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EFFECT OF AMARANTH: MAIZE FLOUR RATIO ON THE QUALITY AND ACCEPTABILITY OF U*gali* AND *Porridge* (KENYAN CEREAL STAPLES)

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ABSTRACT

Food and nutrition security is a major global concern, especially in the developing countries. Currently, many countries in sub-Saharan Africa depend on a narrow base of food, a situation which minimizes variety in food production and contributes to insecurity in food and nutrition. This situation can be highly improved by considering highly nutritious crops that have domestication potential, such as the amaranth grain, which is richer in protein and other mineral elements when compared to commonly consumed cereal grains. The amaranth grain is currently a highly ignored crop, and yet it is very easy to grow, and its survival in harsh conditions also guarantees its yield. In this paper, the knowledge that the Kenyan North Rift farmer and consumer has the amaranth grain plant was established in a survey. Literature sources were used to lay out the nutritive value of the amaranth grain, and nutrition education relayed to 250 randomly sampled consumers and farmers, so as to justify the need for its adoption as a cash/food crop. The functional properties (cook paste and water absorption) and culinary characteristics (colour, texture, flavour) of commonly consumed products (*ugali* and *porridge*) which were made in varying treatments of amaranth flour: maize meal flour (100:00; 80:20; 70:30; 60:40; 50:50) was determined. Data were managed using SPSS version 18. The survey results established that the knowledge that the farmer and consumer had on the amaranth grain was minimal. Time taken for the samples to turn viscous reduced with increasing amounts of amaranth flour, which also took the least time and lowest temperature to form a stable gel. The *porriber* and *ugaber* composites with high amounts of amaranth grain flour (80:20) were the most acceptable, and from the nutritional point, the most nutritious. Increased nutritional awareness, production and consumption of grain amaranth products may be the way to better food and nutrition security.

Keywords: grain amaranth, knowledge, nutritive value, functional properties, culinary characteristics.

INTRODUCTION

Malnutrition is a key issue among the poor and therefore using available food and land resources to build up food reserves may play a great role in reducing hunger and improving the nutritional status of vulnerable populations. According to Rinaudo (2006), if there is to be a "green revolution" for the arid and semi-arid subtropics, it will have to be through plants that thrive under such conditions, yield well and require minimal inputs. Millions of third world farmers have no access to the usual green revolution inputs. Increasingly they are farming on exhausted, marginal lands under adverse climatic conditions that are unsuitable for conventional crops and therefore for them a biological revolution is needed, in which plants are selected and bred to suit the prevailing environmental conditions, rather than a green revolution to suit the plants, in which the crop environment is modified (through irrigation, fertilizers and pesticides). Small-holder farmers who are economically challenged in producing conventional crops may benefit from producing the Amaranth plant which requires less inputs and has the potential to meet thrive under varying conditions.

Studies done in India and Mexico show that the amaranth grain has a food value that is better than that of conventional food grains, and is therefore considered to be a good supplement to the commonly used cereal grains such as maize and rice which are demanding in agricultural perspective and therefore poor choices under marginal conditions (ECHO, 2006).

Nutritive value of amaranth grain

One of the reasons there has been recent interest in amaranth is because of its useful nutritional qualities. Comprehensive reports on the chemical composition of amaranth grain have been published (Sánchez-Marroquín, 1980). The grain has 12 to 19% protein, high in fiber and low in saturated fats (see Table-1), factors which contribute to its use by the health food market. Recent studies have linked amaranth to reduction in cholesterol in laboratory animals (Saunders and Becker, 1983). The grain amaranth contains 8.1% of squalene, an unsaturated fat which decreases plasma cholesterol levels through activation of liver cholesterol 7 alpha hydroxylane (Teutonico RA, and Knorr, D, 1985).

Table-1. Nutritional information of amaranth grain per 100 grams.

Nutrients	Amount in %	Nutrients	Amounts in IU/mg/g
Proteins	19	Vitamin A	6100
Fibre	8	Vitamin B carotene	4.6
Minerals	3.1	Vitamin B1	1.29
Carbohydrates	65	Vitamin B2	2.1
Unsaturated oils	8	Vitamin B3	8.4
Moisture	9	Vitamin C	4.63
		Vitamin E	1.03
		Vitamin BC (Folic or Folate)	49.0

Source: Pedersen, B, Knudsen, K E. and Eggum, B O (1990).

The other attribute always mentioned when describing amaranth grain is its high protein quality predicted on the basis of its relatively well-established essential amino acid patterns. The grain amaranth contains exceptionally high levels of the amino acids lysine; methionine, leucine and tryptophan which are low in the commonly used cereal crops (Table-2). Amino acids are required for building body cells, repairing body tissues and also for the formation of antibodies to combat invading bacteria and viruses. The lysine content is given as the main reason for the high protein quality of amaranth, since the grain contains more of this essential amino acid than cereal grains (Saunders and Becker, 1983, Teutonico and Knorr, 1985).

