Consumer acceptance of yellow, provitamin A-biofortified maize in KwaZulu-Natal

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Abstract

Objectives: To assess the acceptance of popular maize food products (*phutu*, thin porridge and samp), prepared with yellow, provitamin A-biofortified maize varieties, in 212 subjects between the ages of three and 55 years, from rural KwaZulu-Natal.

Design: A cross-sectional study.

Method: Preschool, primary school and secondary school subjects were randomly selected from two primary schools and one secondary school, respectively, while adult subjects constituted a convenience sample. Pre- and primary school children completed a paired preference test. Secondary school and adult subjects completed a five-point facial hedonic and a preference ranking test. Focus group discussions were conducted using adult subjects.

Results: Preschool children preferred yellow maize to white maize food products: *phutu* (81% vs. 19%; p-value < 0.001), thin porridge (75% vs. 25%; p-value < 0.001) and samp (73% vs. 27%; p-value < 0.001). There was no statistically significant difference in preference for white and yellow maize by primary school children. Secondary school and adult subjects preferred white maize to yellow maize. Focus group discussions confirmed the preference for white maize by the adults.

Conclusion: The study findings suggest that yellow, provitamin A-biofortified maize has the potential to succeed as a new strategy of dealing with the serious problem of vitamin A deficiency, especially among children of preschool age. However, in older groups, this strategy is unlikely to be successful, unless other strategies are implemented, including intensive nutrition education programmes on the nutritional benefits of the maize, targeting the market price at which yellow maize is sold, increasing its availability in local grocery stores, and improving its sensory properties through breeding.

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Introduction

Globally, vitamin A deficiency affects approximately 190 million children under the age of five.[1] South Africa has a serious public health problem in the form of poor vitamin A status, particularly affecting children.[1-3] The South African Department of Health is currently addressing micronutrient deficiencies through supplementation, food fortification and promotion of dietary diversification.[4] However, these strategies have not resulted in an improvement in the vitamin A status of South African children since 1994.[5] Recently, biofortification of maize with provitamin A by conventional breeding has emerged as a potential long-term sustainable strategy to improve vitamin A status in humans.[6]

Biofortification of maize with provitamin A carotenoids changes the grain colour from white to yellow-orange, as well as the aroma and flavour of the maize. Studies on consumer acceptance of yellow maize conducted in eastern and southern Africa have shown that there is a cultural preference for white maize to yellow maize, which seems to be due to the unacceptable sensory properties of the yellow maize.[7-12] In South Africa, yellow maize is not readily consumed, except when there is a severe shortage of white maize,[13] and there is a lack of published data on consumer acceptance of yellow maize.The studies on consumer acceptance of yellow maize conducted in eastern and southern Africa targeted adult urban consumers,[10] and yet it is rural consumers who are more at risk of vitamin A deficiency.[14] This study aimed to assess the acceptance of yellow maize food products by consumers in rural KwaZulu-Natal. The food products studied were *phutu* (a stiff porridge made from maize meal), thin porridge and samp. These food products were chosen, as they have been found to be the most popular to rural African communities in KwaZulu-Natal.[15,16]

Method

Maize grain

Five hybrid varieties (crosses between genotypes) of yellow maize were developed by conventional breeding methods at Cedara Research Station, KwaZulu-Natal. The F_1 maize hybrids, which are equivalent to the seeds planted by farmers, were developed by cross-pollination of inbred lines (genetically pure line genotypes). The F_2 generation grain, which represents the commercial grain for consumption, was obtained by full-sib mating, i.e. plant-to-plant cross-pollination, of the F_1 plants. A commercial white maize hybrid variety (SC-701), which is a popular white maize variety in southern Africa, was produced under the same conditions as the yellow varieties. The grain ears (cobs with grain) of these maize varieties were harvested manually, bulked, and then left to dry under ambient conditions (± 25 ºC) for 21 days. The maize was then threshed mechanically, and the grain stored in a cold room (± 4 ºC) before milling. A grain sample of 5 kg was then drawn for food processing.

