International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(2): 328-331

Received: 17-01-2018
Accepted: 18-02-2018

Gadhe KS
Department of Food Science and Technology, College of Food Technology, VNMKV, Parbhani, Maharashtra, India

Thorat PP
Department of Food Science and Technology, College of Food Technology, VNMKV, Parbhani, Maharashtra, India

Sawate AR
Department of Food Science and Technology, College of Food Technology, VNMKV, Parbhani, Maharashtra, India

Shere DM
Department of Food Science and Technology, College of Food Technology, VNMKV, Parbhani, Maharashtra, India

Correspondence
Gadhe KS
Department of Food Science and Technology, College of Food Technology, VNMKV, Parbhani, Maharashtra, India

Effect of particle size distribution on functional properties of dietary fiber extracted from sugar beet (*Beta vulgaris*)

Gadhe KS, Thorat PP, Sawate AR and Shere DM

Abstract
The present study was conducted to investigate the effect of particle size on functional properties of dietary fiber extracted from sugar beet (*Beta vulgaris* L). The dietary fiber extracted from sugar beet. The dietary fiber was sieved through the sieve of 18, 30, 60, 100 and 150 mesh size. The particle size distribution of dietary fiber was calculated and found the highest yield of particle with 60 mesh size. The water holding capacity, water binding capacity, swelling capacity, oil binding capacity and cation exchange capacity were found in decreasing trend while particle density was increased with increase in mesh size. The dietary fiber of 60 mesh size were suitable for incorporation in different functional food products like cookies.

Keywords: functional properties, water binding capacity, cation exchange capacity, sugar beet, dietary fiber

Introduction
Sugar beet is the most important of several crops, including spinach beet, Swiss chard, garden beet (beetroot) and fodder beet, within *Beta vulgaris* species (Gill and Vear, 1980) [1]. The term "dietary fiber" was coined by 'Hipsley' (1953) [2] to refer to the non-digestible constituents of plants that make up the plant cell wall (Potty, 1996) [3]. It covers a wide variety of substances that are broken down extensively but incompletely digested in the large intestine by the symbiotic bacteria yielding fatty acids and thus not supplying the host with carbohydrates. American Association of Cereal Chemists (AACC, 2001) [4] defined dietary fiber as: "the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Dietary fiber includes polysaccharides, oligosaccharides, lignin and associated plant substances. Dietary fiber promotes beneficial physiological effects including laxation, and/or blood cholesterol attenuation, and/or blood glucose attenuation". These unavailable carbohydrates fall into two major groups, based on the structural components (Dhingra *et al*., 2012) [5].
Controlled viscosity is the principal characteristic of dietary fiber, responsible for cholesterol lowering and this effect is due to increased excretion of cholesterol from body (Carr *et al*., 2003) [6]. Increased use of fiber supplementation would therefore not only improve the health benefits and functional properties of many foods, but could also provide ecological benefits to food producers (Makee and Latner, 2000) [7]. However, in view of increasing importance of dietary fiber in human nutrition, the United States Food and Drug Administration and the National Advisory Committee in Great Britain have both recommended a dietary fiber intake of 20-35 g/person/day (Prasad *et al*., 1995) [8].
Dietary fibers are considered as multifunctional substances positively affecting the activities of human body. Sufficient consumption of dietary fiber can have beneficial effects against several diseases such as, cardiovascular diseases, diverticulosis, diabetes mellitus, colon cancer, appendicitis, constipation, hemorrhoids, hernia, duodenal ulcer, gall stone, obesity and other diseases of gastrointestinal tract (Slavin, 2005; Gomez *et al*., 2010) [9, 10].

Methodology
Extraction of dietary fiber from sugar beet
Sugar beets were washed, thinly sliced, and the sugar was extracted from the beets by hot water.

The remaining beet pulp was pressed through grinder, sieved, and dried in cabinet drier to a moisture control of 5% the powder was packed in HDPE pouches until further use (Anonymous, 2014) [11].

Drying Kinetics

Drying kinetics is necessary to determine the rate of drying of product with different intervals of time (Borah *et al.*, 2015) [12]. Of sugar beet dietary fiber at different temperature is determined by determination of moisture content at the interval of 1 h for 8 hours. The moisture content was determined according to method No. 44-15 A of (AACC, 2000). 5 g of sample was taken in tared crucible and dried in a hot air oven at 100 ± 5^{0}C to a constant weight. The moisture content was calculated by the formula given below.

$$\text{Moisture \%} = \frac{\text{Initial weight} - \text{final weight}}{\text{Total weight of sample}} \times 100$$

Particle size distribution

The fiber sample (100 g) was subjected to granulometry (Determination as per Ancona *et al.*, 2004) [13] in analytical sieve shaker (equipped with 18, 30, 60, 100 and 150 mesh sieves). Sample 100 g was placed on top sieve, with the largest mesh and shaken for 20 min. The retained material on each sieve was weighed carefully and expressed as a percent of the original sample weight.

