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SUGAR BEET FIBER AND RICE BASED DISTILLERS DRIED GRAIN AS A FOOD ADDITIVE: A SHORT COMMUNICATION

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ABSTRACT

The utilization of sugar beet fiber (SBF) and rice-based distillers dried grain (RB-DDG) as a source of food ingredients is a prime focus of this short study. SBF and RB-DDG are extracted from waste sugar beet pulp produced in the sugar industry and grain-based distillery respectively. The mixture of SBF and RB-DDG has been given the name HNFP (Healthy nutrients-rich fine powder). The oven drying, grinding, mixing, and mesh screening were used for the preparation of HNFP from the two raw industrial wastes. HNFP has components, Carbohydrates, proteins, fibers, vitamins, and minerals. Which has the potential to be utilized as an essential food ingredient. The prepared HNFP has obtained results that show cation exchange capacity, water holding capacity, and oil binding capacity as 0.5 mEq/gm, 8.5 gm/gm, and 1.95 gm/gm respectively, or the average swelling capacity 12 ml/gm was obtained. These properties complete the requirements of good food ingredients for the human gut system. This communication is the first article that represents an idea that will analyze the use of HNFP as a food additive extracted from sugar beet fiber with a combination of high nutrients rich rice-based distillers dried grain (RB-DDG).

Contribution/ Originality: This short communication is the first article that represents an idea that will analyze the use of HNFP (Healthy nutrients rich fine powder) as a food additive. The powder mixture is prepared from sugar beet pulp with a combination of high nutrients rich rice-based distillery dried grain (RB-DDG) in human diet.

1. INTRODUCTION

The growing population is a matter of discussion for policymakers and intellectuals in every nation. Climate change, global warming, and food crisis are prime concerns from the bucket of challenges occurring because of the growing population [1]. The evidence of the effects of climate change is clearly visible with the increase in the intensity of heat waves, water crises, and floods globally [2]. The rising temperatures are resulting in a shortage of food and high hunger global index in many Asian and African countries leading to a growth in the number of deaths in children due to malnutrition [3]. In contrast, researchers are trying to produce a high yield crop in a large volume for healthy food in a minimum space. Most of the researchers are finding ways to produce food from waste by adopting sustainable sources but the need for awareness from the consumer side is deficit [4]. There are a number of food-based industries that produced tons of waste that are rich in protein, carbohydrates, and other micronutrients. RB-DG and SBP are the waste produced in large quantities from the respective industries as shown in Figure 1.

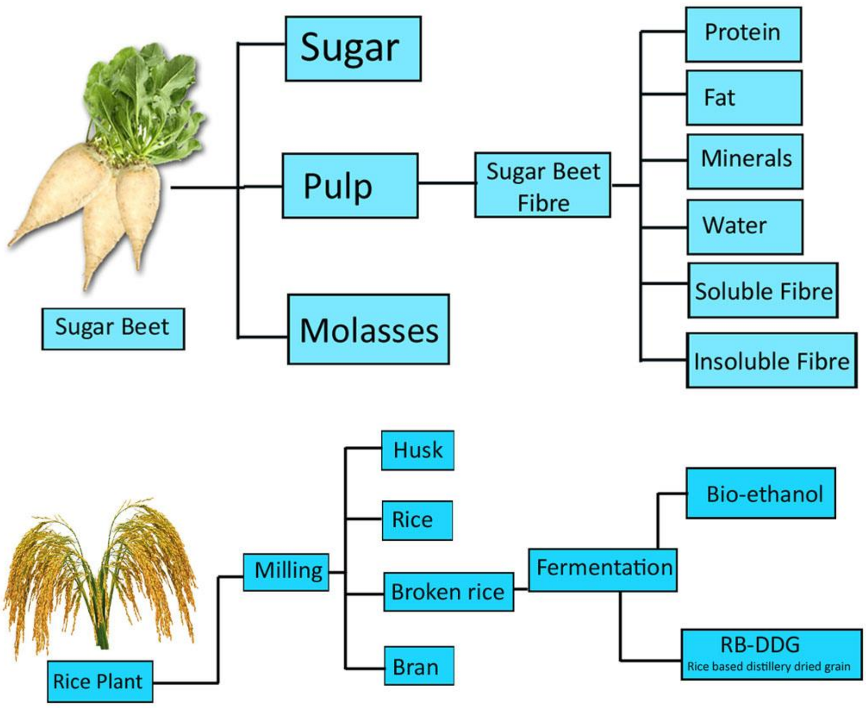

Figure 1. Opportunity available from agriculture crops.