Table-2. Essential amino acids available in amaranth grain.

Essential amino acids g/100g	Amaranth	Wheat	Soya	FAO/WHO standard
Lysine	5.95	0.23	2.30	5.40
Leucine	4.20	0.71	2.80	7.00
Isoleucine	2.71	0.36	1.67	4.00
Phenylalanine	4.70	0.52	1.80	6.00
Methionine	0.64	0.18	0.45	3.50
Threonine	3.25	0.28	1.50	4.00
Tryptophan	1.82	0.13	0.50	1.00
Valine	3.85	0.42	1.7	5.00

Source: Teutonico RA, and Knorr D. (1985).

Table-3 shows the theoretical chemical composition score for amaranth, out of 100, as compared to other grains and milk. This score approaches the ideal amino acid reference pattern established by FAO/WHO in 1973.

Table-3. Chemical score of amaranth grain in comparison with various foods.

Amaranth	Cows milk	Soybean	Wheat	Peanuts	Sorghum	Maize corn
75-82	72	68	60	52	48	44

Source: Amaranth, Modern Prospects for an Ancient Crop, 1984, National Research Council.

Table-4 shows the average composition of grain amaranth as compared to commonly used cereal grains. The amaranth grain rates highly favourably more than the other grains.

Table-4. A comparison of the composition of amaranth grain with commonly used cereals.

Grain	Moisture %	Protein %	Fat %	Fibre %	Ash %
Amaranth	8.0	18.1-19.4	8.0-8.6	3.7-5.7	3.1
Maize	13.8	10.0-13.8	4.6-5.7	2.3	1.2
Brown rice	12.0	7.5-8.0	1.1	1.0	1.2
Wheat	12.5	12.3	1.8	2.3	1.7
Sorghum	11.0	11.0	3.3	1.7	1.7
Oat	8.3	16.2	6.4	1.9	1.9
Millet	11.8	9.9	2.9	3.2	2.5
Barley	9.8	11.6	2.0	2.4	2.1
Rye	11.0	12.1	1.7	2.0	1.8

Source: Amaranth, Modern Prospects for an Ancient Crop, 1984, National Research Council.

Nutritional benefits, including possible treatment for HIV/AIDS

There have been reports of improvement in the health of people who have been fed on amaranth grain (Mwangi, 2009), which include reduction of symptoms of severe malnutrition among children and increased body-mass index of adults formerly wasted by HIV/AIDS. The lysine in amaranth grain makes amaranth particularly helpful for HIV/AIDS patients. Lysine helps the body to "inhibit the growth and multiplication of the [herpes] virus" (Mwangi, 1999). The amaranth grain fiber, especially compared with the fiber in wheat and other grains, is very soft and fine. Eating amaranth has helped to cure diseases caused by nutritional deficiencies (e.g. scurvy, kwashiorkor), helped prevent many lifestyle diseases (e.g. heart disease, high blood pressure), and helped manage or reduce symptoms of diseases such as tuberculosis, diabetes, and HIV/AIDS. All HIV and AIDS complications disappeared. Even for those experiencing side effects from conventional ARVs [antiretroviral] drugs, the side effects disappear (ECHO, 2006).

Grain amaranth is also rich in trace elements such as zinc, selenium and copper. Zinc has been shown to be important for memory, immunity, and wound healing. As for immunity, people with AIDS are almost universally deficient of zinc, which contributes significantly to the continued decline of their already damaged immune systems. Restoring their supply with grain amaranth could be one of the most important strategies for stabilizing their immune function and reducing complications from the disease (ECHO, 2006). Grain amaranth has been used for food by humans in a number of ways. The most common usage is to grind the grain into flour for use in breads, noodles, pancakes, cereals, granola, cookies, porridge or other flour-based products. The grain can be popped like popcorn or flaked like oatmeal. Baby food made from amaranth is similar in composition to commercial baby food, though the amaranth cereal is higher in fiber.

In most parts of Kenya, the vegetable part of the amaranth plant is used in diets but there is minimal knowledge about the grain amaranth which leads to low production and renders it expensive for use. The consumer on the other hand, knows very little about its use, availability, nutritive value, and functional characteristics and thus currently, adoption into diets is at minimal. The objectives of this work were to determine the knowledge that the consumer has of the amaranth plant; to establish the cook-paste and water absorption characteristics of the amaranth grain flour; and to develop amaranth: maize meal composites of "*nyukaber*" and "*ugaber*" and establish the most acceptable composite.

