Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2582-2845.8442

ISSN: 2582 – 2845

Ind. J. Pure App. Biosci. (2020) *8*(6), 590-597

Indian Journal of Pure & Applied Biosciences

Peer-Reviewed, Refereed, Open Access Journal

Research Article

Sugarcane Bagasse as Dietary Fibre

Seema Paroha*, V. P. Srivastava and Neelam Chaturvedi

National Sugar Institute, Kanpur

*Corresponding Author E-mail: seemaparoha@rediffmail.com

Received: 7.11.2020 | Revised: 16.12.2020 | Accepted: 21.12.2020

ABSTRACT

Comparing past and present times the degenerative disorders are seen to be on an exponential increase rate and the solution to this problem is to increase fibre intake in our diets. Hence, alternative sources of fiber must be explored. Bagasse is a rich source of fiber which could be exploited for human consumption. Bagasse was subjected to different treatments namely: steam, acid, alkali at different concentrations (0.1N, 0.25N, 0.5N, 0.75N, 1N) for different time intervals (15min, 30min, 45min, 60min). Out of these treatments acid treatment did not give best results. Analysis of chemical, functional properties, and microbial assay was carried out. Cellulose, hemicellulose, lignin content of the sample ranged from 40-52percent, 07-25percent, 09-27percent respectively. Functional properties namely: solubility index, swelling power, water absorption capacity, oil absorption capacity in the sample ranged from 1-3.25percent, 0.6-1.03percent, 6.8-9.7g/g, 2.47-9.10g/g respectively. Indigenous treated bagasse was also compared with the imported commercial product the results obtained were much better than commercial product. Thus the aim of the present study is to promote bagasse as a good source of dietary fibre which can be successfully incorporated in food products.

Keywords: *Sugarcane bagasse, Dietary fiber, Cellulose, Hemicellulose, Lignin, Functional properties.*

INTRODUCTION

Sugarcane is one of the most important crops in the tropics. As per statistics issued in 2016, Brazil is the largest sugarcane producer in the world at 38.99 MMT followed by India at 24.79 MMT[1], however, the same has increased by around 25% over the last two years. About 30-32% of bagasse is produced from 1 ton of sugarcane. Since bagasse is a by-product of the cane sugar industry, the quantity of production is in line with the quantity of sugarcane produced. Bagasse is the fibrous residue of the cane stalk left after crushing and extraction of juice. It consists of fibre, water and relatively small quantities of soluble solids mostly sugar. A typical chemical analysis of bagasse (on dry weight basis) is as follows: Cellulose 45-55 percent, hemicelluloses 20-25 per cent, lignin 18-24 per cent, ash 1-4 per cent.

Cite this article: Paroha, S., Srivastava, V. P., & Chaturvedi, N. (2020). Sugarcane Bagasse as Dietary Fibre, *Ind. J. Pure App. Biosci. 8*(6), 590-597. doi: http://dx.doi.org/10.18782/2582-2845.8442

The term ‘‘dietary fibre” which is receiving popularity as a functional ingredient is a complex mixture of indigestible polysaccharides (e.g., cellulose, hemicelluloses, oligosaccharides, pectins, gums), waxes and lignin found in plants, mainly as plant cell wall material. The most consistent definition that is now accepted is by (Trowell et al., 1985). “Dietary fibre consists of remnants of plant cells resistant to hydrolysis (digestion) by the alimentary enzymes of man”, whose components are hemicellulose, cellulose, lignin, oligosaccharides, pectins, gums and waxes. Dietary fibre can be further classified into insoluble and soluble fibre fractions. Insoluble fibre primarily promotes the movement of material through the digestive system, thereby improving laxation. The majority of insoluble fibre is fermented in the large intestine, supporting the growth of intestinal microflora, including probiotic species. Soluble fibre can help to lower blood cholesterol and regulate blood glucose levels. The insoluble fibres include cellulose, hemicellulose, and lignin; the soluble fibres include the oligosaccharides, pectins, β-glucans, and galactomanan gums (Filho & Badr, 2000). Inadequate level of dietary fibre in the diet has been implicated in many human diseases like coronary heart disease, blood pressure, obesity, hypercholesterolemia, hyperlipidemia, gall stones, varicose veins, diabetes, constipation and diverticulitis.