Functional properties of dietary fiber from sugar beet

The functional properties of dietary fiber like water holding capacity, water binding capacity, swelling capacity, oil binding capacity, particle density and cation exchange capacity were determined with slight modification in the method given by Sowbhagya *et al.* (2007) [14].

Results

Particle size distribution

The technological interest and physiological effects of fibers are related to their physicochemical properties which in turn are dependent on the ability of fiber to absorb and hold water, its structure, porosity and particle size. Thus, particle size plays a very crucial role in governing the functional and physiological properties of dietary fiber. The data of particle size distribution were presented with the help of Fig. 1.

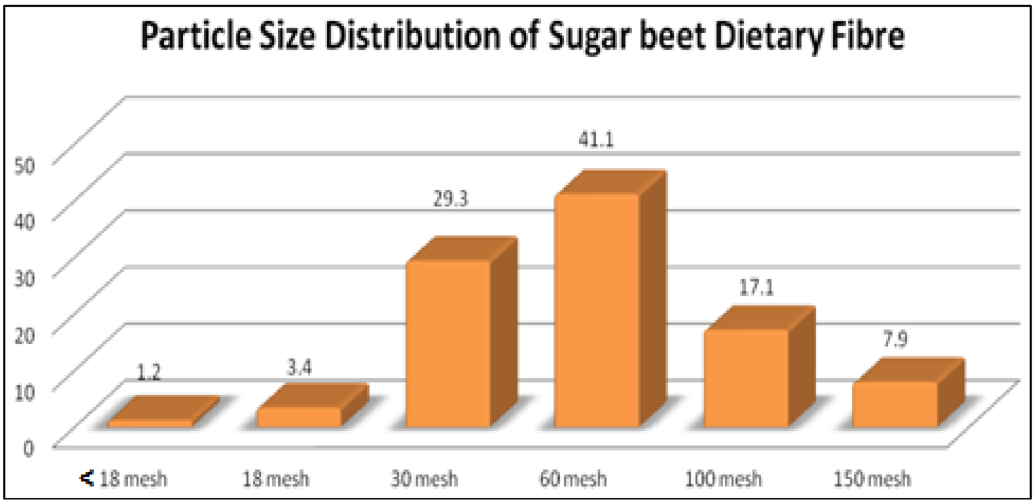

Fig 1: Particle size distribution of sugar beet dietary fiber

The results pertaining to particle size distribution of the fiber reveal that the 60 mesh particles recorded highest yield, as compared to other mesh sieves followed by 30 mesh and 100 mesh particles. Prakongpan *et al.*, (2002) [15] reported that in case of pineapple dietary fiber, the largest amount of fiber was retained on the 80 mesh screen and the process of grinding is the major factor affecting particle size of the fiber. The particle size has relevance on the functional properties thereby on the physiological effects and application in the food products.

Effect of particle size on the dietary fiber content

In the present investigation dietary fiber profile of sugar beet dietary fibers were studied at three different particle sizes i.e. 30 mesh (250-410 µm), 60 mesh (140-230 µm) and 100 mesh (40-110 µm) and results are presented in Table 1.

Table 1: Effect of different particle sizes on dietary fiber content.

Particle Size (mesh)	Insoluble Dietary Fiber (%)	Soluble Dietary Fiber (%)	Total Dietary Fiber (%)
30 (250 to 410 µm)	48.84	23.80	72.64
60 (140 to 230 µm)	46.01	15.81	61.82
100 (40 to 110 µm)	39.17	19.32	58.49

The present study revealed that a balanced ratio of insoluble dietary fiber and soluble dietary fiber fractions was found in sugar beet dietary fibers in the ratio of 3:2 which justifies the finding of these results in comparison with reported results Fox (1991). Ragaee *et al*., (2006) [16] studied the dietary fiber profile of various cereals and reported that soluble dietary fiber was quite low (1.4 to 3.7 per cent) compared to that in fruits, vegetables and legumes.

Functional properties of sugar beet dietary fibers

Particle size is a very critical parameter for maintaining homogeneity of the products. It affects the functional properties, which has paramount importance in development of food products and also in human physiology. It has been reported that incorporation of finely ground wheat bran in a low-fiber diet causes severe constipation in human subjects.

