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Development of instant breakfast cereals from optimized flours of pearl millet, red and white sorghum

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ABSTRACT

Objective: This was to develop instant breakfast cereals from optimized flours of red and white sorghum and pearl millet.

Methodology and results: Breakfast cereals were developed from optimally treated flours of red sorghum, white sorghum and pearl millet. Legume complementation was done using pigeon peas. Other ingredients included pigeon peas, wheat, sugar, salt, water and fat. Control products contained the same ingredients but with untreated flours and without the pigeon peas. The most preferred breakfast cereal was determined through sensory evaluation. A comparison of the most preferred product with two breakfast cereals in the market and shelf life analysis was also done.

Conclusion and application: The developed breakfast cereals from optimized fours of sorghum and millet were generally acceptable to the consumer with their nutritive values being as high as that of similar products in the market. This technology can be adopted, further refined and up scaled to be used by interested entrepreneurs to process sorghum and millet based breakfast cereals for commercial purposes. In this way these orphaned crops can be revived and the technologies developed to detoxify the anti-nutrients associated with them adopted in their utilization.

INTRODUCTION

In order to encourage consumption and utilization of sorghum and millets, domestic and commercial product development can be employed as has been the case in many other countries which use these cereals as their staples. Convenient ready to eat foods especially cereal products are on the increase as favorite foods in urban areas. Since it is in these places that the consumption of these cereals has had a sharp decline, research was undertaken to develop ready to eat breakfast cereals from red sorghum, white sorghum and pearl millet. The three cereals were first treated by alkali, malting and fermentation in order to detoxify the anti-nutrients tannins and increase their nutritive value before crushing them into flours for use in developing the breakfast cereals. Several ingredients including, pigeon pea flour, oil, sugar, wheat flour, and salt were used during the product development. biochemical, sensory and shelf life analysis of the developed breakfast cereals were carried out and the results compared with the existing products in the market.

MATERIALS AND METHODS

Cereals and legume: The cereals and the legume were obtained from Mwingi District one of Kenya's ASAL regions. Sampling was done three times from different sources. The first samples of the cereals were obtained from farmers' stores from previous harvest, the second sampling was from the current harvest and the third were from local cereal stores in that town. The varieties of the sorghums, *Sorghum bicolor (L) Moench* acquired were white sorghum -KARI *Mtama* 1 (KM1) and the red sorghum-*Seredo*. The pearl millet *Pennisetum glaucum*, variety was ICMV and the legume was pigeon peas, *Cajanus cajan*.

Methodology: In order to improve the nutritional quality of the cereals, several treatments were applied including alkali treatment, malting and fermentation (Au and Fields, 1981; Muindi and Thomke, 1981; Butler, 1988; Udayasekhara Rao and Deosthale, 1988; Osuntogun et.al*.,* 1989; Mukuru, 1992; Egli et al*.,* 2002; Yasmine, 2002,). After subjecting the grains to alkali treatment and malting, flours were made and fermentation done. The subsequent ferments were used to prepare breakfast cereals with the addition of pigeon peas, wheat flour, salt, sugar and oil. Preliminary trial recipes were prepared and tested before an acceptable one was adapted. After the product development, packaging was done in transparent polyethylene bags and the products stored at room temperatures (25ºC) in a dry cupboard. Sensory evaluation was done to determine the most preferred breakfast cereal product among the 3 cereals. Organoleptic parameters of color, taste, aroma, texture and overall acceptability were analyzed. Shelf-life studies involving microbial tests on the products were carried out fortnightly and the results compared with acceptable microbial load for cereal products. The tests included total plate count (TPC) and yeast and moulds. The comparison chemical analyses done on the products included proximate composition, tannins and phytates content, protein-digestibility and B-vitamins.

Chemical analysis

Proximate analysis: Moisture, protein, fat, ash and crude fiber were determined according to AOAC methods specification 950.46 (AOAC, 1996). Results were reported on fresh weight basis.

Sensory evaluation: The three breakfast cereal products developed were randomly subjected to sensory evaluation to determine the most preferred. This was done by a team of 47 untrained panelists who represented the common consumer most likely to use the product. Each recorded their degrees of likes and dislikes on the taste, color, texture, aroma and overall acceptability of the samples using a nine point hedonic scale (Ihekoronye and Ngoddy, 1985). Before each sample testing the panelists rinsed their mouth with water. The assessment was carried out under natural light at a temperature of 25ºC. A questionnaire was used to record the panelists preferences of taste, color, texture, smell and overall acceptability. The data was analyzed using the three way analysis of variance (ANOVA). Significant means were separated by Duncan's Multiple Range tests (Steel and Torrie, 1980).