Sugarcane bagasse can be a rich source of dietary fibre but its major limitation is its low digestibility which is due to association of lignin with cellulose and hemicellulose. Lignin reduces the digestibility of cellulose and hemicellulose by physically protecting them against enzyme degradation. To overcome this difficulty a number of chemical and biological treatments have to be done for delignification (Tosh & Yada, 2010).

MATERIALS AND METHODS

Bagasse sample for research purpose was procured from the Experimental Sugar Factory of National Sugar Institute (NSI).

A) Delignification of the bagasse

To study the quantity of delignification the bagasse was first washed thoroughly with water to remove dust and the remaining sugar. Washed bagasse was air dried and then kept in oven for overnight at 90°C. Dried bagasse was grounded and sieved through 80 meshscreen. Sieved samples were given different chemical treatments for different time intervals. 3g of bagasse was taken in conical flask and 30ml of alkaline solution was added to it. The pretreatments include 0.1N, 0.25N, 0.5N, 0.75N and 1N of NaOH. Pretreatment was given for different time intervals 15min, 30min, 45min and 60min. Left over solid fraction resulted from filtration washed to a neutral pH & dried in an oven for 24hour at 70°C. Before and after pretreatment, bagasse was analyzed for cellulose, hemicellulose and lignin content using standard methods. From sieved bagasse, 10g sample was taken in conical flask to isolate cellulose, hemicellulose and lignin. Separation of these three was done in stages.

Samples were digested with different concentrations of NaOH and for steam they were autoclaved at 120°C for 1hour. Then the digested samples were washed thoroughly with distilled water. Alkaline extract were collected along with the washings. For each samples following was done.

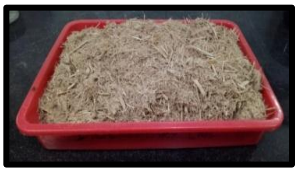
(a)Residue obtained for each sample in this step was used for estimation of cellulose after drying it at 60°C overnight. Filtrate along with the washings was acidified with 5N HCl to 2.0 pH which gave brown ppt. Brown ppt obtained was kept at 4°C in refrigerator for overnight. Settled ppt was removed from liquor by centrifugation at 4°C. After centrifugation obtained brown ppt was washed thoroughly with distilled water to neutral pH.

(b) Brown ppt obtained was oven dried overnight at 60°C, which was used as lignin.

(c) Liquid was used for hemicellulose determination.

a, b, and c of untreated and alkali treated bagasse obtained from above method were used for analysis of cellulose, hemicellulose and lignin using Semi-Micro Method**,** Orcinol Reagent Methodand Denis Reagent Method respectively (Sadasivam & Manickam, 1991).

Research Design:

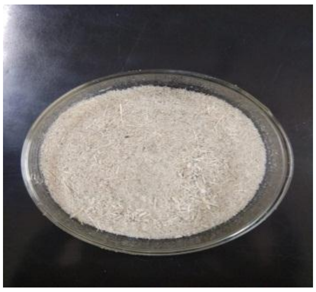


SAMPLE

DRIED SAMPLE

GRINDED SAMPLE

SIEVED SAMPLE



PRODUCT

B) Physico-chemical analysis of raw and treated bagasse

Moisture Content& Ash content of Raw and treated bagasse was estimated by (AOAC, 1980) Water Absorption and Oil Absorption Capacity by Rosario and Flores method (Rosario & Flores, 1981). Swelling Power and Solubility Index was done by Adebooye and Singh procedure (Adebooye & Singh, 2008).

RESULTS AND DISCUSSION

Bagasse is the fibrous residue of the cane stalk left after crushing and extraction of juice. It consists of total dietary fibre, mainly fibre fractions like cellulose, hemicelluloses, lignin and pectin. The determination of chemical composition of bagasse is therefore important, not only has to support clinical programme, but also to provide and validate data for legal requirements such as food labeling. Analysis of composition provides information on the basic chemical composition. These components are fundamental to the assessment of the nutritive quality of the food being analyzed.

A. Chemical composition of Untreated sugarcane bagasse

The chemical composition of untreated sugarcane bagasse shown in Table1 indicates that the moisture, ash, and crude fibre content was 23.5%, 1.2%, 57.553% respectively. However, the fat content of the bagasse was negligible. Cellulose, Hemicellulose, and Lignin of untreated sugarcane bagasse samples were 40.61%, 25.08%, and 27.22% respectively. The analysis performed and the reported values are expressed in relation to the dry weight of raw bagasse. It can be seen that the cellulose content (40.61%) obtained in the present study is at par than that reported by others from Brazil and China (Filho & Badr, 2004, Sun et al., 2004, Trindade et al., 2004, Mei et al., 2004, & Frollini et al., 2000).