Colour measurements and maize variety selection

Three maize varieties, whose colour ranged from light yellow to darker yellow, were selected, based on the Hunter *L*, *a*, *b* system, in which *L* is measure of lightness (0 = black to 100 = white), *a* redness (+*a* = redness; -*a* = greenness), and *b* yellowness (+*b* = yellowness; -*b* = blueness).[17] Based on the Hunter *L*, *a*, *b* values, the hybrid KP-77 was chosen as the darkest yellow variety, KP-79 as the medium-yellow variety, and KP-78 as the lightest yellow variety.

Maize milling

The maize grain was first cleaned with a grain-cleaning machine. Grain moisture was adjusted to 15% (w/v) before milling. Samp was produced by milling the maize grain with a degerminator mill (Dayton Electric Manufacturing Company, Reston, Virginia, USA). The whole milled product coming out of the degerminator was collected. A pilot plant roller mill (Model MK 150, Roff Industries, Kroonstad, South Africa) with a three-break system was used to mill the maize grain into super meal, maize grits, bran and fine meal. The three-break system consisted of a set of three roller mills of decreasing roller gap size, which progressively broke up maize grain into smaller particles. The mill fractions of larger particle size were manually transferred to the next roller mill for further size reduction. The super meal was the mill fraction which passed through a 495 µm aperture screen.

Preparation of maize food products

Three women with appropriate cooking experience from rural KwaZulu-Natal were recruited to cook the popular maize products, *phutu*, thin porridge and samp. The food products were prepared in a food-processing laboratory at the University of KwaZulu-Natal, using standardised procedures developed during several trials. *Phutu* was prepared by boiling 375 ml of tap water, after which 1 ml of salt was added. Two cups (268 g) of maize meal were added to the water, and stirred as soon as the mixture reached boiling point. The *phutu* was cooked, covered, on low heat for approximately 75 minutes, with occasional stirring. The thin porridge was prepared by boiling eight cups (2 000 ml) of tap water. Two cups (268 g) of maize meal were added to two cups (500 ml) of cold water to make a paste, which was then added to the boiling water and stirred until smooth. The porridge was cooked, covered, on medium heat for 25 minutes, with occasional stirring. During the cooking period, 1 ml of salt and 50 ml of sugar were added to the porridge. Two cups of samp (369 g) were soaked overnight in four cups (1 000 ml) of cold water. Four cups (1 000 ml) of boiling water were then added to the pre-soaked samp and boiled, covered, for an additional 135 minutes. An additional two cups (500 ml) of water and 5 ml of salt were added to the samp during the cooking period. The food samples were transported to the study site in insulating plastic containers closed with tight-fitting lids.

Consumer sensory evaluation

Black African male and female subjects who were regular consumers of *phutu*, thin porridge and samp, were recruited from the Mkhambathini Municipality in KwaZulu-Natal. The Mkhambathini Municipality was chosen as a site for the study as it has a large black African population (approximately 93% of the total population) and can be regarded as a low-income area because of the high unemployment rate (44% in 2001) and low average annual household income (R5 742 in 2004).[18] The schools that participated in the study were selected on the basis that they fell into Quintile 1 and Quintile 2 of the South African national quintile for public schools, which indicates that the school is located in an area with a high general prevalence of poverty.[19] Preschool (n = 52), primary (n = 56) and secondary school (n = 54) subjects were selected from two primary schools and one secondary school in the area. The schools were a convenience sample and were selected based on their accessibility and close proximity to each other. The learners were randomly selected using their class registers, which listed the learners numerically in the alphabetical order of their surnames. The numbers that listed the learner were each written on a piece of paper and mixed together. The subjects for sensory evaluation were then drawn randomly. The adult subjects (n = 50) were a convenience sample drawn from the school-parents meetings held at the schools. The sample size for each age group was 50 or more subjects, which was in accordance with the accepted sample sizes for consumer acceptance and preference tests.[20]

