using low fat sweet sorghum crispies as one of the ingredients. The crispies were prepared from sweet sorghum grains using extrusion technology. In addition, sweet sorghum syrup was used as a binder and sweetener in formulating the product. Approximately 12% of sweet sorghum syrup was used in the binder formulation. The product is a healthy and ready source of energy and can be used as part of normal diet or as a source of energy in emergency and disaster management.

G) Multi-grain cookies with sweet sorghum syrup

The multigrain cookies were prepared using sweet sorghum flour, wheat flour and other cereal grains. Sweet sorghum syrup used in the product acts as an alternative sweetener, replacing sugar in the product. The syrup also imparts a typical flavor to the product. Approximately 18% of syrup was used in formulating the product. The product can be consumed directly as a snack product and has a good potential to be sold in coffee parlors etc.

H) Sweet sorghum-based toffee

Sweet sorghum-based toffee was prepared using sweet sorghum syrup along with milk solids and other ingredients. The product formulation used approximately 16% of the syrup.

5. Product packaging and storage

All bottled products can be packed in glass or PET bottles and should be stored in a cool and dry place. The products are shelf-stable at ambient conditions and should be refrigerated (4-10°C) after opening. The energy bar and cookies can be packed in laminated aluminum foil or other similar packaging materials. High molecular weight high density poly ethylene (HM-HDPE) or poly propylene (HM-HDPP) or other similar compatible laminates can be used for packaging of toffees.

III. Regulatory status of sweet sorghum

Sweet sorghum (Codex Code No. 0658) is classified under Group 021, Grasses for sugar or syrup production along with sugar cane[2]. In addition sweet sorghum molasses finds mention in the Codex, under “Miscellaneous derived edible products of plant origin” (Group 069) along with other similar edible products[3]. Hence the juice and syrup obtained from sweet sorghum can be used as a GRAS (Generally Recognized as Safe) substance.

Source: Codex classification of foods and animal feeds (http://www.codexalimentarius.net/download/standards/41/CXA_004_1993e.pdf).

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IV. The way forward

ICRISAT's efforts are presently focused on the establishment and promotion of small-scale decentralized sweet sorghum crushing and syrup making enterprises in rural areas, with the aim of reducing poverty and improving the livelihoods of the smallholder farmers of the semi-arid tropics. As discussed, the NutriPlus Knowledge Program of the Agribusiness and Innovation Platform at ICRISAT has successfully developed sweet sorghum-based food products with complete or partial replacement of sugar with sweet sorghum syrup. In addition, ICRISAT conducts workshops and entrepreneur development programs on establishing and managing commercial sweet sorghum syrup enterprises. Further, it is now proposed to scale up the food grade syrup production process and commercialize the food grade sweet sorghum syrup and syrup-based products, in order to establish new market opportunities and linkages for developing a sweet sorghum food value chain.