Handling of these waste materials is a major concern for the industry because of the presence of microbes that pose several environmental issues [5]. Rather than the small proportion of the above waste has been used in ruminant feed. The minerals and micro-nutrients present in this industrial waste make it a source of nutrient-rich food [6, 7]. A solid pathway or process is required to convert these wastes into nutritious food. In this short commentary, we will analyze the opportunity to utilize these two wastes sugar beet pulp (SBP) and rice-based distillery dried grain (RB-DDG) to produce healthy and nutrients rich fine powder (HNFP). This fine powder has the potential to be used as an additive in different food-making processes. SBF is produced after the processing of sugar beet pulp (SBP) obtained from a sugar mill. The commercial fibrex or sugar beet fiber was firstly produced by Sweden and UK [8]. The fibrex is a processed material obtained after the processing of sugar beet pulp (5% by weight of SBP). According to the association of agriculture chemists, fibrex is composed of protein (8%), sugar (6%), fat (1%), and ash (4%) by weight. The remaining part consists of water-soluble pectin and insoluble hemicellulose. On the other hand, rice-based distillery dried grain (RB-DDG) is a by-product of grain-based distilleries [9]. In Asia, broken rice produced by rice millers during the milling process has been utilized by brewers to produce ethanol [10]. The particles of RB-DDG have produced during the fermentation of milled broken rice in distilleries after ethanol production. After fermentation with enzymes, the carbohydrates, and protein value of RB-DDG gets increased within 24 hours [11]. Most of the energy in the form of carbohydrates and protein present in RB-DDG is used in animal feed in small amounts and most of it is still remaining unused because of the lack of potential utilization by human beings [12]. The total production data of sugar beet and rice crops from the world indicates the potential of 77.66 Mt RB-DDG and 13.22 Mt SBF to produce the HNFP in the form of a food additive for a healthy diet for human consumption [13]. Traditionally SBP and rice-based distillery dried grain from the respective industries are sold in the slurry to local buyers to be used as feedstock for ruminants. The nutrients present in SBF and RB-DDG promote these components as a health-promoting agent for their hypoallergenic and gluten-free properties [14, 15]. These materials can find potential applications in bakery products, protein powder, baby food, puffing snacks, and base cake items for people suffering allergy from the wheat [16]. Apart from being a rich source of carbohydrates, proteins, and some minerals, SBF has 67 percent soluble and insoluble fiber content [17]. These health-promoting components present in SBF and RB-DDG make it nutrients rich diet for human use. This gives us the mixing of SBF and RB-DDG at optimum parameters to produce HNFP (Highly nutrients rich fine powder). Moreover, the prebiotic effects of fermented rice equivalent to RB-DDG on the human intestine have been investigated in various studies. The continuous use of SBF and RB-DDG in a controlled consumption can prevent constipation and lethargic health conditions [18]. The fibrex produced from SBF has the advantage to clean the small intestine which reduces the possibility of colon cancer [19]. Also, the RB-DDG can be advantageous to boost immunity due to the abundance of carbohydrates and protein-rich sources. However, the processing of these waste materials is a major issue for the industries. There is limited literature available on the processing of RB-DDG waste materials. The opportunity for the use of RB-DDG and SBF in a human diet would be discussed in this short commentary. The processing techniques and the future scope of nutrients rich HNFP as a food additive from SBF and RB-DDG will be analyzed.

2. SUGAR BEET FIBER (SBF)

Sugar beet fiber (SBF) is a by-product of waste sugar beet pulp obtained from the sugar beet processing industry RSL Buttar sevian, obtained after the extraction of juice from cossets of sugar beet in the wet slurry. This slurry has a mixture of beet pulp and hot water consisting of high moisture content (80-95 %). At present, it is widely used in animal feed and low-valued energy products. SBF is used as a binding agent, bulking agent, anticaking agent, source of dietary fiber, stabilizing agent, texturizing agent, or thickening agent. Sugar beet fiber is not used itself due to its tasteless nature. It is widely used 1-5 % for food products, 1-10 % for bread products, and 1-15 % for muesli and cereals. For the past 30 years, Nordic Sugar uses sugar beet pulp as a source of energy and produces fibrex for human consumption. The next step after processing of SBP with an acidic medium the sugar beet fiber (SBF) extraction takes place. The chemical composition of sugar beet fiber makes it a good source of soluble fiber for human consumption. One ton of sugar beet pulp contains 35 kg of sugar beet dietary fiber mainly composed of insoluble hemicellulose and water-soluble pectin. As per the requirements of the final food product, SBF is used according to a variety of food additives.