Sensory evaluation was carried out in small groups of between five and eight panellists. Preschool and primary schoolchildren completed a paired preference test, which can be performed reliably with children over the age of two years.[21,22] The test involved tasting a sample and the reference of each of the three food products (*phutu*, thin porridge and samp) prepared with KP-79 (medium-yellow maize variety) and SC-701 (reference white maize variety), separately. Fieldworkers assisted the preschool and primary schoolchildren to record their responses. The secondary school subjects and adults tasted each of the three food products prepared with four maize varieties (SC-701; KP-78; KP-79; KP-77), separately. Prior to each session, the sensory attributes of aroma, texture and flavour were explained to the secondary school and adult subjects in Zulu. The panellists seemed to understand the sensory attribute concepts, although the researchers could not ascertain that all subjects were able to distinguish between the different sensory attributes. The food products were evaluated using a five-point facial hedonic test (1 = very bad; 5 = very good) and a preference ranking test

(1 = most preferred; 4 = least preferred). Secondary school subjects were able to record their own responses, while some adult subjects were assisted by the fieldworkers. The food samples were warmed in small batches to ± 45 ºC in a microwave oven just before serving. The samples (± 30 ml) were served in 125 ml polystyrene cups. The samples were blind-labelled with three-digit codes obtained from a table of random numbers, and were served in a random order, which was determined using a table of random permutations of nine.[23] Each panellist was provided with a spoon and a cup of water to cleanse the palate between samples.

Focus group discussions

Nine men and nine women were randomly selected and participated as separate gender groups in the focus group discussions, which were conducted after the sensory evaluation sessions. The accepted sample size for focus group discussions is eight to 12 subjects.[24] Although several focus group discussions using different participants would have been desirable, as a result of time constraints, only two adult focus group discussions were conducted. Themes on consumer perceptions of, and attitudes towards, yellow maize were developed, and corresponding focus group discussion questions generated (see Table I). The focus group discussion sessions were conducted in Zulu by a trained research assistant. Both sessions were recorded using a digital voice recorder and the recordings were translated into English by a Zulu-speaking person. The English translations were then compared with the Zulu recordings and checked for accuracy by another Zulu-speaking person.

Ethics approval

Ethics approval to carry out this study was obtained from the University of KwaZulu-Natal Humanities and Social Sciences Ethics Committee (Ref HSS/0591/09D). Written consent to participate in the study was obtained from all adult subjects and the caregivers of all schoolchildren. Assent was obtained from children over the age of seven years old.

Statistical analyses

Statistical Package for Social Sciences (SPSS) version 15.0 (SPSS, Chicago, Ill, USA) was used to analyse the data. Referenced statistical methods were used.[25] The Z-test was used to compare the proportions of subjects who preferred each of the two varieties in the paired preference test. Logistic regression and simple linear regression analyses were performed to determine the effect of age on maize variety preference in all groups. Chi-square analysis was used to determine the relationship between gender and maize

Table I: Adults perceptions of, and attitudes towards, the consumption of yellow maize food products

