Studies on Utilization of Coconut Flour as a Source of Cell Wall Polysaccharides

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ABSTRACT. *Coconut flour was obtained by extraction of virgin coconut oil from Komet DD 85 expeller. The residue left after virgin oil extraction was ground to obtain flour. The composition of coconut flour; moisture 3.7%, fat 13.4%, protein 21.8%, ash 5.1%, total sugars 18.8% and crude fiber 9.3%. When it was fractionated into different fibers, it contained 38.3% neutral detergent fiber. Out of this, 24.2% are acid detergent fibers, 14.0% hemicelluloses and 10.3% celluloses. The flour was defatted with petroleum ether. The defatted flour was deproteinized with dilute sodium hydroxide (pH 13). Defatted, deprotenized flour was extracted with 80% hot ethanol to remove sugars. The purified fiber contained 81.4% neutral detergent fiber. Out of this, 44.5% acid detergent fibre and 36.9% are hemicelluloses. It also contained 16.1% celluloses and 1.3% lignin. An ingredient formula was standardized to make acceptable coconut fiber substituted cookies. It was observed that coconut fiber could be substituted to the level of 10% to prepare cookies with good overall acceptability. The substitution level could be increased to 20% with modification of the formula to increase neutral detergent fiber content from 0.9% in the control to 6.1% in fiber substituted cookies.*

INTRODUCTION

Coconut is an important source of vegetable oil used for both edible and industrial applications. Coconut oil can be extracted either from fresh kernel (wet processing) or dry kernel (dry processing) of coconut fruit. The residue or press cake from these routes are wasted or used in animal feed to a limited extent. But this residue contains high protein (Chakraborty, 1985) and fiber contents (Trinidad *et al*., 2001), which can be utilized in preparation of various foods.

The press cake from coconut oil processing contains; proteins 19-20%, crude fiber 12% and carbohydrates 43-45% (Saittagaroon *et al.,* 1983). The composition indicates that it can be utilized in enrichment and fortification of foods if it is hygienically processed. At present, coconut oil is produced by dry processing of copra in Sri Lanka.

Due to unhygienic way of processing, the copra press cake is not suitable for human consumption. Coconut flour is produced from hygienically produced press cake obtained from virgin coconut oil extraction. Coconut flour has been incorporated in many

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food products like baked products, snack foods and steamed products up to 25% (Bayalan, 2000).

High fiber content in cereal flour can play an important role in intake of dietary fiber. Coconut dietary fiber is particularly important as it is reported to produce high amount of butyric acid in stomach, which helps in inhibiting tumor formation. Coconut flour incorporated foods show low glyceamic index, which is good for proper control and management of diabetes mellitus and in the maintenance of weight. It can reduce serum total cholesterol, LDL cholesterol and triglycerides in moderately raised serum cholesterol levels of human (Trinidad *et al.*, 2001).

The objectives of this study were to study the composition of cell wall polysaccharides of coconut, to standardize methods for isolation of food grade fiber from fresh coconut kernel and to utilize coconut fiber in preparation of cookies.

MATERIALS AND METHODS

Fully mature and seasoned coconuts obtained from Bandirippuwa estate of Coconut Research Institute were processed to obtain virgin coconut oil in DD 85 Komet expeller. The residue left after extraction of oil was ground in hammer mill to obtain coconut flour. The flour was brought to the Mahatma Phule Agricultural University, Maharastra State, India for further studies.

Chemical composition

The flour was analyzed for proximate composition; Moisture (AOAC 934.01, 1999), Fat (Pearson, 1972), Protein (Pearson, 1972), total Sugars (Nelson, 1944), Crude fiber (Pearson, 1972) and Ash (AOAC 942.05, 1990). Neutral detergent fiber (NDF), Acid detergent fiber (ADF), Hemicelluloses and Celluloses were determined using the method described by Vansoest (1963).

Methods were standardized to separate residual fat, protein and sugars present in coconut flour to obtain cellular components. The cellular components obtained after removal of fat, protein and sugars is considered as food grade fiber.

Removal of fat

Fat was removed using the method used by Sindurani and Rajamohan (1998) to prepare NDF from coconut kernel. The residue was mixed with petroleum ether (40-60^{0}C) in 1:3 ratio (w/v) and the contents were kept overnight. Then the contents were filtered to remove oil. The extraction was repeated, but reducing extraction time to 8 h. The defatted residue was dried under room temperature using a fan to remove solvent residues.