Shelf life analysis: Samples of 100g of the product were stored in Kraft paper packages at room temperatures of 25ºC and 80% RH in the dark for 120 days. Total Plate Count, Yeast and mold counts were determined after every 14 days to determine how long the product would store and still be suitable for consumption. A portion of the sample was taken from the same package each time during the analysis after which the package was carefully sealed and kept at room temperature.

Total plate count (TPC): Total bacterial counts were done according to AOAC, (1996) methods**.** Initial product sample homogenates were prepared in sterile diluents in ratios of 1:10. For each homogenate, 1ml was aseptically diluted through a series of tubes containing 9ml sterile diluents. Approximately 1ml of diluents of each tube were spread plated on to Plate Count Agar (PCA) and incubated for 48 hrs at 35ºC. Plates with less than 300 colonies were counted and the number of bacterial colonies expressed as colony forming units per gram (CFU/g) of the sample using the formula from International Dairy Federation (IDF) method 1996 as follows

$$\text{Log } C = \Sigma\, x/n_1 + (0.1n_2)^{x}\, d$$

Where: C = Count CFU/g;

x = Total number of colonies in all plates; n_1 = number of plate from initial dilution where counts were made;

n_2 = number of plates from second dilution from where counting was done; and d = initial dilution of counting.

Yeast and mould count: The mould count was carried out using potato dextrose agar (PDA) AOAC (1996). Initial product sample homogenates were prepared in sterile diluents in ratios of 1:10. 1ml of each

homogenate was then aseptically diluted in series up to a dilution of 10^{-3}. The diluents were pour plated in duplicates. Incubation was done at 25ºC for 72hrs. Yeast and mold counts were expressed as colony forming units per gram (CFU/g) using the formula in TPC determination.

Data analysis: Data was analyzed using Microsoft word Excel, SAS (the three way analysis of variance-ANOVA) and SPSS Statistical packages, significant means were separated by Duncan's Multiple Range Tests (Steel and Torrie, 1980).

