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Rheological and Nutritional Characteristic of Weaning Mush Prepared from Mixed Flours of Taro [*Colocasia esculenta* (L) Schott], Pigeon Pea (*Cajanus cajan*) and Malted Maize (*Zea mays*)

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Abstract: An infantile flour was prepared from mixed flours of Taro (*Colocasia esculenta* (L) Schott), leguminous plant (*Cajanus cajan*) and maize (*Zea maïs*) was prepared. This flour contained 70% total carbohydrates, 15.7% proteins and 4.6% lipids. It also characterized by some essential amino acids such as histidine, threonine, valine, lysine, leucine and phenylalanine. It had some fatty acids (linolein acid, oleic acid) and some essential minerals such as calcium, magnesium, iron, copper, zinc, phosphorus, potassium, chloride, sodium, manganese in variable concentrations. These minerals and fatty acids are necessary for children growth. The energy density of mush prepared from this mixed flour was very high (about 119 kcal/100 ml). This weaning mush had a fluid consistency, the important rheological characteristic for young children energy intake.

Key words: Infantile flour, weaning mush, energy density, fluid consistency

INTRODUCTION

In Africa's local language, weaning is merged in breast-feeding substitution by solid food. Therefore, from fourth to sixth months the infant is bound to family meals or to eating gruels made of cereal or tuber flours. Even, if cereals and tubers represent important carbohydrates and fibres source for worldwide population (Helland *et al*., 2002), their nutritional quality and their derivate products remain poor than milk products (Blandino *et al*., 2003). In deed on the one hand, the composition in nutriment of baby's cereal is poor (De Benoist, 1994; Trèche, 1998); on the other hand, the richness in starch gives a high viscosity to the gruels (Moursi *et al*., 2003; Vieu *et al*., 2001). The limited gastric capacity in infants was about 30-40 ml / kg body weight (Sanchez-Grinan, *et al.*, 1992). As matter of fact, preparing mush is not a simple flours cooking in water but that needs a mastery of the nutritional value of flour, consistency of mush and energy density.

That's why, we suggested in this study weaning mush prepared from mixed flours of Taro, leguminous plant and malt maize with nutritional properties in accordance to WHO criteria (1998).

MATERIALS AND METHODS

Raw material plant: Raw materials used in mixed flours production were constituted of low ground Taro (*Colocasia esculenta*), seeds of Pigeon pea (*Cajanus cajan*) and malted maize (*Zea mays).*

Production of flours

Taro flour: Taro was peeled, washed, jagged, washing at 90°C during 5 min and then dried in an incubator at 65°C during 5 days. Then, the dried pieces of taro were crushed with a Forplex type grinder. Flour was obtained after sieving with sieve diameter from 180-500 µm.

Malted maize flour: Seeds are soaked during 48 h then spread out on cloth humidified for 3 days. Malted maize is dried, sorted out, degermed and crushed. After sieving from 180-500 µm size sieves, malted maize flour was obtained.

Pigeon pea flour: Seeds are sorted, washed, roasted and then crushed with Forplex type grinder. Flour was obtained after sieving with size sieve diameter from 180-500 µm.

Preparation and characterization of weaning mush: Mush was prepared in aluminium saucepan and different proportions of Taro, Pigeon pea and malted maize flours were mixed in water (180 ml) in accordance with Mouquet method (1998). The flow distance (mm / 30 sec) of the gruels obtained was measured using a Bostwick consistometer according to the method used by Vieu *et al*. (2001). Dry Matter contents (DM) and consistency of mush were followed; the objective was to establish the best possible formulation.

Preparation of compound flour: The weaning flour is a mixing of Taro, Pigeon pea and malted maize flours and sucrose in proportions 58/18/14/10.

Biochemical analyses: The Dry Matter contents (DM) of 1g of sample was measured after flours drying in an oven at 105°C for 24 h according to AOAC (1990).

Ash content (5 g) was determined by incineration of flour at 500°C in an oven.

Chloride was determined by the method of mercury measurement, Phosphates by Briggs's method and iron for colorimetric method of Orthophenanthroline (Audigie *et al*., 1978).

Magnesium, Potassium, Sodium, Calcium, Zinc, Copper and manganese were determined by spectrometry of atomic absorption, Perkin-Elmer, Model 1100 (BIPEA, 1976).

The dosage of total nitrogen contents of flours was analyzed by a Kjeldahl method with a Kjeltec digester and distilling (AOAC, 1990). One gram of the flour was used for analysis. Protein contents of the samples were calculated by multiplying the nitrogen content by 6.25 the conversion coefficient.

Lipid contents were determined by the method of extraction with Soxhlet using n-hexane (AOAC, 1990).