Removal of protein

Different solvents were used to remove protein from defatted residue. Series of Sodium hydroxide (of different pH from 7 to 13) and Sodium hexametaphospate (SHMP) solutions with various concentrations (0.5, 1 and 2%) were used to remove protein. The

residue and each solvent was mixed (1:3 w/v) and kept 2 h with occasional stirring in centrifuge tubes. The tubes were centrifuged at 8000 rpm. The protein content extracted by each solvent was determined (Lowery *et al.*, 1951). The solvent which removed the highest percentage of protein was selected for isolation of fibers.

Removal of sugars

The removal of sugars was standardized using aqueous alcohol (80% v/v), hot water and cool water. The defatted, deproteinized sample was extracted with each solvent for 30 min. and it was centrifuged at 10,000 rpm for 15 min. The total sugars in the extracts were determined (Nelson, 1944). The solvent removing the highest percentage of protein was used for isolation of fibers.

The process for isolation of dietary fiber from coconut kernel was carried out with optimized conditions. The fiber was analyzed for NDF, ADF, hemicelluloses, cellulose and ash.

Preparation of Cookies

The isolated fiber was used for preparation of cookies. The cookies were prepared according to AACC (1975). The standard recipe contained wheat flour 250 g, sugar 75 g, fat 125 g, corn flour 5 g, salt 1g, ammonium carbonate 1.5 g, sodium bicarbonate 1.5 g and water 50 ml. The fiber isolate was substituted 10% and 20% of wheat flour. Further, the recipe was modified to make cookies with good overall acceptability.

Sensory evaluation of cookies

Sensory evaluation was carried out using the methods described by Ranganna (1986). The cookies were evaluated for various sensory characteristics; appearance, aroma, texture and taste on 9-point scale using 25 semi-trained panelists. Mean scores for appearance, aroma, texture and taste was reported as overall acceptability. The significance differences between control and other treatments were tested using Duncan's Multiple Range test.

RESULTS AND DISCUSSION

Composition of coconut flour

Coconut flour contained; moisture 3.7%, fat 13.4%, protein 21.8%, total sugars 18.8%, crude fiber 9.3%, ash 5.1% and other polysaccharides 27.9%. The data indicated that the press cake or flour obtained after oil extraction contains appreciable amount of residual fat. It is fairly rich source of protein and fiber. Anon (1979) reported similar values of moisture (3.8-6.3%), fat (2.5-12.2%), crude fiber (9.7-20.0%), proteins (N x 6.25) (4.3-24.9%) and ash (1-5.3%) and carbohydrates (43-45%) for coconut flour. These values are correlated with the results obtained in present investigations.

Fiber in coconut flour

Coconut flour was fractionated in to various dietary fiber fractions, namely NDF, ADF, hemicelluloses, celluloses and crude fiber. The coconut flour contained 38.3% of NDF out of which 24.2% is ADF and 14.0% is hemicelluloses showing that the coconut fiber is mainly the NDF type, in which ADF is a major fraction. It contained appreciable proportion of hemicelluloses and cellulose too. The results suggest that residual fat, protein and sugars should be removed to concentrate the cell wall polysaccharides in coconut flour.

Therefore, the process was developed using the optimized conditions for removal of protein and sugars. According to results, sodium hydroxide (pH 13) removed the highest percentage of proteins from the defatted residue and hot aqueous ethanol (80^0C, 80%) removed highest percentage of sugars from the defatted and deproteinized residue. Therefore, sodium hydroxide (pH 13) and hot aqueous ethanol (80^0C, 80%) were used for isolation of food grade fiber from coconut flour.

The defatted flour was air dried to remove residual petroleum ether. The defatted flour was extracted with sodium hydroxide (pH 13). After extraction, residue was washed with distilled water to remove sodium hydroxide and then 80% ethanol was added (1:1.5) to remove sugars. The residue was washed 3 times with 80% ethanol and dried at 50-55^0C to obtain coconut fiber. The process is given in Figure 1.

The concentrated cell wall polysaccharides isolate was white in colour, odourless and had free flowing properties. The fiber composition of isolated coconut fiber is given in Table 1.

Table 1. Fractionation of coconut fiber.