MATERIALS AND METHODS

The study aimed at determining the knowledge that the consumer has on the grain amaranth's nutritive value and establishing the functional and sensory characteristics of various composites of amaranth: maize meal flour "*nyukaber*" and "*ugaber*". This study used the descriptive survey design and the experimental design. A survey was carried out among 100 randomly sampled farmers who attended the Agricultural Society of Kenya Show in 2010 to determine their knowledge on the value of the amaranth plant as a food/cash crop and whether farming practices have included the Amaranth plant, and in particular, high grain-yielding varieties. The survey also included 200 randomly sampled adult consumers, of ages 18-30 who were exposed to two common foodstuffs made out of wheat/amaranth grain mixtures (*chapati and mandazi*) in which amaranth grain flour and wheat flour was used at the ratio of 1:1 and asked to state whether it tasted very nice, nice or bad, for the purposes of sampling and capturing their attention to an education session on the nutritive value of the amaranth grain. The consumers were then given nutritional education on the amaranth grain, which was done in small groups of 20, using amaranth nutrition information charts. Secondary sources of information were used to gather information on the nutritive value of the amaranth grain. An interview schedule was used to determine whether the farmers and consumers knew anything about the amaranth grain, and if they grew or used it for food at all.

Laboratory tests

The experimental design method was used in the various treatments of the maize-amaranth mixtures so as to establish functional properties of the amaranth flour products (*ugaber*, and *nyukaber*) and their sensory characteristics. Seven (7) willing panelists were trained to carry out the sensory characteristics where they rated the products for colour, texture, smell, taste, and general acceptability on a Likert scale ranging from 5 = highly acceptable to 1 = not acceptable. The functional properties were carried out in the Chepkoilel university foods laboratory. Whole maize meal flour was obtained through milling of maize (*zea mays*) obtained from the Chepkoilel University College farm, whereas the amaranth grain flour was obtained by milling amaranth grain from the Chepkoilel University College where a demonstration plot had been prepared so as to raise awareness of the amaranth plant *(amaranthus hybridus)*.

The functional and sensory characteristics of 100 gram samples of *"ugaber"* that is better ugali, and *"porriber"* which connotes better porridge, were established using the following ratios in three replicates each:

100: whole amaranth flour.
80:20 whole amaranth flour: whole maize meal flour.
70:30 whole amaranth flour: whole maize meal flour.
60:40 whole amaranth flour: whole maize meal flour.
50:50 whole maize meal: whole amaranth flour.

The data obtained was analyzed in percentages, Analysis of Variance (ANOVA) and Pearson Product Moment Correlation on the SPSS 18 statistical software.

RESULTS AND DISCUSSIONS

Only one 5% of the farmers surveyed (n = 5) and 5% of the consumers (n = 10) had any knowledge of the food and nutritional value of the amaranth grain. However, they all knew about the leafy amaranth as they used it as a vegetable frequently. This justified the need for an educational appraisal approach to enhancing the nutritional knowledge and use of the amaranth grain. All those who participated in the tasting of amaranth products given i.e., mandazi and chapati, (consumers N = 200, farmers N= 100), said that they tasted very nice, and this indicated that amaranth grain products are capable of gaining high acceptability among consumers, and thus the need to introduce their products in household diets.

Functional properties of the amaranth: maize meal samples

The water absorption and cook-paste characteristics of the samples tasted are important to their general use. The time taken for a change in viscosity increased with reducing amounts of amaranth flour in the sample, as well as the temperature at which the change in viscosity was observed, with the 100% amaranth grain sample taking the least time (33seconds) to turn viscous, and at the lowest temperature (74◦F), (see Table-5).

Table-5. The water absorption characteristics of various flour samples of amaranth: maize meal.

Flour sample ratios Amaranth: Maize (Per 100grams)	**Time taken a change in viscosity** (seconds)	**Temperature at which change in viscosity was observed degrees** (◦F)
100:0	33	74
80:20	35	78
70:30	37	84
60:40	40	84
50:50	45	84

Increasing amounts of maize meal flour in the sample caused a reduction in the time taken for a stable gel to form. As the temperature increased, a stable gel formed, with the 100% amaranth flour taking the longest time (85 seconds), at the lowest temperature of 74◦F (Table-6), compared to the 50:50 sample, which took less time (60 seconds) at a higher temperature (84◦F). It is notable that low cooking temperatures are favourable for nutrient conservation.

Table-6. The cook- paste characteristics of various samples.