Table1: Chemical composition of untreated sugarcane bagasse sample

S.No.	Parameters	Values(%)
1	Moisture Content	23.5
2	Ash Content	1.2
3	Crude Fibre	57.55
4	Fat	00.00
5	Cellulose	40.61
6	Hemicellulose	25.08
7	Lignin	27.22

Per cent swelling power, Per cent solubility index, water absorption capacity and oil absorption capacity of **untreated** sugarcane bagasse samples has been presented in **Table 2.**

Table 2: Physical properties of untreated sugarcane bagasse sample

S.No.	Parameters	Value (%)
1	Swelling Power	0.35
2	Solubility Index	2.90
3	Water Absorption Capacity	5.71
4	Oil Absorption Capacity	4.83

Despite the fact that humans cannot digest cellulose, it is nonetheless a very important part of the healthy human diet. This is because it forms a major part of the dietary fibre which is important for proper bowel movement. Since cellulose cannot be broken down and it passes through our systems basically unchanged, it increases fecal bulk and frequency of stool.As lignin reduces the digestibility of cellulose it was observed that the different treatments increased the cellulose content by breaking the ester bond between lignin and cellulose through hydrolysis reaction. Such a reaction damaged the ester bond linkage between lignin and carbohydrate and released cellulose from the encapsulation of lignin, making more cellulose exposed and available (Firdos et al., 1989).

B. Pretreatment of Sugarcane bagasse using acid + steam and alkali +steam of different concentrations

For this purpose fibres must be processed before utilizing for better absorption and assimilation. Hence, bagasse was subjected to the following treatments which include 0.1N, 0.25N, 0.5N, 0.75N and 1N of NaOH. Initially bagasse was also treated with acid of 0.1N and 1N HCL but acid did not give better results as compared to alkali. The particle size in the present study for both the untreated and the treated bagasse sample was 80 mesh.It can be observed (Table No. 3) that treated bagasse samples have better digestibility of cellulose than untreated or acid ones. Compared to untreated bagasse sample and acid treated, the alkali treated sample had lower lignin content because alkaline treatment reduces lignin and increases its solubility since lignin dissolves in alkali.

Table 3: Fibre fractions content of sugarcane bagasse samples using acid andalkali of different concentrations

S.No.	Treatment	Cellulose (%)	Hemicellulose (%)	Lignin (%)	Reduction (%) of lignin
	Untreated	40.61	25.08	27.22	-
	0.1N HCL	44.19	23.58	35.23	No reduction
	1.0N HCL	49.86	21.01	39.15	No reduction
	0.1N NaOH	40.75	24.82	21.10	22.48
	1.0N NaOH	51.32	9.40	10.23	62.41

C. Pretreatment of Sugarcane bagasse using alkali + steam of different concentrationsfor different time intervals

Sugarcane bagasse sample was given pretreatment for different time intervals 15min, 30min, 45min and 60minusing different alkali concentrations. The results revealed that, the higher NaOH concentration and the higher submersion time resulted in higher degree of delignification. But as we all know lignin is also the part of our daily food which is not harmful for human consumption instead of higher concentration of alkali we can pretreat it with 0.1N or 0.25N for maximum 30 minutes time interval, we can focus on cost effective method to make product which can give value addition to sugar industries rather on delignification.

Table 4: Fibre fractions content of sugarcane bagasse samples using different alkali concentration for different time intervals

S.No.	Treatment	Time(min)	Cellulose (%)	Hemicellulose (%)	Lignin (%)	Reduction (%) of lignin
		15	40.75	24.82	21.10	22.48
1		30	41.12	22.40	20.95	23.03
	0.1N NaOH	45	40.85	21.69	20.58	24.39
		60	41.10	20.58	20.43	24.94
		15	41.02	20.12	19.58	28.06
2		30	42.85	19.56	18.01	33.83
	0.25N NaOH	45	43.07	17.23	18.39	32.43
		60	43.12	15.42	17.71	34.93
		15	42.67	15.49	12.20	55.18
3		30	43.98	14.24	12.01	55.87
	0.5N NaOH	45	45.28	12.58	11.83	56.53
		60	45.16	11.14	11.44	57.97
		15	46.24	10.85	11.20	58.85
4		30	46.94	10.12	10.58	61.13
	0.75N NaOH	45	48.56	9.42	10.10	62.89
		60	49.89	9.26	10.06	63.04
		15	51.32	9.40	10.23	62.41
5		30	51.10	8.78	9.98	63.33
	1N NaOH	45	52.12	8.40	9.20	66.20
		60	52.49	7.10	9.53	64.98