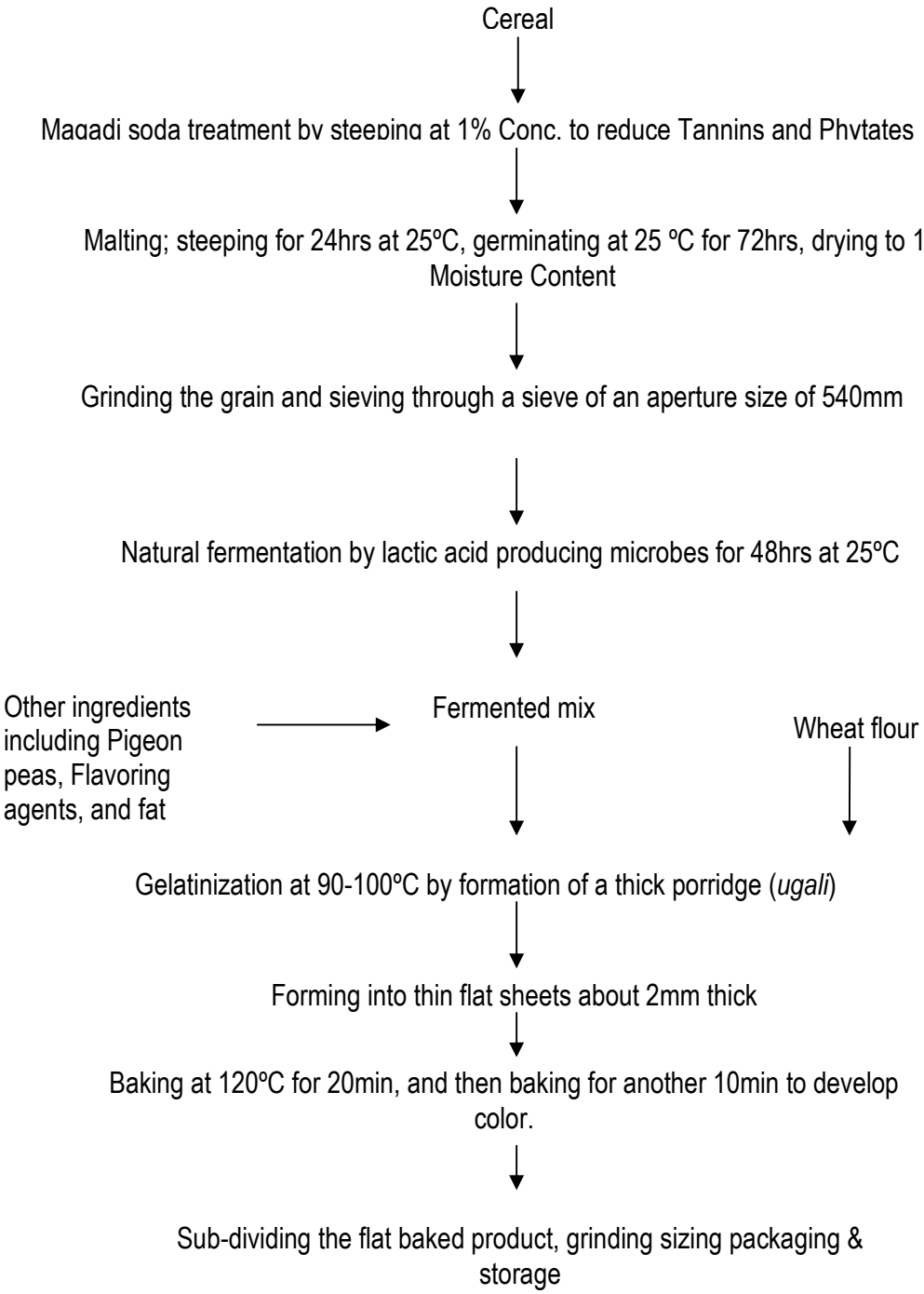

Figure. 1: Flow chart for breakfast cereal product development

RESULTS AND DISCUSSION

Breakfast cereal products: Pictures of the developed breakfast cereals from the optimally treated flours and pigeon pea are shown on Plates 1-3. The optimal treatments included steeping the cereals in 1% *magadi soda* for 2 days to detoxify the anti-nutrients tannins and phytates, malting for 3 days followed by fermentation for 2 days. The benefits of these treatments included reduction of anti-nutrients, breakdown of complex sugar to simple sugars, and increase in water soluble vitamins. These products are in powder form so they are easy to handle, dispense and store. Their physical nature requires that they be mixed with water or milk before consumption.

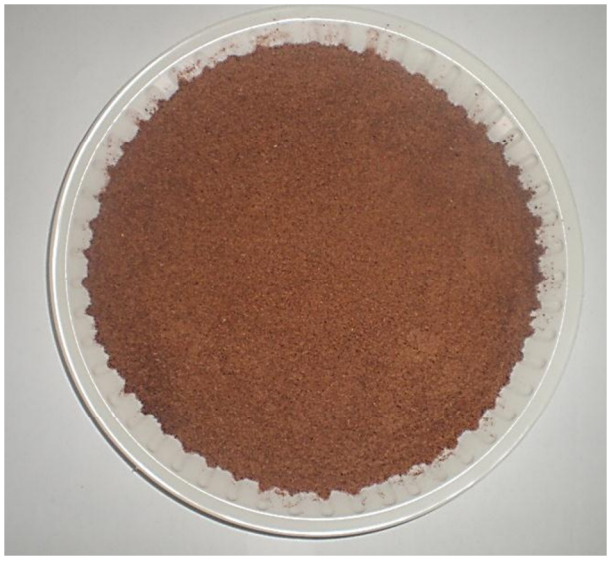

Plate 1: Red sorghum breakfast cereal-a brown-coloured powder

Plate 2: White sorghum breakfast cereal -a golden brown-coloured powder

Plate 3: Pearl millet breakfast cereal-a tan–coloured powder

Table 1: Proximate composition of control products and developed breakfast cereal products

Control products				
Parameter	**White sorghum**	**Red sorghum**	**Pearl millet**	**LSD**
Moisture	$10.6^{a}\pm0.11$	$10.8^{a}\pm0.19$	$10.7^{a}\pm0.20$	0.34
Protein	$11.6^{ba}\pm0.30$	$11.3^{b}\pm0.30$	$12.0^{a}\pm0.06$	0.50
Fat	$2.4^{b}\pm0.02$	$2.4^{b}\pm0.03$	$2.8^{a}\pm0.05$	0.07
Ash	$1.3^{b}\pm0.07$	$1.3^{b}\pm0.03$	$1.6^{a}\pm0.06$	0.11
Fibre	$1.6^{b}\pm0.14$	$1.6^{b}\pm0.14$	$2.4^{a}\pm0.04$	0.24
Carbohydrate	$72.6^{b}\pm0.29$	$72.5^{b}\pm0.52$	$70.5^{a}\pm0.10$	0.70
Developed breakfast cereal products				
Parameter	**White sorghum**	**Red sorghum**	**Pearl millet**	**LSD**
Moisture	$10.5^{a}\pm0.18$	$10.6^{a}\pm0.22$	$10.6^{a}\pm0.05$	0.33
Protein	$13.6^{ba}\pm0.11$	$13.5^{b}\pm0.26$	$13.9^{a}\pm0.12$	0.35
Fat	$2.2^{b}\pm0.02$	$2.2^{b}\pm0.02$	$2.6^{a}\pm0.03$	0.05
Ash	$1.6^{b}\pm0.06$	$1.6^{b}\pm0.02$	$1.8^{a}\pm0.03$	0.09
Fibre	$2.5^{b}\pm0.09$	$2.5^{b}\pm0.12$	$3.0^{a}\pm0.05$	0.18
Carbohydrate	$69.6^{a}\pm0.10$	$69.5^{a}\pm0.38$	$68.1^{b}\pm0.08$	0.46