Themes	Focus group questions	Discussion	Direct quotes
Concerns about consuming yellow maize food products	What did you like, or not like, about the food products that you tasted today? What do you feel about the flavour and colour of the food products that you tasted today?	Sensory properties such as flavour, aroma, colour and texture affected the likelihood of people accepting, and consuming, yellow maize food products. Both genders shared the same concerns about consumption of yellow maize food products.	"I cannot stand the colour." "The colour is unusual." "One will have to get used to the colour." "I hate its smell." "It is tasty, but the smell…" "It tastes like it is uncooked." "It tasted a bit salty."
Likelihood of people accepting yellow maize food products	How did you perceive the yellow maize food products that you tasted today?	Female participants showed an unfavourable attitude towards the taste of all the yellow maize food products. They thought that the taste would be unacceptable to children. This might have influenced their attitudes. Male participants were eager to accept yellow maize food products, and perceived them to be "nutritious", "filling" and "healthy".	"I think it's got more nutrients than the white porridge. It is good for the body." "…. It is making me healthy." "After eating, you can feel that you had something."
Likelihood of people purchasing yellow maize for consumption	If the yellow-orange maize was available in the shops, and was cheaper than white maize, would you buy it, and why?	The majority of participants stated that they would buy yellow maize for human consumption. Price factors and availability in grocery stores were identified as the two main determinants in this regard. The female group was willing to buy the yellow maize if it was cheaper, and would divert the money saved to other household needs. This indicates that domestic economic factors should be used to determine the possibility of people purchasing and consuming yellow maize. The majority mentioned that the maize could not be found easily in local grocery stores. Availability and supply of yellow maize to local grocery stores could influence buying decisions.	"I would not buy the maize, because I am not used to it." "I would try to get used to it if it was cheaper." "I would buy it if it were cheaper, to save money."
	Have you seen yellow-orange maize being sold anywhere? If yes, where?		"Yes, in shops selling animal food, like Agricol, but not in shops selling food." "I used to see it in shops long ago. These days, I don't see it."
Psychological factors	If the yellow-orange maize was available for you to grow in your garden, would you grow it, and why?	Both gender groups showed an unfavourable attitude towards the colour of the maize, which seemed to be influenced by past experiences. Both gender groups mentioned that they preferred white maize for human consumption, and believed that yellow maize was used to feed chickens. Their perception that yellow maize is chicken feed resulted from the fact that it is mostly found in animal feed stores.	"Yellow maize is good for feeding chickens." "I would not buy the maize, because I am not used to it."
Socio-cultural factors	Besides samp, *phutu* and thin porridge, what other foods would you make using yellow-orange maize?	The participants suggested a higher acceptance of yellow maize if it were served in maize food forms other than those presented to them in this study. The other food forms suggested by the participants included maize bread, mealies with bean soup, grilled mealies, sour porridge, and African beer. With regard to the food forms served in this study, both gender groups chose thin porridge as the best food form that could be made from yellow maize.	"I can use it to make maize bread, and cook dry mealies and beans." "I can also make African beer." "…I can drink sour porridge."

variety preference in the secondary school and adult groups. Multiple linear regression analysis was performed to determine the sensory attributes that had significant influence on the overall acceptance of a sample. One-way analysis of variance (ANOVA) and Tukey post-hoc multiple comparison of means were used to analyse for differences in the acceptance of the sensory attributes evaluated. The level of significance was p-value < 0.05.

Results

Consumer sensory evaluation

Consumer panel demographics are reported in Table II.

The number of preschoolchildren who preferred yellow maize food products was statistically significantly higher than that of children who preferred white maize food products (see Table III). In the primary school group, there was a tendency to prefer white thin porridge to yellow thin porridge, although this was not statistically significant (p-value > 0.05).

The mean sensory attribute scores for all three food products from the secondary school and adult groups are shown in Table IV. In the secondary school group, the white variety had the highest scores for the acceptability of the sensory attributes of *phutu* and thin porridge, compared to the yellow varieties. However, with regard to samp, the yellow variety, KP-79, had the highest scores for appearance and aroma acceptability, while KP-77, another yellow variety, had the highest mean score for texture, flavour and overall acceptability. The white maize food products were generally more acceptable to adults, relative to the yellow maize food products.

Table II: Consumer panel demographics

Group	Total number of subjects (n)	Number of males (%)[a]	Number of females (%)[a]	Age range (years)[b]	Mean age (years) (SD)
Preschool	52	22 (42)	30 (58)	3.1-6.5	5.4 (0.7)
Primary school	56	28 (50)	28 (50)	6.1-16.0	10.7 (3.0)
Secondary school	54	26 (48)	28 (52)	13.2-21.3	17.6 (1.9)
Adults	50	21 (42)	29 (58)	20.8-55.5	41.4 (8.1)

a = Percentage (%) of total sample within each age group, b = Age of subjects was obtained from the class register.