3. RICE BASED DISTILLERY DRIED GRAIN (RB-DDG)

The broken rice is a leftover wastage of the rice milling industry obtained after the processing of rice paddy. The broken rice is milled in the grain-based distillery and bio-ethanol industries for processing in the fermentation tank where the milled rice is set for the fermentation process. Rice-based distillery dried grain (RB-DDG) is a co-product of the production of bio-ethanol from broken rice. In a grain-based distillery (Rana sugar distillery, karnal), an enzymatic reaction converts the starch present in the rice into bio-ethanol. The leftover material has low sugar and high protein content and is known as RB-DDG having a nutritious composition (rich in protein, carbohydrates, phosphorous, calcium, potassium, zinc, copper, and iron). The chemical composition and physical properties of RB-DDG make it a source of food supplement or an essential constituent of the human diet. In developing countries, the demand for bio-ethanol due to rising crude oil prices increase. Most of the bioethanol is produced by grains. At present this material is widely used in the cattle feed industry. Large volumes would be problematic for the grain-based bio-ethanol industry. There is a need to find an alternative method to utilize this nutritious material as a food supplement for human consumption to remove starvation in underdeveloped countries.

4. HNFP AND METHOD FOR PREPARATION OF HNFP USING SBF AND RB-DDG

The high nutrients rich fine powder (HNFP) is a mixture of SBF and RB-DDG. The preparation of HNFP by applying various processes to the waste raw materials obtained from the industries is shown in the Figure 2.

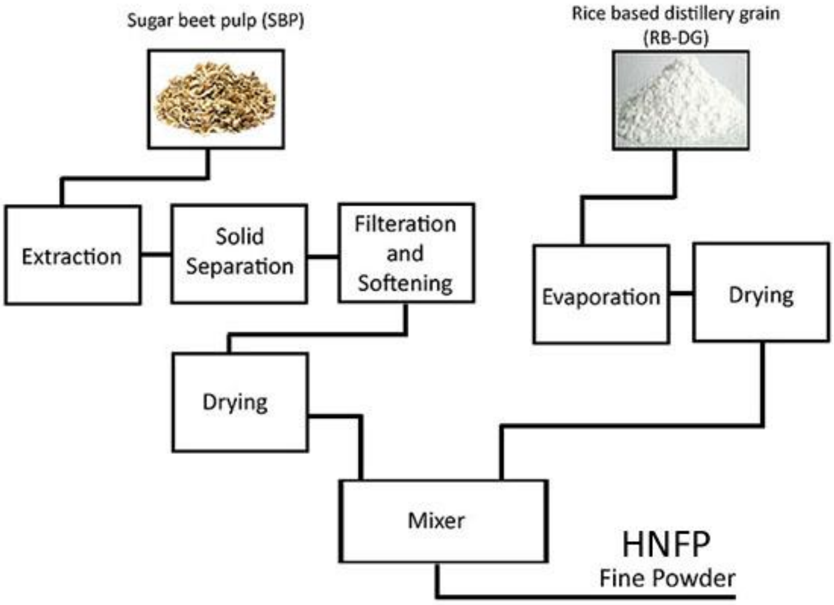

Figure 1. Preparation of HNFP using SBF and RB-DDG.

Table 1. Nutrients and minerals present in HNFP[1].