Value =Mean ± S.D. on dry weight basis. Each value is a mean of 3 replicates. Means on the same row with the same letter(s) are not significantly different ($p\leq0.05$). S.D=Standard Deviation. LSD= Least significant difference of the mean replicates. Control products are breakfast cereals produced from the untreated grains (with no alkali treatment, malting and fermentation) and without protein complementation with pigeon peas.

Tannin and Phytate, digestibility and B-vitamin composition of breakfast cereal products: Table 2 compares the control breakfast cereals and developed breakfast cereals. The developed breakfast cereals had better nutrient attributes in comparison to their control products. Protein digestibility ranged from 35.8-41.2% for control products while that of the developed products was 87-92%. Anti-nutrient tannin range was 0.8-2.8% Catechin Equivalent (CE) in control products and 0-0.1% CE for developed breakfast cereals. The B-vitamin contents were significantly higher in the developed products ($p\leq0.05$). However, not all the nutrients survived the cooking process. A similar phenomenon has been noted by other researchers like Khalil and Sawaya (1984) who found that bread prepared from pearl millet flour by a traditional method was significantly lower in thiamin, pantothenic acid and folic acid than the flour itself.

The nutrient content of the optimally treated flours exhibited higher values than those of the developed breakfast cereals due to nutrient losses during processing. The losses varied; thiamin content decreased by 18%, riboflavin by 12%, niacin by 0%, folic acid by 40% and pyridoxine by 13%. This suggests that cooking loss is nutrient dependent as all are not lost. Such losses due to the cooking processes have been previously reported (Dassenko, 1980). Cooking also lowers digestibility of sorghum due to formation of starch complexes with proteins but malting raised protein digestibility which is in agreement with results reported by Mosha (1994).

These cooking losses result from many factors including effects of heat, leaching, and dilution with other nutrients. The overall effect of the processing involved in the breakfast cereal was a positive one as it not only lead to an increase in digestibility of breakfast cereal products but it also lead to both a decrease in anti-nutrients of tannins and phytates and an overall increase in the B-vitamins when compared to the control products.

Table 2: Other nutritional attributes of developed breakfast cereal products and their controls

Control Products				
Parameter	**White sorghum**	**Pearl millet**	**Red sorghum**	**LSD**
Tannin	0.79^{c}	1.03^{b}	2.85^{a}	0.11
Phytates	83.50^{b}	84.64b^{a}	85.32^{a}	1.56
Digestibility	41.21^{ba}	49.49^{a}	35.77^{b}	10.78
Folic acid	0.01^{b}	0.01^{c}	0.01^{a}	<0.01
Thiamin	0.29^{a}	0.28^{a}	0.29^{a}	0.03
Pyridoxine	0.16^{c}	0.24^{a}	0.22^{b}	0.01
Riboflavin	0.18^{a}	0.13^{c}	0.15^{b}	0.01
Niacin	3.93^{b}	4.03^{a}	3.74^{c}	0.10
Developed Breakfast Cereal Products				
Parameter	**White sorghum**	**Pearl millet**	**Red sorghum**	**LSD**
Tannin	0.06^{b}	0^{c}	0.13^{a}	<0.01
Phytates	42.37^{a}	33.49^{b}	40.56^{a}	1.97
Digestibility	92.90^{a}	91.14^{a}	87.67^{a}	8.68
Folic acid	0.02^{c}	0.03^{b}	0.04^{a}	<0.01
Thiamin	0.43^{c}	1.36^{b}	1.50^{a}	0.04
Pyridoxine	0.17^{c}	0.47^{a}	0.24^{b}	0.02
Riboflavin	0.29^{a}	0.24^{c}	0.25^{b}	0.01
Niacin	9.95^{c}	12.97^{a}	12.11^{b}	0.87

Values are Means of 3 replicates on dry weight basis. Means on the same raw followed by the same letter(s) are not significantly different (p≤0.05). *ND=Not Detected. Vitamins, tannins and phytates are in mg/100g. Digestibility is in %. LSD= Least significant difference of the mean replicates. Control products are breakfast cereals produced from the untreated grains (with no alkali treatment, malting and fermentation) and without protein complementation with pigeon peas.