Table III: Paired preference test results

	Phutu		Thin porridge		Samp	
Group	**SC-701**	**KP-79**	**SC-701**	**KP-79**	**SC-701**	**KP-79**
Preschool						
Number of males (%)[a]	3 (14)	19 (86)	4 (18)	18 (82)	5 (23)	17 (77)
Number of females (%)[a]	7 (23)	23 (77)	9 (30)	21 (70)	9 (30)	21 (70)
Total number of subjects (%)[a]	10 (19)	42 (81)	13 (25)	39 (75)	14 (27)	38 (73)
P-value[b]	p-value < 0.001		p-value < 0.001		p-value < 0.001	
Primary school						
Number of males (%)[a]	14 (50)	14 (50)	16 (57)	12 (43)	15 (54)	13 (46)
Number of females (%)[a]	17 (61)	11 (39)	19 (68)	9 (32)	14 (50)	14 (50)
Total number of subjects (%)[a]	31 (55)	25 (45)	35 (63)	21 (38)	29 (52)	27 (48)
P-value[b]	p-value = 0.478		p-value = 0.065		p-value = 0.779	

a = Percentage (%) of sample within gender group; b = Z-test to compare proportions of subjects. P-value is given for the total age group.
SC-701: reference white maize. KP-79: medium-yellow variety

Table IV: Five-point facial hedonic rating of maize food products

Food products	*Phutu*				Thin porridge				Samp			
Varieties	**SC-701[a]**	**KP-78[b]**	**KP-79[c]**	**KP-77[d]**	**SC-701**	**KP-78**	**KP-79**	**KP-77**	**SC-701**	**KP-78**	**KP-79**	**KP-77**
Secondary school												
Appearance	3.9 (1.0)	3.4 (1.1)	3.1 (1.1)[e]	3.3 (1.1)[e]	4.2 (0.9)	3.4 (0.9)[e]	3.5 (1.0)[e]	3.4 (1.0)[e]	2.8 (1.2)	3.1 (1.1)	3.3 (1.1)	3.2 (1.1)
Aroma	3.9 (0.8)	3.4 (1.1)[e]	3.3 (1.0)[e]	3.5 (0.8)	3.6 (1.0)	3.2 (1.0)	3.4 (0.9)	3.4 (0.9)	3.1 (1.1)	3.2 (1.0)	3.4 (1.0)	3.2 (0.9)
Texture	3.8 (1.2)	3.5 (1.1)	3.2 (1.2)[e]	3.6 (0.9)	3.9 (0.9)	3.6 (1.1)	3.4 (1.3)	3.4 (1.3)	2.9 (1.1)	2.8 (1.0)	3.1 (1.0)	3.1 (1.1)
Flavour	4.0 (1.0)	3.7 (1.1)	3.2 (1.1)[e]	3.4 (1.1)[e]	4.0 (1.1)	3.8 (0.9)	3.5 (1.0)	3.6 (1.0)	3.2 (1.0)	3.0 (1.1)	3.0 (1.0)	3.2 (1.0)
Overall acceptability	4.2 (1.0)	3.9 (1.1)	3.3 (1.2)[e]	3.9 (1.1)	4.2 (1.0)	3.9 (0.9)	3.7 (1.0)[e]	3.9 (1.0)	3.2 (1.3)	3.0 (1.1)	3.2 (1.0)	3.4 (1.1)
Adults												
Appearance	4.3 (0.9)	3.1 (1.3)[e]	3.0 (1.1)[e]	3.2 (1.3)[e]	4.4 (0.8)	3.4 (1.3)[e]	3.4 (1.2)[e]	3.6 (1.0)[e]	3.6 (1.2)	3.2 (1.1)	3.2 (1.2)	3.3 (1.1)
Aroma	4.1 (1.0)	3.3 (1.2)[e]	3.0 (1.2)[e]	3.0 (1.2)[e]	4.1 (0.8)	3.3 (1.2)[e]	3.4 (1.1)[e]	3.5 (1.0)[e]	3.5 (1.0)	3.2 (1.1)	3.2 (1.1)	3.2 (1.0)
Texture	4.3 (0.9)	3.5 (1.3)[e]	3.1 (1.3)[e]	3.1 (1.3)[e]	4.5 (0.7)	3.4 (1.2)[e]	3.3 (1.2)[e]	3.7 (1.2)[e]	3.8 (1.1)	3.0 (1.2)e	3.4 (1.1)	3.4 (1.2)
Flavour	4.5 (0.8)	3.1 (1.2)[e]	3.1 (1.3)[e]	3.2 (1.4)[e]	4.5 (0.6)	3.3 (1.3)[e]	3.5 (1.2)[e]	3.4 (1.1)[e]	3.7 (1.1)	3.1 (1.1)e	3.2 (1.0)	3.2 (1.1)
Overall acceptability	4.5 (1.0)	3.3 (1.3)[e]	3.0 (1.3)[e]	3.1 (1.3)[e]	4.5 (0.7)	3.4 (1.3)[e]	3.3 (1.4)[e]	3.7 (1.2)[e]	3.6 (1.2)	3.1 (1.2)	3.2 (1.1)	3.3 (1.2)