The effect of particle size on the functional properties of selected fiber samples have been presented in Table 2. Hydration properties have been widely studied in food functionality, due to their importance in foods. It is the major mechanism by which dietary fiber increases stool output. It provides more information on the fiber, which will help to understand the behavior of fiber in foods or during gut transit (Adiotomre *et al.*, 1990) [17].

Table 2: Effect of particle size on functional properties of sugar beet dietary fiber

Particle size (Mesh)	WHC (g/g)	WBC (g/g)	Swelling capacity(ml/g)	OBC (g/g)	Particle Density (g/cm^3)	Cation Exchange Capacity (Meq/g)
30 (250 to 410 µm)	12.67±1	17.91±1	25.92±2	2.31±0.05	1.14±0.05	0.92±0.05
60 (140 to 230 µm)	10.87±1	14.32±1	23.78±2	2.14±0.05	1.21±0.05	0.87±0.05
100 (40 to 110 µm)	9.53±1	11.72±1	19.37±2	1.72±0.05	1.29±0.05	0.84±0.05

Water holding capacity: Maximum water holding capacity was observed in case of 30 mesh particles, while it decreased in case of 60 and 100 mesh samples indicating a significant increase ($p\leq 0.05$) with coarseness of the particles. Sangnark and Nomhorm (2004) [18] also reported that the water holding capacity of rice straw also decreased significantly with decrease in particle size and this trend is highly correlated for the water holding capacity of the fiber samples studied.

Water binding capacity: The measurement of water binding capacity is considered as a useful parameter for predicting the faecal bulking ability of a fiber source and is generally related to its structure, particle size and also the number and nature of its water binding sites (Chau and Huang, 2004). The water binding capacity in sugar beet fiber samples ranged from 11.72 to 17.91±1 g/g. The water holding and water binding capacities of both the fiber samples increased with increased coarseness of particles. Raghavendra *et al*., (2006) [19] reported that the hydration capacity decreased with a decrease in particle size, which is in concurrence with our results.

Swelling capacity: The results revealed that larger particle size could significantly bind more water and also exhibit higher swelling capacity as compared to finer particles. The differences in the swelling capacity between the fibers may be due to their individual characteristics and the physical structure of the fiber matrix. Similar decreasing trend was obtained by Izydorczyk *et al*., (2008) [20], stating that during grinding, the spaces available for free water (cell wall lumen) will decrease, may be due to damaging of the fiber matrix and the collapse of the pores and so will be the water imbibing properties.

Oil binding capacity: The oil binding capacity also followed a similar trend as that of hydration capacity *i.e.* it decreased with decrease in particle size. The ability of fiber to bind oil is more of a function of the porosity of the fiber structure than the affinity of the fiber molecules for oil. These results are in concurrence with our results reported by Chau and Huang (2003) [21].

Particle density: Particle Density of 30 mesh fiber particles was lowest. The particle density followed an opposite pattern i.e., it increased with decrease in particle size. Sangnark and Noomhorm (2004) [18] reported that density of the rice straw increased inversely with particle size ranging from 1.06 to 1.34 g cm-3 for the 0.5 to 0.3 mm diameter particle and 0.075 mm, respectively, which is in accordance to our results.

Cation exchange capacity: The ability of dietary fiber to bind minerals may lead to mineral deficiency in individuals consuming high-fiber diets (Mongeau and Brooks, 2003) [22]. One mechanism by which dietary fiber may influence mineral availability is cation exchange capacity, which measures the ability of the fiber matrix to bind and hold ions on its surface (Sharma *et al.*, 2006) [23]. Amongst the samples, cation exchange capacity ranged from 0.84 meq/g to 0.92±0.05 meq/g. In general, cation exchange capacity slightly decreased with decrease in particle size. Similar results were drawn by Michel *et al.* (1988) [24].

Hence, the difference in these functional properties amongst the fibers might be attributed to their different chemical and physical structures as well as different preparation methods (Chau and Huang, 2003) [21]. Thus, these properties are common quality of concern when considering plant fibers as food ingredients and are related to the microstructure of materials. Grinding is not only a particle size reduction but can be related to deep structural modifications of fiber.

Conclusion

The functional properties of plant fibers depend on the individual properties and structure of the various cell wall components, dietary fiber profile, particle size, extraction condition and plant source. The 60 mesh dietary fibers were found to be having best functional characteristics to be utilised in the functional food products. Hence, it could be concluded that functional properties were increased with reduction in size to the optimum level.