Sensory evaluation of breakfast cereal products: The results of the panelists' evaluation were statistically analyzed and their mean values obtained as shown in Table 3.

Table 3: Sensory evaluation of cereal products

Cereal	**Variable**	**Mean ± S.D**	**Minimum**	**Maximum**	**LSD**
White sorghum	Colour	8.0^{a}±0.91	4	9	1.2441
	Taste	7.2^{a}±1.40	3	9	1.3488
	Aroma	6.1^{a}±1.42	3	9	1.1861
	Texture	6.7^{a}±1.69	3	9	1.5548
	Acceptability	7.5^{a}±1.32	3	9	1.3895
Pearl millet	Colour	6.3^{b}±1.66	1	9	1.1893
	Taste	5.9^{b}±1.90	2	9	1.3488
	Aroma	6.2^{a}±1.68	1	9	1.236
	Texture	6.0^{a}±2.00	1	9	1.4625
	Acceptability	6.0^{b}±1.69	1	9	1.2428
Red sorghum	Colour	4.3^{c}±2.02	1	9	1.1465
	Taste	5.0^{c}±1.92	1	9	1.2106
	Aroma	5.5^{b}±1.70	2	8	1.0882
	Texture	4.3^{b}±2.34	1	9	1.4103
	Acceptability	4.6^{c}±2.04	1	9	1.0465

Values = Mean ± SD. Each value is a mean of 3 replicates. Means on the same raw with the same letter are not significantly different (p≤0.05). S.D=Standard deviation. LSD= Least significant difference of the mean replicates. Panelists = 47. Cereals products are the developed breakfast cereals.

The product having the highest means on the parameters analyzed were considered the most preferred. White sorghum breakfast cereal had the highest means for each of the parameters evaluated followed by pearl millet breakfast cereal and red sorghum breakfast cereal

Shelf life studies of stored products: Table 4 shows results of the microbial analysis during the study period. Total microbial counts were undetectable from week 0 to week 8. Microbial loads were detected in the white sorghum breakfast cereal at week 10 although the levels were low and within the acceptable limits of microbial standards on cereal products (ICMSF, 1996). From week 12-18 there was a steady increase in the total number of microorganisms. The levels ranged from 0.10 log CFU/ml for red sorghum, 0.24 log CFU/ml for white sorghum and 0.14 log CFU/ml for pearl millet but these values were within the acceptable limits provided for cooked cereal products.Cereals and their products are prone to attack by yeast and molds, therefore these were analyzed. There were no detectable levels of yeasts and molds from 0-10 weeks. Low levels of yeasts and molds were detected from week 12 and increased for the remainder of the storage period. The levels remained within the acceptable standard levels.

Table 4: Total plate count on product (log_{10} CFU/ml)

Week	Red sorghum	White sorghum	Pearl millet
TPC			
0	*ND	*ND	*ND
2	*ND	*ND	*ND
4	*ND	*ND	*ND
6	*ND	*ND	*ND
8	*ND	*ND	*ND
10	*ND	0.18	*ND
12	*ND	0.20	0.02
14	0.02	0.12	0.02
16	0.10	0.21	0.02
18	0.10	0.24	0.14
Yeasts & Molds			
0	*ND	*ND	*ND
2	*ND	*ND	*ND
4	*ND	*ND	*ND
6	*ND	*ND	*ND
8	*ND	*ND	*ND
10	*ND	*ND	*ND
12	*ND	0.12	*ND
14	*ND	0.12	*ND
16	0.12	0.24	0.12
18	0.12	0.40	0.14

Values=Mean of 2 replicates (log_{10} CFU/ml) *ND=Not detected.

CONCLUSION

Instantized breakfast cereal products were successfully developed from detoxified white, red sorghum and pearl millet flours composited with the pigeon pea. The most preferred breakfast cereal product (white sorghum) had similar nutritive values as the ones in the market. The product shelf-life was the same as those of similar products in the market (*Weetabix* and Rice crispes). The most preferred product was from white sorghum. This product can be recommended for further improvement and industrial large scale production.

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