Total carbohydrates and total sugars were determined according to the method of Bertrand and Thomas (1910). Starch content was deducted by calculating the difference between total carbohydrates content and total sugars content.

Dietary fibres contents were determined by the gravimetric method of Prosky *et al*., 1984.

Amino acid analysis of weaning flour were measured out by liquid chromatography high performance in inverse phase (Colonne PTC RP-18, 220 mm long, 2.1 mm intern diameter and pré-colonne, Applera Corp, Fosters City, CA, USA). The sample is hydrolysed in vacuum at 150°C during 60 min in Pico-Tag station (Waters, Milford, MA, USA) with HCl 6 N at 1% phenol. Amino acids are separated in two buffer solution. Results are exploited thanks to application program Model 600 Data Analysis System.

Fatty acids are measured out by chromatography on gaseous phase. The sample (100 mg) is firstly methyled by BF_3 , at 14% concentration in Methanol. The methyled esters are analyzed on a chromatograph on gaseous phase type HP 6890 series GC system. Fatty acids are identified thanks to fatty acids of reference.

Determination of the energy density in kilocalorie: The Energy Density (DE) was calculated with 4 kcal /g for carbohydrates, 4 kcal /g for proteins and 9 kcal /g for lipids according to Atwater and Benedict (1902) by the product of dry matter content of weaning mush.

DE = [9 x Lipids (%) + 4 x Proteins (%) + 4 x Carbohydrates (%)] x DM (%)

RESULTS AND DISCUSSION

Chemical composition of simple flours: Chemical composition of Taro, Pigeon pea and malted maize flours is shown in Table 1. Total carbohydrates contents were 82.6, 58.5 and 75.8% respectively Taro, Pigeon pea and malted maize flours. Taro flour had a good source of carbohydrates. And proteins contents were 8.8% for Taro, 26.5% Pigeon pea and 10.0% malted maize. Pigeon pea flour could be used to enrich Taro flour in protein. Total ash contents were variable 4%, 4.5% and 1.9% respectively for Taro, Pigeon pea and mated maize flours.

Dry contents and consistency of Taro mush according to Taro flour quantity were represented in Table 2. We observed a considerable increase in dry matter content (2 at 12.8% DM) as one goes along the quantity of Taro flour increased. In the same time, the flow distance (mm/30 sec) of the gruel measured using a Bostwick consistometer decreased to nullify. At 30 g of Taro flour, the flow distance of Taro mush become null.

As soon as the proportions of the malted maize mixed increased, the fluidity of mush improved (10 at 130 mm / 30 sec) and accompanied by increase of dry matter content. It was a brought of 16.2% of malted maize which gave the best consistency (90 mm/ 30 sec) with 16.20% dry matter (Table 3).

Table 1: Chemical composition of Taro, Pigeon pea and malted maize flours

Characteristics (mg /100g DM)	Flours		
	Taro	Pigeon pea	Malted maize
Total carbohydrates (%)	82.6 ± 2.0	58.5 ± 0.0	75.8 ± 0.0
Starch (%)	74.1 ± 0.5	41.6 ± 1.0	25.5 ± 0.0
Proteins (%)	8.8 ± 0.2	26.0 ± 0.5	10.9 ± 0.0
Fatty matter (%)	0.1 ± 0.0	1.8 ± 0.3	6.8 ± 0.5
Ash (%)	4.0 ± 0.2	4.5 ± 0.2	1.9 ± 0.1
Cellulose (%)	4.5 ± 0.1	8.7 ± 0.5	4.6 ± 0.0

Table 2: Dry matter and consistency of Taro gruel variation as a function of quantity of Taro flour

Rheological characteristics	Quantity of Taro (g)					
	5	10	15	20	25	30
Bostwick flow distance of Taro gruel (mm/30 s)	230	190	90	70	10	0
Dry matter of Taro gruel (%)	2.0	4.3	6.7	8.6	10.5	12.8

Table 3: Dry matter and consistency of gruel prepared with a fixed quantity of Taro (30 g) and variable proportions of malted maize

Rheological characteristic	Quantity of malted maize flour (g)			
	2	4	6	8
	Percentage of incorporation (%)			
	6.7	13.3	16.2	16.8
Dry matter of gruel (%)	14.8	15.5	16.2	16.8
Bostwick flow distance of gruel (mm/30)	10	60	90	130

Table 4: Consistency and proteins content of gruel prepared from variable proportions of Taro and Pigeon pea flours

Pigeon pea flour (%)	100	70	30	15
Taro flour (%)	0	30	70	85
Bostwick flow distance of gruel (mm/30 s)	0	0	0	0
Proteins of gruel (%)	28	20.5	15.8	10.0

Table 5: Elaboration of weaning flour constituted by Taro, Pigeon pea and malted maize flours