Component	Content (%)
Major fiber fractions	
Neutral detergent fiber	81.4
Cellulose	16.1
Lignin	1.3
Ash	1.2
Fiber fractions in Neutral detergent fiber	
Acid detergent fiber	44.5
Hemicellulose	36.9

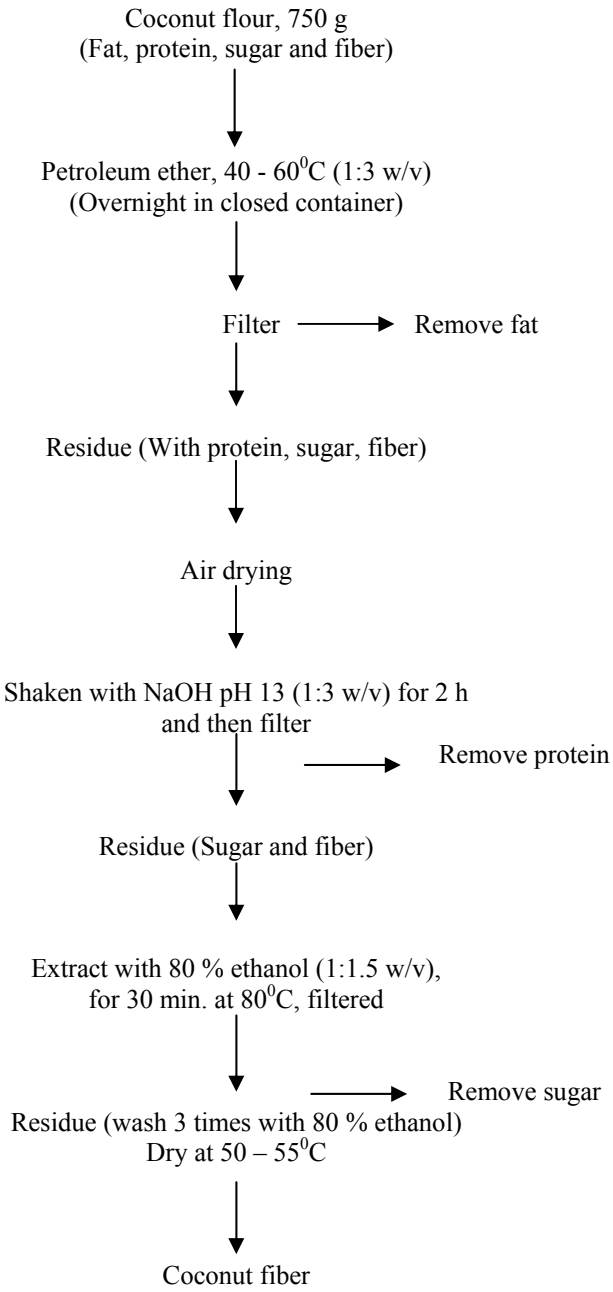

Fig. 1. Schematic diagram for preparation of coconut fiber.

The purified coconut fiber product was found to contain more than 80% of NDF of which 44.5% is ADF and 36.9% is hemicelluloses. The purification process concentrated the fiber content from 38.3 to 81.4%. The removal of fat, protein and sugar from flour enhanced the acid detergent fiber content by about twice while that of hemicellulose by more than 2.5 times in fiber product.

Components of coconut cell wall polysaccharides prepared in this method can be compared with that of cell wall polysaccharides of other sources. Sukhminder *et al*. (1992) reported wheat fiber contained; NDF 51.2%, ADF 18.9%, cellulose 13.8%, Lignin 5.1%, hemicelluloses 32.3%, and ash 5.5%. Maize fiber contained; NDF 76.4%, ADF 30.6%, cellulose 21.4%, Lignin 9.2%, hemicelluloses 45.8%, ash 0.9%. Soybean fiber contained; NDF 88.4%, ADF 39.6%, cellulose 26.6%, Lignin 12.4%, hemicelluloses 49.8% and ash 2.2%. Therefore, coconut flour can be used to isolate cell wall polysaccharides which are comparable to cell wall polysaccharides from other sources.

Utilization of coconut fiber in cookies

Coconut fiber contains 81.4% neutral detergent fiber (Table 1) and it was used for preparation of fiber fortified cookies. Fat, protein and neutral detergent fiber content of coconut fiber fortified cookies is given in Table 2.

Table 2. Composition of coconut fiber cookie.

Level of substitution							
Wheat flour : Coconut fiber	**Sugar (g)**	**Fat (g)**	**Moisture (%)**	**Ash (%)**	**Fat (%)**	**Protein (%)**	**Carbohydrates (%)**
100 : 0	75	125	0.20	0.30	29.6	4.9	0.9
90 : 10	75	125	1.20	0.49	28.7	4.8	4.1
80 : 20	75	125	1.10	0.58	28.7	5.1	7.6
80 : 20	100	175	0.39	0.26	33.2	4.5	6.8
80 : 20	150	200	0.38	0.21	30.2	4.2	6.1

Moisture content of cookies varied from 0.20 to 1.20%. The lowest moisture content was observed in the control while the highest was observed in the product where the coconut fiber was incorporated (90:10). This indicates the higher water absorption capacity of fiber. Moisture content is lower in products supplied with extra fat and sugar.