SBF (Sugar beet fibre) (gm/100 gm)		RB-DDG (Rice based distillery dried grain) (Percentage)	
Protein	8	Protein	8
Water	8	Ash	1.13
Sugar	5	Total dietary fibre	2.47
Minerals	4	Insoluble fibre	1.35
Fat	1	Soluble fibre	1.12
Ash	NA	Phosphorus	20.57
Total dietary fibre	67		
Percentage basis		**(Micro gram/gram) ug/g**	
Glucose	68	Phytic acid	128
Arabinose	22	magnesium (ug/g)	19.7
Uronic acids	18	Zinc (ug/g)	14
Galactose	5	Calcium (ug/g)	105.75
Rhamnose	2	Iron (ug/g)	5.09
Xylose	2	γ-Oryzanol	262
Mannose	1	Riboflavin (ug/g)	0.24
Saccharose (residual)	4	Nicotinic acid	6.87
Ferulic acid	0.5	α-Tocopherol	4.03
Acetic acid	1.6	γ-Tocopherol	2.95
Methanol	0.4	α-Tocotrienol	2.52
Protein	8		

The wet sugar beet pulp is obtained from the sugar beet mill and sent to the extraction process for fiber extraction. The pulp obtained is added to a solution in the pH range of 6.5 to 7.5 at 80 ^{0}C. After completion of the reaction, the solution has been sent for solid separation to centrifugal and filtration systems. The sugar beet fiber (SBF) obtained from the solution was separated and sent to the mixer. The wet rice base distillery grain (RB-DG)

[1] The data in this table has taken an average of three cumulative research articles [20]; [21].

obtained from the distillery is dried in the evaporator to obtain the remaining solute. In the end, both the processed SBF and RB-DDG are sent to the mixture where superior fine particles of the mixture rich in nutrients and mineral shown in Table 1 is obtained.

5. PROPERTIES OF HNFP OBTAINED FROM A MIXTURE OF RB-DDG AND SBF

The mixture of SBF and RB-DDG has proven to contain physiochemical properties favorable for human consumption as an additive. The water absorption capacity of SBF supports microbial growth in the intestine resulting in a healthy digestive system, low glycemic index, and maintained cholesterol level [22]. SBF is approved under clinical trial for gut system and colonel of human as superior food. Although, the literature has not too much evidence of the usage of RB-DDG in human trials. But traditionally fermented rice had been widely used for human consumption [23]. Various studies suggested that fermented rice has the potential to be used as a prebiotic and can be safely consumed by healthy adults. The fermented RB-DDG increased organic acids and enhanced the bifidobacterial number in feces improving the bowel system [24]. According to the literature survey, the physical and chemical composition of SBF and RB-DDG has often been considered waste materials are nutrient-rich food additives [21]. The replacement of HNFP made from SBF and RB-DDG could be used as some additives in bakery and nutraceutical products as shown in Figure 3.

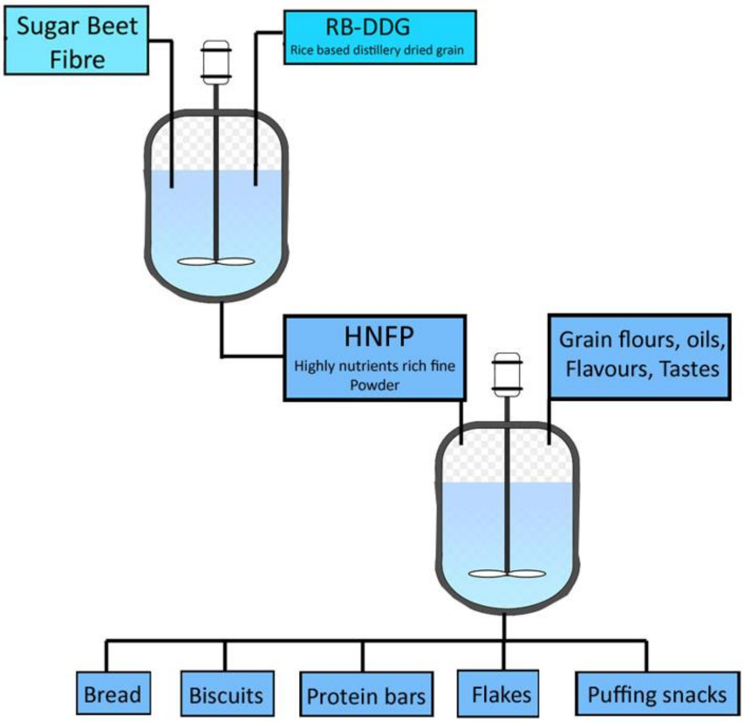

Figure 2. HNFP as a food additive.

6. FUNCTIONAL PROPERTIES OF HNFP

There has been an extensive study in the literature on different functional properties to be present in the materials used as food additives. The following properties have suggested the usage of HNFP in food as an additive.

