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Pre-treatment effect on the nutritional and functional properties of selected cassava-based composite flours

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ABSTRACT

The low protein and lack of gluten in cassava (*Manihot esculenta* Crantz) are disadvantageous for its use for product development and is overcome through the use of composite flours incorporating cereal and/or legume flours. The functionality and nutritional attributes of cassava flour were altered in the present study by pre-treatment with termamyl and green gram amylase, pre-gelatinization and subsequent blending with cereals, legumes, bran sources etc. Malting of cassava flour with termamyl followed by pre-gelatinization reduced the starch and increased the sugar content of the mixes. Pre-gelatinization had little effect on the crude protein of the mixes; nevertheless, the fat content was higher by 0.15–1.0 units. Energy content was around 1176 and 1217 KJ/100 g for the rice bran added mixes from malted cassava, which slightly increased in the respective pre-gelatinized cassava mixes. The peak viscosity of termamyl treated cassava-based flour mixes was much lower than the respective gram amylase based mixes, indicating that the latter had much less amylolytic activity than termamyl and pre-gelatinization further reduced the viscosity. The very low viscosity for the enzyme treated cassava-based mixes was due to the inability for retrogradation of the hydrolyzed starch. Significant improvement in *in vitro* starch digestibility (IVSD) (enhancement by 5.0–16.0 units in termamyl treatment *vs* 5.0–9.0 units in gram amylase treatment) was observed for the pre-gelatinized mixes. Lowest IVSD (25–29 units) was for the two bran based mixes, suggesting its use in the nutrition therapy for controlling obesity linked diseases.

Industrial relevance: With the development in human society, the incidence of chronic diseases like diabetes, cancer, cardiovascular problems and conditions like obesity contributing to several diseases is on the increase. This has led to an increasing awareness and research efforts on the development of functional foods, pharmafoods etc, which have wide potential application in medical nutrition therapy. The present work aims at improving the nutritional and functional attributes of cassava through fortification with cereal and/ or legume flours, bran sources etc. and through pre- treatment with enzymes to improve the functionality and reduce the energy content. The study led to the development of cassava based composite flours with low starch digestibility, high protein content and low energy content which could be effectively utilized for developing designer foods for obese and diabetic people. Enhanced digestibility of pre- gelatinized malted flours from cassava finds potential application for the development of foods for geriatric and convalescent people.

1. Introduction

Cassava (*Manihot esculenta* Crantz), cultivated in more than 102 countries of the world for its edible starchy tubers, is consumed as a dietary source of energy by around 500 million people (FAO, 2000). Nevertheless, the very low protein content (<1.0% on FW basis) and absence of gluten are considered disadvantageous for its exclusive use in food products, especially in those, where elasticity of the dough is essential for product quality. Efforts have been made worldwide by the researchers, to overcome this through the use of composite flours (Chatelanat, 1973; Kim & de Ruiter, 1968).

The Composite Flour Programme, originally introduced by the FAO aimed at the development of bakery products from locally available materials. Subsequently, the definition changed and the technology is presently used to develop a range of products with differences in nutritional, functional and textural attributes (Akubor & Ukwuru, 2003; Chavan & Kadam, 1993; Devi, Nerlekar, Zanver, Pagare, Deshmukh & Kalbande, 2000; Estevez, Figuerola, Vasquez, Castillo, & Yanez, 1987). In contrast to the earlier concepts of taste, mouthfeel and nutritional quality of food products, lot of importance is given of late for the functional and prophylactic/therapeutic benefits, a food can offer to the consumers. Depending on the type of ingredients used, the functionality and nutritional attributes of food products could be altered to develop designer foods (Marques, Bora, & Narain, 2000; Singh, Bajaj, Kaur, & Sidhu, 1993). Owing to their ability to provide better nutrition, prevent diseases and ensure a healthy life, the functional food market is expected to witness a

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Table 1
Starch and sugar content of composite flours from malted cassava (Termamyl treated)

Treatment combinations	Malted flour		Pre-gelatinized malted flour[a]	
	Starch (%)	Sugar (%)	Starch (%)	Sugar (%)
Cassava (70): WWF (20): CP (10) (T1)	69.50 ± 2.03	5.20 ± 0.85	58.30 ± 1.35	11.00 ± 1.02
Cassava (70): CP (30) (T2)	67.16 ± 2.12	5.31 ± 0.75	55.82 ± 1.54	13.62 ± 1.25
Cassava (70): FM (30) (T3)	64.00 ± 1.35	4.50 ± 0.98	60.34 ± 1.65	10.90 ± 1.04
Cassava (70): Wheat bran (30) (T4)	67.00 ± 2.31	5.40 ± 0.89	65.25 ± 1.36	13.15 ± 1.12
Cassava (70): Rice bran (30) (T5)	61.50 ± 0.65	3.90 ± 0.65	58.22 ± 1.46	10.30 ± 1.03
Cassava (70): PRF (30) (T6)	64.50 ± 0.98	3.70 ± 0.25	60.62 ± 1.62	10.00 ± 1.04

[a] Pre-gelatinized flour mixes are represented by T1p–T6p in the text; Each value is Mean ± S.D of six observations.

rapid growth in the coming years. Cassava flour was fortified with legume/cereal flours, bran sources etc. and the nutritional quality and physical properties of such composite flours were studied in our laboratory (Jisha & Padmaja, 2004, 2005; Jisha, Moorthy, & Padmaja, 2005). The effects of malting and pre-gelatinization in modifying the nutritional and functional properties were further studied and reported here.

2. Materials and methods

2.1. Samples

2.1.1. Cassava flour

Edible grade cassava flour was prepared from peeled tubers of the cassava variety, M4, grown at the Institute Farm. The peeled tubers were sliced to chips of uniform thickness (0.5 cm) and sun-dried for 48 h. The dry chips were powdered in a hammer mill and sieved through a fine mesh sieve.