Ash content varied from 0.21 to 0.58%. Ash was contributed by both wheat flour and fiber. Ash content increased when fiber was incorporated. Fat content varied from 28.7 to 33.2%. Fat content was similar in products, when incorporated the same amount of fat, but increases when more fat was added to improve the quality of cookies. Protein content was approximately equal in control, product with 90:10 wheat flour and 80:20 wheat flour. Protein is contributed only by wheat flour. It gets reduced in other two products due to the addition of extra fat and sugar.

The NDF content varied significantly in all products from 0.9 to 7.6% with the highest value is for the product with 20% fiber with sugar (75 g) and fat (125 g). The fiber content is less in cookies with 80:20 (wheat flour:coconut fiber) improved formulae (Sugar 100 g and fat 175 g; sugar 150 g and fat 200 g). This is due to the addition of more sugar and fat. Fiber in cookies is mainly contributed by coconut fiber and wheat flour contains only 2.7% dietary fiber (Leelavathi and Rao, 1993). Therefore, coconut fiber supplemented cookies can be prepared with high fiber content.

Sensory evaluation of cookies

The results in Table 3 indicates that the appearance, aroma, taste and texture of cookies prepared without coconut fiber exhibited the highest score over other treatments. The supplementation of coconut fiber at 10% level of substitution lowers the sensory characteristics, but it scored more than 7 in all sensory attributes when compared with control product except the taste.

Table 3. Sensory properties of coconut fiber cookies.

Level of substitution							
Wheat flour : Coconut fiber	**Sugar (%)**	**Fat (%)**	**Appearance**	**Aroma**	**Taste**	**Texture**	**Overall acceptability**
100 : 0	75	125	8.4	8.3[a]	8.2[b]	8.4[c]	8.3[d]
90 : 10	75	125	7.2	7.2	6.8	7.1	7.7
80 : 20	75	125	6.9	6.5	6.1	6.4	6.5
80 : 20	100	175	6.9	6.9	6.8	7.5	7.0
80 : 20	150	200	7.6	7.8[a]	8.0[b]	8.0[c]	7.9[d]

Note: The values with same letter (a, b, c and d) are not significantly different with the control product and the fiber substituted cookies from improved formula at 5 % level.

When the level of substitutions were increased to 20%, the sensory properties were significantly decreased, particularly the taste. Attempts were made to improve the sensory properties of cookies with 20% level of substitution of coconut fiber by increasing fat and sugar content. The cookies with improved formula scored very close to the control product and the aroma, taste, texture and overall acceptability was not significant with the control product.

CONCLUSIONS

The coconut flour obtained from oil extraction from Komet DD 85 contained; moisture 3.7, fat 13.4, protein 21.8, total sugars 18.8, crude fiber 9.3 and ash 5.1 g/100g. It also contained 38.3% of NDF, 24.2% of ADF, 14.0% hemicelluloses and 10.3% celluloses.

The isolated coconut cell wall polysaccharides (coconut fiber) contained 81.4% NDF, out of which 44.5% is ADF, and 36.9% is hemicellulose. It also contained 16.1% cellulose, 1.3% lignin and 1.2% ash.

Coconut fiber supplemented cookies were acceptable with 10% level substitution of coconut fiber. Use of additional sugar and fat by 30% each in the ingredient formula facilitated to incorporate coconut fiber to the extent of even 20%, to produce excellent quality cookies. Incorporation of 20% coconut fiber in wheat flour improved the NDF content of cookies from 0.9% (control) to 6.1% in 20 % coconut fiber substituted cookies with modification of the formula.

ACKNOWLEDGEMENTS

Authors convey their gratitude to Dr. (Mrs.) C. Jayasekara, Director/Coconut Research Institute, Lunuwila, and Prof. H.P.M. Gunasena, Executive Director, Council for Agricultural Research Policy, Colombo 7, for the financial assistance given for the Postgraduate Degree leading to M.Sc. in Food Science and Technology under ICAR-CARP Work Plan 2003-2004. The facilities provided by the Mahathma Phule Agricultural University, Maharastra State, India are also greatly acknowledged.

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