6.1. The Cataion Exchange Properties

The cation exchange property of prepared HNFP proves that it can be used as a food additive for different food preparation. The cation exchange capacity of HNFP from the range of 0.2 to 0.7 mEq/gm with an average result of 0.5 mEq/gm prepared from 30, 40, 50 and 60, mesh-sized SBF and RB-DDG mixture.

6.2. Water and Oil Binding Capacity

The mixture of HNFP (healthy nutrient-rich fine powder) prepared from the two industrial wastes has good water and oil holding binding capacity of 8.5 gm/gm and 1.95 gm/gm. Which can be suitable for bakery-making products. There is evidence of obliteration of inositol and gluten compounds in both the waste materials [25, 26]. The high-water holding capacity would increase the softness of the food products made from HNFP [27]. The prepared additive has a neutral water holding capacity with other cereals. The properties of hydration capacity are dependent on the SBF manufacturing process. The methods used for the production of SBF have effects on swelling capacity, particle blending, and particle size of the SBF. The study conducted [28] shows that the emulsion formed by SBF using corn oil has a good emulsion droplet diameter. The conducted study shows that a 7 percent addition of SBF in corn oil gives a droplet diameter of range 6.2 to 7.5 µm with average emulsification of 70-74 percent. In the RB-DDG case after the enzymatic reaction and fermentation the physicochemical properties of the HNFP have changed [29]. After fermentation, the fermented RB-DDG has changed water and oil holding capacity. Although the slight reduction in viscosity and swelling power has taken likewise other components protein, minerals, and vitamins were enhanced.

6.3. Swelling Capacity

The preparation method of HNFP from SBF and RB-DDG has a significant impact on swelling capacity. If the particle size of HNFP reduces from 60 mesh size the swelling capacity of the HNFP is reduced which is not suitable for the bread-making process. Alternatively, the fine size could be used in the cookies and biscuits-making process. The average swelling capacity has concluded at 12 ml/gm from the HNFP. Which is suitable for puffing snack making and cookies preparation.

7. FUTURE APPLICATION OF HNFP AS FOOD ADDITIVE

The HNFP has the potential to produce futuristic food for human consumption. The powder has similar properties to an additive used in bread-making flour. The rheological and texture quality of the base flour used for baking was found to improve the mixing of HNFP as an additive. Analysis of dough used for bread making and its rheological properties of SBF and fermented rice has been discussed by a number of researchers Djordjević, et al. [30]. El-Adly and El-Gendy [31] performed experiments on bread-making flour using modified SBF. Nakorn, et al. [32] has studied the pasting properties, rheological properties, and textural properties of the fermented rice flour [33]. The conclusion of the above studies shows that the yield of dough, bread quality, chewiness, resilience, and cohesiveness have increased after the addition of SBF and fermented rice flour (equivalent to RB-DDG). The future products made from HNFP have the capability to tackle food insecurity and can be used to prepare puffing snacks, cookies, muffins, instant flakes, protein bars, and biscuits.

8. HEALTH BENEFITS OF HNFP

The chemical composition of SBF and RB-DDG makes them nutrients rich and healthy food additive components. Pectin present in SBF increases the viscosity and slows down the diffusion occurring in the intestine lowering the blood glucose levels in humans [34]. It also reduces the bad cholesterol level in the blood. The fermented rice or RB-DDG is a bioactive nutraceutical product that helps to develop a healthy metabolite [35]. The HNFP made from a mixture of SBF and RB-DDG could serve as a healthy additive to food items to curb starvation. Although, in this short commentary the evidence indicates that consumption of fermented cereal products reduced the incidence of chronic disease [36]. The HNFP is a good source of nutrients used as an additive for different food.

9. CONCLUSION

This short commentary has discussed the details of the sustainability and functional use of the two industrial wastes. However, some evidence has provided scientific and technical data for the use of SBF and RB-DDG to produce HNFP as a food additive. These wastes are a major concern for the sugar and grain processing industries. The present proposed commentary for the utilization of this waste as an HNFP in food additives is a viable solution for the respective industries. This article provides a pathway for researchers and analysts to conduct clinical trials and feasibility studies of prepared HNFP.

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Authors' Contributions: All authors contributed equally to the conception and design of the study.

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