Flour sample ratios Amaranth: Maize (Per 100grams)	**Time taken to form a stable gel** (seconds)	**Temperature at which a stable gel is formed** (Degrees ◦F)
100:0	85	74
80:20	75	78
70:30	70	84
60:40	65	84
50:50	60	84

Results of sensory analysis of *"Porriber"*

The different variations of *"porriber"* samples were all generally acceptable in a non-significant relationship (F = 1.709, p >.05). The most acceptable sample was the 100gram pure amaranth flour *"porriber"* sample, with acceptability reducing with a decrease in the amaranth flour ratio. The ratings of the colour, texture, and smell of the different samples varied significantly at p <.05, see Table-7. The colour of the amaranth: maize meal (60:40) was rated highest (M = 3.68), on a scale of 5 = highly acceptable to 1 = not acceptable, whereas the texture of the 50:50 sample was rated highest (M = 3.61), attributed to higher amounts of maize meal flour in the sample which made it more course and therefore more acceptable. The most pleasant smell and taste was given to the whole amaranth flour *"porriber"* due to its nutty flavour.

Table-7. ANOVA table showing the sensory characteristics of different samples of *"porriber"*.

Sensory evaluation characteristics	***"Porriber"*samples of Amaranth: Maize meal** (Per 100grams)						
	100:0	80:20	70:30	60:40	50:50	F values	Sig p
General acceptability	3.19	3.17	2.99	2.89	2.79	1.709	.193ns
Colour	3.14	2.44	3.34	3.68	3.37	4.923	.028*
Texture	2.53	2.83	2.89	3.44	3.61	3.916	.049*
Smell	3.40	3.22	3.06	2.56	2.65	5.504	.020*
Taste	3.34	3.06	3.02	2.08	3.14	2.993	.085ns

* Significant at p<.05; ns = not significant.

The correlation results showed that general acceptability was positively and significantly correlated with increasing concentrations of amaranth flour in the *"porriber"* (r = +.277, p<.01), (Table-8).

Table-8. Correlation table showing the relationship between general acceptability and varying ratios of *"porriber"*.

"Porriber" samples of Amaranth: Maize meal (Per 100grams)	**Pearson r**	**Significant p**
100:0	+ .277	.000**
80:20		
70:30		
60:40		
50:50		

**Significant at p < .01

Results of sensory analysis of *"Ugaber"*

The different variations of *"ugaber"* samples were all generally acceptable in a significant relationship (F = 6.464, p < .05). The 70:30 and 60:40 amaranth flour: maize meal flour samples were the most acceptable, both with a mean of M = 3.30. The 100gram amaranth flour sample was rated lowest (M = 2.39) indicating that preferred *"ugaber"* was that in which amaranth flour and maize meal flour were mixed. The colour and taste of the different samples varied significantly at p < .05 see Table-9. The colour of the 100 grams amaranth flour "*ugaber"* was highly preferred (M = 4.00), whereas its taste was rated lowest (M = 2.42). Both the texture and the smell of the different samples of *"ugaber"* were non-significantly different.

Table-9. ANOVA table showing the sensory characteristics of different samples of "*ugaber*".

Sensory evaluation characteristics	***"Ugaber"* samples of Amaranth: Maize meal** (Per 100grams)						
	100:0	80:20	70:30	60:40	50:50	F values	Sig p
General acceptability	2.39	2.66	3.30	3.30	3.12	6.464	.012*
Colour	4.00	2.72	3.87	3.77	3.26	4.264	.040*
Texture	3.45	3.00	3.17	3.52	3.45	1.365	.244ns
Smell	3.17	2.50	2.78	2.67	2.64	3.009	.084ns
Taste	2.42	2.95	3.36	3.22	3.17	4.945	.027*

Significant at $p < .05$; ns = not significant.

The correlation results showed that general acceptability was negatively and non-significantly correlated with increasing concentrations of amaranth flour in the *"ugaber"* (r = -.106, p>05), (Table-10). That is, an increase in the amaranth flour concentration did not necessarily increase the general acceptability of the *"ugaber"* samples.

Table-10. Correlation Table showing the relationship between general acceptability and varying ratios of "*ugaber*".

***"Ugaber"* samples of Amaranth: Maize meal** (Per 100grams)	**Pearson r**	**Significant p**
100:0	-.106	.134ns
80:20		
70:30		
60:40		
50:50		

ns = not significant.

SUMMARY AND CONCLUSION

The amaranth grain is highly nutritious and its products are highly acceptable, when used on its own or mixed with other cereal grains such as maize meal. The more the amaranth used in a mixture, the higher its nutritive value, and the better its functional properties. It can be an important grain for combating malnutrition particularly among vulnerable groups and areas that are prone to malnutrition, thus enhancing food security. Farmers in Kenya should be educated and motivated into growing amaranth for its quality food and nutritional values.

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