2.1.2. Legume flour

Chick pea (Cp) flour (*Cicer arietinum*) was purchased from the local market, sieved through the same sieve and used for the study. Green gram (*Vigna radiata*; Gg) required for the preparation of native amylase, was procured from the local market.

2.1.3. Cereal flours

Whole wheat flour (WWF) available in the local market was used. Finger millet (*Eleusine coracana* (*L.*) Gaertener) was procured from the local market, cleaned and washed to remove dirt, sun-dried, powdered and sieved to get the flour (FM).

2.1.4. Wheat bran

Edible grade wheat bran (WB), marketed by M/s Bagrrys India Ltd., New Delhi, India was used.

2.1.5. Rice bran

Edible grade rice bran (unstabilized; RB) procured from local rice mills was sieved to remove coarse fractions and used.

2.1.6. Popped rice flour (PRF)

Popped rice was procured from the local market, dried overnight at 60 °C in an air oven and powdered in a blender for use.

2.1.7. Enzyme sources

Termamyl 60 L (thermostable alpha-amylase) was procured from M/s Novo Industries, Denmark. Native amylase was prepared from green gram as follows: Green gram was soaked overnight and then drained. The soaked legume was spread on a moist paper and allowed to germinate for 18 h. The alpha-amylase activity was quantified each day after germination following the method of Bernfeld (1955). Maximum α-amylase activity of 3.30 units per ml of the extract (1 unit = mg reducing sugars liberated during 15 min incubation at 30 °C) was observed during the 3rd day of germination and hence this enzyme was used for the study.

2.2. Flour mixes

2.2.1. Preparation of malted cassava flour

Termamyl (120 mg) was added to 500 g cassava flour, moistened earlier with 400 ml water to raise its moisture content to 60%. Mixed thoroughly and incubated for 18 h at 55 °C. Loss of water during incubation was replaced to enable enzyme action. After incubation, the flour was dried at 70 °C overnight, powdered and used for blending with other ingredients. Alpha-amylase was extracted from One hundred gram of the germinated green gram paste using distilled water (20 ml) (3.3 units of alpha-amylase activity/ml of the extract) and added to pre-moistened cassava flour, mixed well and incubated for 18 h for 55 °C. The flour was then dried and powdered.

2.2.2. Preparation of pre-gelatinized malted flour

Part of the malted flour (termamyl and native amylase treated) was partially dried to a moisture level of 40% and subjected to hydrothermal treatment in a Steam Cooker for 30 min. The cooked flour was dried, powdered and used for the study.

2.2.3. Flour mixes

Six flour mixes were prepared from each type of malted cassava flour, based on the earlier studies on low calorie mixes (Jisha & Padmaja, 2005). The treatment combinations were: T1 (70% cassava flour + 20% whole wheat flour + 10% chick pea flour), T2 (70% cassava flour + 30% chick pea flour), T3 (70% cassava flour + 30% finger millet flour), T4 (70% cassava flour + 30% wheat bran), T5 (70% cassava flour + 30% rice bran) and T6 (70% cassava flour + 30% popped rice flour). In the treatments, T1–T6, termamyl based malted flour was used. The respective combinations with native amylase based malted flour were designated T7–T12. The pre-gelatinized combinations are represented with a suffix ‘p’ also.

2.3. Nutritional studies

The various composite flours were analysed for the nutritional parameters, *viz*., starch, total sugars, crude protein and fat by standard procedures. The starch and total sugars were estimated by the titrimetric method standardised in our laboratory (Moorthy & Padmaja, 2002). Crude protein was determined by the Kjeldahl method by multiplying the nitrogen content with a factor of 6.25 (AOAC, 1960). The total fat (ether extractives) was determined by the method of Folch, Lees, & Sloane Stanley (1957). The energy value was computed using the Atwater formula (FAO/WHO, 1985) as:

$$\text{Energy (KJ/100g)} = 17\ (\%\ \text{protein}) + 38\ (\%\ \text{fat}) + 17\ (\%\ \text{starch}) + 16\ (\%\ \text{total sugars})$$

2.4. Functional studies

The viscosity of the malted flour mixes as well as pre-gelatinized malted combinations was studied using the Rapid Visco Analyser (New Port, Australia). *In vitro* starch digestibility of the flour mixes

Table 2
Starch and sugar content of composite flours from malted cassava (gram amylase treated)

Treatment combinations	Malted flour		Pre-gelatinized malted flour[a]	
	Starch (%)	Sugar (%)	Starch (%)	Sugar (%)
Cassava (70): WWF (20): CP (10) (T7)	69.95 ± 0.35	5.90 ± 0.35	66.31 ± 1.64	5.76 ± 1.06
Cassava (70): CP (30) (T8)	67.50 ± 0.98	6.55 ± 0.68	64.72 ± 1.46	6.41 ± 1.07
Cassava (70): FM (30) (T9)	68.50 ± 0.65	4.75 ± 0.46	67.45 ± 1.37	5.03 ± 1.04
Cassava (70): Wheat bran (30) (T10)	69.10 ± 0.48	7.18 ± 0.78	69.56 ± 1.74	6.25 ± 1.16
Cassava (70): Rice bran (30) (T11)	57.50 ± 1.20	5.50 ± 0.65	59.15 ± 1.37	5.55 ± 1.35
Cassava (70): PRF (30) (T12)	68.50 ± 0.97	5.70 ± 0.97	67.15 ± 1.26	6.25 ± 1.25

[a] Pre-gelatinized flour mixes are represented by T 7p–T 12p in the text.