a = white variety (reference), b = light-yellow variety, c = medium-yellow variety, d = deep-yellow variety, e = Mean acceptability scores were significantly different from those of the reference maize (SC-701), according to the Tukey (HSD) test (p-value < 0.05). All values are given as the mean, with the standard deviation in brackets. Significant differences are indicated in rows. Five-point facial hedonic ranking ranged from 1 to 5 (1 = "very bad", 5 = "very good").

Table V: Preference ranking of maize food products

Food products	*Phutu*				Thin porridge				Samp			
Maize varieties	**SC-701**	**KP-78**	**KP-79**	**KP-77**	**SC-701**	**KP-78**	**KP-79**	**KP-77**	**SC-701**	**KP-78**	**KP-79**	**KP-77**
Secondary school												
Most preferred	31[a] (57)[b]	8 (15)	6 (11)	9 (17)	24 (44)	7 (13)	13 (24)	9 (17)	23 (43)	11 (20)	9 (17)	11 (20)
Second preferred	3 (6)	25 (46)	14 (26)	11 (20)	10 (19)	18 (33)	16 (30)	10 (19)	9 (17)	16 (30)	12 (22)	17 (32)
Third preferred	9 (17)	10 (19)	16 (30)	20 (37)	4 (7)	20 (37)	8 (15)	22 (41)	5 (9)	15 (28)	21 (39)	13 (24)
Least preferred	11 (20)	11 (20)	18 (33)	14 (26)	16 (30)	9 (17)	17 (32)	12 (22)	17 (32)	12 (22)	12 (22)	13 (24)
Adults												
Most preferred	41 (82)	5 (10)	3 (6)	1 (2)	38 (76)	5 (10)	4 (8)	3 (6)	27 (54)	7 (14)	8 (16)	8 (16)
Second preferred	5 (10)	13 (26)	16 (32)	16 (32)	4 (8)	10 (20)	14 (28)	22 (44)	8 (16)	9 (18)	16 (32)	17 (34)
Third preferred	1 (2)	16 (32)	19 (38)	13 (26)	6 (12)	15 (30)	15 (30)	14 (28)	5 (10)	14 (28)	15 (30)	16 (32)
Least preferred	14 (14)	16 (32)	12 (24)	20 (40)	2 (4)	20 (40)	17 (34)	11 (22)	10 (20)	20 (40)	11 (22)	9 (18)

a = Number of subjects, b = Percentage of total number of subjects
Preference ranking ranged from 1-4 (1 = most preferred; 4 = least preferred)

Preference ranking of maize food products revealed that all three white maize food products were the most preferred by both the secondary school and adult groups, when compared to the yellow maize food products, (see Table V).