Nº testing of formulation	Ingredient	Incorporation (%)	Bostwick flow distance of gruel (mm / 30 s)	Dry matter of gruel (%)
1	Taro flour	85	0	10.10
	Pigeon pea flour	0		
	Malted maize flour	0		
	sucrose	15		
2	Taro flour	68	0	14.2
	Pigeon pea flour	20		
	Malted maize flour	0		
	sucrose	12		
3	Taro flour	60	70	32.4
	Pigeon pea flour	18		
	Malted maize flour	12		
	Sucrose	10		
4	Taro flour	58	90	30.9
	Pigeon pea flour	18		
	Malted maize flour	14		
	Sucrose	10		
5	Taro flour	66	90	16.6
	Pigeon pea flour	20		
	Malted maize flour	14		
	Sucrose	0		

Table 6: Nutritional value of weaning flour prepared by a combination (58/18/14/10) of Taro, Pigeon pea, malted maize flours and sucrose

Nutriments (g for 100 g of flour)	Weaning flour	Standard flour (Sanogo, 1994)
Moisture	4.5 ± 0.3	5
Total carbohydrates	70.0 ± 2.0	68
Cellulose	3.4 ± 0.8	5
Proteins	15.7 ± 0.2	13
Fatty matter	4.6 ± 0.6	7
Ash	1.8 ± 0.2	2
Minerals (mg / 100 g)		
Phosphorus	42 ± 0.5	-
Chloride	74 ± 0.8	-
Magnesium	70 ± 0.9	-
Calcium	13 ± 0.7	-
Potassium	730± 1.5	-
Sodium	60 ± 0.2	-
Zinc	10 ± 0.1	-
Manganese	4 ± 0.05	-
Iron	10 ± 0.1	-
Copper	2 ± 0.05	-

Different testing of formulation were carried out with the flours of Taro, malted maize, Pigeon pea and sugar (Table 5). Formulation 4 present 30.9% of dry matter content and 90 mm/30 sec of consistency of mush was the best formulation of infant flour. That formulation respected the criteria of WHO (1998).

Nutritional value of weaning flour formulated: The compound flour basis of Taro, Pigeon pea and malted maize contained 70% of total carbohydrates, 15.7% not sufficient to cover the young children needs (De Benoist, 1994). This deficit could be filled by the minerals provided by the weaning flour. The consumption of this infantile flour could protect the children from infantile malnutrition.

Further, the fatty acids content and amino acid profile of weaning were presented respectively Table 7 and Table 8. Nine fatty acids were identified with four fatty acids of short chain (caprylic acid, capric acid, lauric acid and myristic acid); two of middle chain (palmitic acid and palmitolein acid) and three of long chain (stearic acid, oleic acid and linoleic acid). Linoleic acid was a polyunsaturated acid which had a beneficial effect on the nervous system development (Bourre, 1996; Vancassel, 2004). Oleic acid was not an essential fatty acid but it had a preventive role on cardiovascular disease (Bouderlique *et al*., 1997). Fatty acids of weaning mush would supply some calories necessary to young child to stay alive. Seven essential amino acid werre obtained in weaning flour (Table 8). Threonine (50,6 mg/g protein), valine (60 mg/g protein) and isoleucine (49, 7 mg/g protein) were in the majority compared to the FAO/UNICEF reference protein (1986). The lysine content collected from weaning flour (47.7mg /g protein) was lower than values reported on FAO reference protein. These essential amino acids would be useful of synthesis protein.

The infant flour mush had a high energy density (119 kcal/100 ml of mush) true to international criteria of WHO/UNICEF (1998). This energy could be sufficient to satisfy the energy needs of young children. Moreover, the

Table 7: Fatty acids of weaning flour prepared by a combinaison (58/18/14/10) of Taro, Pigeon pea, malted maize flours and sucrose

Common name of fatty acids	Content in fatty acids (mg/100 g total fatty acids)	Criteria of FAO/ WHO (mg/100 Kcal of flour)
Caprylic acid (C_8 : 0)	4.21	-
Capric acid (C_{10} : 0)	4.32	-
Lauric acid (C_{12} : 0)	1.89	-
Myristic acid (C_{14} : 0)	3.65	-
Palmitic acid (C_{16} : 0)	25.4	-
Palmitoléic acid (C_{16}) 9)	3.04	-
Stéaric acid (C_{18} : 0)	18.6	-
Oléic acid (C_{18}) 9)	32.7	-
Linoléic acid (C_{18}) 9, 12)	6.15	> 480 mg

Table 8: Essential Amino acids of weaning flour prepared by a combinaison (58/18/14/10) of Taro, Pigeon pea, malted maize flours and sucrose