A. Physical properties of untreated & treated sugarcane bagasse sample using alkali + steam of different concentrations

Solubility index (SI) measures the amount of product sediment after the application of low centrifugal process under specified condition. Finer the particle size higher will be the solubility index.It is important in the product development to improve the quality as well as consumer acceptability. Higher the solubility index better is the quality of the end product as it reduces the sedimentation especially in beverages because sedimentation is not an acceptable quality in any food product. Highersolubility index will also result in lower fat absorption capacity. Hencehigher solubility index is preferred.

Swelling power is the volume occupied by a known weight of the sample under controlled conditions. The sample is hydrated with water for a particular time with no external stress except gravity. Decrease in particle size increases the swelling capacity.

Water absorption (ml water/ g fibre) is the kinetics of water movement under controlled condition. Particle size of a dietary fibre has a role in colonic function by affecting transit time, fermentation and faecal bulking. The smaller the particle size the better is the water uptake.

Better water absorption capacity (WAC) can be incorporation into food products would keep the products soft and moist for a longer period. Dietary fibre with high WAC can be used as functional ingredients to avoid synergies and modify the viscosity and texture of some formulated foods.The increased W.A.C. and Swelling Power (S.P.) of digest could slow down gastric emptying and concurrently increase stomach distention, which may trigger afferent vagal signals of fullness.

Oil absorption is the ability of flours to retain oil and it is important in food applications because if oil absorption capacity of flours is high it makes the flours suitable in facilitating enhancement in flavor and mouth feel when used in food preparations. Higher oil absorption also keeps the texture of food products soft. Oil absorption capacity was observed to be higher in the treated samples than in the untreated one. Dietary fibre with high Oil Absorption Capacity (OAC) allow the stabilization of high fat food products and emulsions. Physical properties of untreated & treated sugarcane bagasse sample using alkali + steam of different concentrations are presented in Table 4.which reveals that solubility index,swelling power, water absorption capacity increased when treated with different concentration alkali & oil absorption capacity whereas oil absorption capacity showed decreasing trend except increased with 0.1 N NaOH concentration.

Table 5: Physical properties of treated sugarcane bagasse sample using acid and Alkali at different concentration

S.No.	Treatment	Solubility Index (%)	Swelling Power (%)	Water Absorption Capacity (g/g)	Oil Absorption Capacity (g/g)
1	Untreated	2.90	0.35	5.71	4.83
2	0.1N	3.65	0.9867	8.69	5.10
3	0.25N	3.90	0.8525	7.49	3.92
4	0.5N	4.00	0.6366	7.16	2.17
5	0.75N	4.35	0.6912	6.86	2.48
6	1N	4.12	0.6056	7.02	2.47

A. Chemical & Physical properties of untreated, treated (0.1N NaOH) & Commercial product of bagasse sample

The comparison of physicochemical properties of untreated, treated (0.1N NaOH) & Commercial product of bagasse samples are presented in Table 5 which shows that the physico- chemical properties of bagasse samples pretreated with the lowest concentration ie. 0.1N NaOH was better that the commercial product available in the market.

Table 6: Chemical &Physical properties of untreated, treated (0.1N NaOH) & Commercial product of bagasse sample

S.No.	Treatment	Untreated	0.1N NaOH	Commercial product
1	**Cellulose (%)**	40.61	40.75	25.15
2	**Hemicellulose (%)**	25.08	24.82	15.02
3	**Lignin (%)**	27.22	21.10	10.10
4	**Swelling Power (%)**	0.35	0.98	0.25
5	**Solubility Index (%)**	2.90	3.65	3.20
6	**Water Absorption Capacity (g/g)**	5.70	8.69	4.52
7	**Oil Absorption Capacity (g/g)**	4.83	5.10	4.17

A. Microbial study of sugarcane bagasse sample

Microbial load becomes an important issue from safety point of view as bagasse sample will be incorporated into food products. Hence, in the present study, microbial study was carried out both for untreated and Acid + steamed & Alkaline + steamed bagasse samples. In all the three groups of microorganisms, i.e., bacteria, molds andyeasts the microbial load was found only in untreated samples once treated no micro flora was detected. Sangeetha et al. (2011) studied the influence of acidtreatment, alkali treatment and steaming on the microbial load of sugarcane bagasse fibre and observed that steaming was effective in making the bagasse microbiologically safe (Sangeetha et al., 2011).