Table VI: Multiple linear regression coefficients (r^2) showing the influence of the sensory attributes on the overall acceptability of the maize food products by the secondary school and adult groups

Group	Food product and variety	Appearance	Aroma	Texture	Flavour
Secondary school	***Phutu***				
	SC-701	0.080	0.145	0.524[a]	0.185
	KP-78	0.049	0.049	0.465[a]	0.529[a]
	KP-79	0.265	0.486[a]	0.389[a]	0.018
	KP-77	-0.049	0.399[a]	0.431[a]	0.346[a]
	Thin porridge				
	SC-701	0.235	0.061	0.561[a]	0.122
	KP-78	-0.142	0.216[a]	0.462[a]	0.262[a]
	KP-79	0.069	0.097	0.560[a]	0.184
	KP-77	0.141	0.071	0.372[a]	0.144
	Samp				
	SC-701	-0.090	0.176	0.029	0.763[a]
	KP-78	-0.003	0.239[a]	0.375[a]	0.413[a]
	KP-79	0.064	0.207	0.141	0.470[a]
	KP-77	0.266	0.189	0.548[a]	0.071
Adults	***Phutu***				
	SC-701	0.142	-0.460	0.558[a]	0.549[a]
	KP-78	0.141	0.102	0.295	0.574[a]
	KP-79	-0.014	0.071	0.418[a]	0.495[a]
	KP-77	-0.132	0.062	0.471[a]	0.416[a]
	Thin porridge				
	SC-701	0.107	-0.114	0.793[a]	0.208
	KP-78	0.068	0.021	0.321[a]	0.614[a]
	KP-79	-0.012	-0.018	0.698[a]	0.405[a]
	KP-77	-0.077	0.140	0.433[a]	0.593[a]
	Samp				
	SC-701	-0.233	0.112	0.618[a]	0.529[a]
	KP-78	0.116	0.048	0.344[a]	0.534[a]
	KP-79	0.119	0.091	0.371	0.459[a]
	KP-77	0.107	0.026	0.290[a]	0.602[a]

a = Multiple linear regression analysis, significant at p-value < 0.05

Logistical regression analysis showed that among females, the likelihood of accepting yellow maize food products decreased significantly as age increased (r^2 = -0.275; p-value = 0.003). Although the same tendency was observed in males, it was not statistically significant (r^2 = -0.132; p-value = 0.128). In the secondary school and adult groups, chi-square analysis showed that there was no statistically significant relationship between gender and maize variety preference (p-value < 0.05). Simple linear regression analysis of the effect of age on maize variety preference showed that with regard to *phutu* and thin porridge, preference for white maize increased with age (p-value < 0.05). However, there was no association between preference for a maize variety and age with regard to *phutu*, thin porridge, and samp, made from KP-79 and KP-77.

Multiple linear regression analysis showed that in the secondary school group, texture had a significant influence on the overall acceptability of *phutu* and thin porridge, while flavour, texture and aroma had a significant influence on the overall acceptability of samp (see Table VI). In the adult group, flavour had a significant influence on the overall acceptability of *phutu* and samp and texture influenced the overall acceptability of thin porridge. Overall, in both the secondary school and adult groups, texture and flavour had the greatest influence on overall acceptability of all three maize food products.

Focus group discussions

The results indicate that the participants disliked the colour, flavour, aroma and texture of the yellow maize (see Table I). However, the participants were willing to consume yellow maize if it was cheaper than white maize, and was readily available in local grocery stores.

Discussion

The higher preference for white maize food products among the older children (primary and secondary schoolchildren) and adults compared with the younger children (preschool) could be due to the fact that older consumers had become more accustomed to white maize, as they had been consuming it for a longer time than the younger children. The results suggest that provitamin A-biofortified maize has the potential to solve the problem of vitamin A deficiency in

children of preschool age, but this is dependent on the bioavailability of the β-carotene from the maize, and the consumption of adequate amounts of the maize.[26] However, it is generally the adult caregivers, particularly women, who purchase and prepare meals in the home. It is unlikely that the adult caregiver would prepare yellow maize food products separately for pre-schoolchildren and white maize for the rest of the household. This implies that education on the nutritional benefits of consuming yellow maize should be aimed at the adult caregivers, particularly women. The alternative would be to include yellow maize food products in preschool feeding schemes.