Essential amino acids	mg/g of protein	Criteria of FAO /OMS (mg/g protein)
Histidine	18.8	26
Threonine	50.6	43
Valine	60.0	55
Lysine	47.7	66
Isoleucine	49.7	46
Leucine	72.4	93
Phenylalanine + Tyrosine	47.8	72
Cystine + Methionine	-	42
Tryptophan	-	17

Table 9: Density energy of mush weaning prepared by a combinaison (58/18/14/10) of Taro, Pigeon pea, malted maize flours and sucrose

Dry matter of weaning mush prepared from mixed flours (%)	30.90
Density energy of weaning mush prepared from mixed flours (kcal / 100 ml of mush)	119

Density energy of weaning mush = [(4. 6x9)+(70x4)+(15.7x4)]x30. 90%

supply of malted maize has improved the consistency of mush flour infant. The children would eat easily that gruel.

Conclusion: The results obtained from the analysis of weaning flour and weaning mush prepared from mixed flours showed that this infantile flour could cover the energy's needs and nutriments needs of young children. The weaning flour prepared from mixed flours of Taro, Pigeon pea and malted maize contained some protein in important quantity, several minerals, essentials amino acids and fatty acids like linoleic acid. Therefore, the mush weaning had a good consistency, a good content of dry matter and high energy density sufficient for children.

REFERENCES

AOAC, 1990. Official Methods of Analysis. 15th Ed., Association of Official Analytical Chemistry, Washington, DC.

Atwater, W.O. and F.G. Benedict, 1902. Experiments on the metabolism of matter and energy in human body, 1898-1900. United States. Office of experiment *stations*. Bulletin No. 109. Government Printing Office, Washington, DC.

Audigié, C., J. Figarella and F. Zonszain, 1978. Manipulations d'analyse biochimique, Doin éditions, Paris.

Bertrand, G. and P. Thomas, 1910. Guide pour les manipulations de chimie-biologique, Dunod éd., Paris, p: 67.

B.I.P.E.A., 1976. Bureau interprofessionnel d'Etudes Analytiques. Recueil des Méthodes d'Analyses des Communautés Européennes.

Bouderlique, J.R., G. Mann and D. Aignan, 1997. Nutrition humaine et industrie agro-alimentaire. Techniques de l'ingénieur, Traité Génie des procédés, P: 1-16.

Bourre, J.M., 1996. Développement du cerveau et des acides gras polyinsaturés. OCL, 3: 173-177.

Blandino, A., M.E. Al-Aeeri, S.S. Pandiella, D. Cantero and C. Webb, 2003. Cereal-based fermented foods and beverages. Food Res. Int., 36: 527-543.

De Benoist, B., 1994. Le sevrage: un défi pour l'enfant et pour sa mère. In: Trèche S., De Benoist B., Benbouzid D., Delpeuch F., L'alimentation de complément du jeune enfant, p: 7-13.

F.A.O/OMS/ONU, 1986. Besoins énergétiques et besoins en protéines. Séries Rapports Techniques N°724, Genève, OMS.

Helland, M.H., T. Wicklund and J.A. Narvhus, 2002. Effect of germination time on alpha-amylase production and viscosity of maize porridge. Food Res. Int., 35: 315-321.

Moursi, M., M. Mbemba and S. Trèche, 2003. Does the consumption of amylase-containing gruels impact on energy intake and growth of Congolese infants. Public Health Nutr., 6: 249-257.

Mouquet, C., 1998. Bulletin du Réseau Technologique et Partenariat en agro-alimentaire.

Prosky, L., N.G. Asp, J. Furda, J.W. de Vries, T.F. Schweizer and B.F. Harland, 1984. AOAC, J. Int., 67: 350-356.

Sanogo, M., 1994. La production artisanale de farines infantiles: expériences et procédés. Paris, Les editions du GRET, 80 p.

Sanchez-Grinan, M.I., J. Person and K.H. Brown, 1992. Effect of dietary energy density on total at libitum energy consumption by recovering malnourished children. European J. Clin. Nutr., 46: 197-204.

Trèche, S., 1998. Les aliments de compléments: Enjeux, contraintes et potentialités. Bulletin du réseau TPA, 5-7.

Vancassel, S., 2004. Oméga 3 et neurotransmission cérébrale. OCL., 11: 59-63.

Vieu, M.C., T. Traoré and S. Trèche, 2001. Effects of energy density and sweetness of gruels on Burkinabe infant energy intakes in free living conditions. Int. J. Food Sci. and Nutr., 52: 213-218.

WHO/UNICEF, 1998. Complementary feeding of young children in developing countries: a review of current scientific knowledge. UNICEF/ University of California-Davis /WHO/ORSTOM, Geneva: WHO/NUT/98., 1.