CONCLUSION

From the analysis carried out in the present study, sugarcane bagasse fibre can be considered as an alternate source for dietary fibre for fortification. As we know that dietary fibre has been claimed as a functional ingredient which is useful in nutraceutical formulations in the management of lifestyle disorders. Use of cereal bran, vegetable and fruit peels, as a source of dietary fibre is already in practice. Hence, bagasse fibre can be commercially exploited for human consumption. Generally, all these fibres cannot be consumed raw and thus have to be processed,to make fit for human consumption. The findings of the present study strongly supports bagasse as a good source of dietary fibre which can be successfully incorporated in food products and further efficacy of fibre fortified products developed may be confirmed through clinical trials. Alternate sources like bagasse fibre still needs more exploitation as it is a by-product of sugar industry, once commercialized it can be the better option which may be the source to increase the revenue of the sugar mills.

REFERENCES

Adebooye & Singh (2008). Physico-chemical properties of the flours and starches of two cow pea varieties (*Vigna uniguiculata (L.) Walp*). *Innovative Food Science And Emerging Technologies*, *9*, 92-100.

AOAC, International (1980). Official Methods of Analysis, 13th edition, Association of Official Analytical Chemists, Washington. DC.

Baphiralang, W., Kamal, G., Ravindra, U., Chandru, R., & Vijayalaxmi, K. (2012). Processing and utilization of sugarcane bagasse for functional food formulations. *J Food Process Technology*, *3*, 10.

Firdos, T., Khan, A. D., & Shah, F. H. (1989). Improvement in the digestibility of bagasse pith by chemical treatment. *FoodBiochemistry*, *2*(2), 89-92.

Filho & Badr (2000). *Biomass resources for energy in north-eastern brazil Appl Energy*, *77*(1), pp. 51-67.

Filho & Badr (2004). *Biomass resources for energy in north-eastern brazilAppl Energy*, *77*(1), pp. 51-67.

Frollini, E., Leão, A. L., & Mattoso, L. H. C. (2000). Natural polymers and agro fibers based composites, USP/UNESP and Embrapa, São Carlos, Brasil; ISBN: 85-86463-06-X.

https://www.isosugar.org/sugarsector/sugar (ISO Sugar Yearbook 2016), The Statistical Division.

Mei, L. H. I., Mattoso, L. H. C., & Curvelo, A. A. S., editors. Proceedings of fifth international symposium on natural polymers and composites (ISNaPol-2004), São Pedro, SP, Brasil; 12–15 September 2004. ISBN: 85-86463-13-2.

Rosario & Flores (1981). Functional properties of flour types on mung bean flours. *J. Sci. Food Agri.*, *32*, 172-180.

Sadasivam & Manickam (1991). Second edition, Biochemical methods. New age International Publishers.

Sangeetha, A. V., Mahadevamma, S., Begum, K., & Sudha, M. L. (2011). Influence of processed sugarcane bagasse on the microbial, nutritional, rheological and quality characteristics of biscuits. *International Journal of Food Science and Nutrition*.

Sun, J. X., Sun, X. F., Zhao, H., & Sun, R. C. (2004). Isolation and characterization of cellulose from sugarcane bagasse *Polym Degrad Stab*, *84*, pp. 331-339.

Trowell, H., Burkitt, D., & Heaton, K. (1985). Definitions of dietary fibre and fibre-depleted foods and disease. London: Academic; pp. 21–30

Tosh & Yada (2010). Dietary fibres in pulse seeds and fractions: Characterization, functional attributes and applications. *Food Res. International*, *43*, 450-460.

Trindade, W. G., Hoareau, W., Razera, I. A. T., Ruggiero, R., Frollini, E., & Castelan, A. (2004). Phenolic thermoset matrix reinforced with sugar cane bagasse fibers: attempt to develop a new fiber surface chemical modification involving formation of quinines followed by reaction with furfuryl alcohol *Macromol Mater Eng*, *289*, pp. 728-736.