References

1. Gill NT and Vear KC. Agricultural Botany, Dicotyledonous Crops, 3rd edition. Duckworth, London. 1980.
2. Hipsley EH. Dietary fibre and pregnancy toxaemia. British Medical Journal. 1953; 2:420-422.
3. Potty VH. Physico-chemical aspects, physiological functions, nutritional importance and technological significance of dietary fibre – A critical appraisal. Journal of Food Science and Technology. 1996; 33(1):1-18.
4. AACC. Official Methods of Analysis of AACC International, American Association of Cereal Chemists, Washington D.C. 2001.
5. Dhingra D, Michael M, Rajput H, Patil RT. Dietary fiber in foods: a review. Journal of Food Science and Technolog. 2012; 49(3):255-266.
6. Carr TP, Wood KJ, Hassel CA, Bahl R, Gallaher DD. Raising intestinal contents viscosity lead to greater excretion of neutral steroids but not bile acids in hamsters. Nutrition Research. 2003; 23:91-102.
7. Makee LH, Latner KC. Underutilized sources of dietary fibre; A review. Plant Foods for Human Nutrition, 2000; 55:285-304.
8. Prasad NN, Khanum F, Siddalingaswamy M, Santhanam K. Proximate composition and dietary fibre content of various foods/rations processed to suit the Indian palate. Food Chemistry, 1995; 52:373-378.

9. Slavin JL. Dietary fiber and body weight. Nutrition, 2005; 21:411-418.
10. Gomez M, Moraleja A, Oliete B, Ruiz E, Caballero PA. Effect of fibre size on the quality of fibre-enriched layer cakes. Lebensm-Wissenschaft-und-Technologie, 2010; 43:33-38.
11. Anonymous. Sugar Beet Fibre - Physiological effects & Clinical studies. Nordic Sugar, Member of Nordzucker Group. Nordic Sugar AB, Malmo-Sweden. Link: www.nordicsugar.com. June, 2014.
12. Borah A, Hazarika K, Khayer SM. Drying kinetics of whole and sliced turmeric rhizomes (*Curcuma longa* L.) in a solar conduction dryer. Information Processing in Agriculture, 2015; 2(2):85-92.
13. Ancona DB, Mercado GP, Ordonez YM, Blanco SF. Physicochemical characterization of lima bean (*Phaseolus lunatus*) and Jack bean (*Canavalia ensiformis*) fibrous residues. Food Chemistry, 2004; 84:287-295.
14. Sowbhagya HB, Florence-Suma P, Mahadevamma S, Taranathan RN. Spent residue from cumin - a potential source of dietary fibre. Food Chemistry, 2007; 104:1220-1225.
15. Prakongpan T, Nitithamyong A, Luangpituksa P. Extraction and application of dietary fibre and cellulose from pineapple cores. Food Chemistry and Toxicology, 2002; 67(4):1308-1313.
16. Ragaee S, Abdel-Aal EM, Noaman M. Antioxidant activity and nutrient composition of selected cereals for food use. Food Chemistry. 2006; 98:32-38.
17. Adiotomre J, Eastwood MA, Edward CA, Brydon AG. Dietary fibre: *in vitro* methods that anticipate nutrition and metabolic activity in humans. American Journal of Clinical Nutrition. 1990; 52:128-134.
18. Sangnark A, Noomhorm A. Chemical, physical and baking properties of dietary fibre prepared from rice straw. Food Research International. 2004; 37:66-74.
19. Raghavendra SN, Ramchandraswamy SR, Rastogi NK. Grinding characteristics and hydration properties of coconut residue: A source of dietary fiber. Journal of Food Engineering. 2006; 72:281-286.
20. Izydorczyk MS, Chornick TL, Paulley FG, Edward NM, Dexter JE. Physicochemical properties of hull-less barley fibre-rich fractions varying in particle size and their potential as functional ingredients in two-layer flat bread. Food Chemistry, 2008; 108:561-570.
21. Chau CF, Huang YL. Comparison of the chemical composition and physicochemical properties of different fibers prepared from peel of the *Citrus sinensis* L. Cv. Liucheng. J Agric Food Chem. 2003; 51:2615-2618.
22. Mongeau R, Brooks PJ. Properties, sources and determination. In Encyclopedia of Food Science and Nutrition, 2003, 3, 2nd Edition.
23. Sharma BR, Rana V, Naresh L. An overview on dietary fibre. Indian Food Industry, 2006; 25(5):39-46.
24. Michel F, Thibault FJ, Barry LJ. Preparation and characterization of dietary fibre from sugar beet pulp. Journal of the Science of Food and Agriculture. 1988; 42: 77-85.