In this study, the strong preference for white maize food products by older consumers is in agreement with the findings of other studies.[9-12] Since the acceptability of the yellow maize food products was influenced by flavour and texture, developing yellow maize with suitable flavour and texture traits may improve consumer acceptability. However, it may be impossible to change the flavour of the yellow maize, as it is dependent on the oil and amino acid content and storage time and conditions, as well as processing.[27] Storing yellow maize under suitable conditions to prevent the development of unacceptable sensory properties is also an important factor in ensuring its overall sensory acceptability. Furthermore, varying product formulation and processing methods may also contribute to increased acceptance of yellow maize, as was suggested by the variation in the acceptance of the different yellow maize food forms by the secondary school group.

Focus group discussions showed that adult subjects had a negative attitude towards the colour, flavour and aroma of yellow maize food products, which concurred with the sensory evaluation results that consumers preferred white maize to yellow maize. Although sensory evaluation results showed that gender had no effect on preference for yellow maize, the focus group discussions indicated that male subjects had a more positive view of yellow maize, compared to female subjects. This suggests that education initiatives on the nutritional benefits of yellow maize should be directed at both men and women. The willingness to purchase yellow maize, if it were sold at a lower price than white maize, and the association of yellow maize with animal feed by participants, is consistent with other studies.[10-12]

Study limitations and recommendations

The results of this study should be interpreted with caution because of the small sample size (n = 212). Elderly consumers were not included in this study, because of the decrease in sensory sensitivity with ageing. However, this group is also vulnerable to vitamin A deficiency and should be included in future studies. Although descriptive sensory analysis using a trained panel was not conducted in this study, it should be included in future research so that the relationship between sensory characteristics of the provitamin A-biofortified maize, and consumer acceptability of the biofortified maize, can be determined.

Conclusion

Yellow, provitamin A-biofortified maize has the potential to succeed as a new strategy of dealing with the serious problem of vitamin A deficiency, especially among children of preschool age. The inclusion of yellow maize food products in preschool feeding programmes may be a strategy to promote its consumption in this group. However, in older groups the use of yellow maize to alleviate VAD is unlikely to be successful unless intensive nutrition education programmes that highlight the nutritional benefit of this maize are developed. Other strategies should target the market price at which yellow maize is sold, in addition to increasing its availability in local grocery stores, and improving its sensory properties through development.

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References

1. Global prevalence of vitamin A deficiency in populations at risk 1995-2005. WHO global database on Vitamin A deficiency. Geneva: World Health Organization, 2009 [homepage on the Internet]. c2010. Available from: http://whqlibdoc.who.int/publications/2009/9789241598019_eng.pdf
2. Labadarios D (ed). National Food Consumption Survey: Fortification Baseline (NFCS-FB). South Africa, 2005. Pretoria: Department of Health, 2007.
3. Labadarios D, Van Middelkoop AM. Children aged 6-71 months in South Africa, 1994: their anthropometric, vitamin A, iron and immunisation coverage status. Johannesburg: South African Vitamin A Consultative Group, 1995.
4. Labadarios D, Steyn NP, Mgijima C, Dladla N. Review of the South African nutrition policy 1994-2002 and targets for 2007: achievements and challenges. Nutrition. 2005;21(1)100-108.
5. Swart R, Sanders D, McLachlan M. Nutrition: a primary health perspective. In: Barron P, Roma-Reardon J, eds. South African Health Review 2008. Durban: Health Systems Trust, 2008: 129-147.
6. Nestel P, Bouis HE, Meenakshi JV, Pfeiffer W. Biofortification of staple food crops. J Nutr. 2006;136(4):1064-1067.
7. Stevens R, Winter-Nelson A. Consumer acceptance of provitamin A-biofortified maize in Maputo, Mozambique. Food Policy. 2008;33:341-351.
8. HarvestPlus Brief. HarvestPlus: Breeding crops for better nutrition. Washington DC, 2006.
9. Muzhingi T, Langyintuo AS, Malaba LC, Banziger M. Consumer acceptability of yellow maize products in Zimbabwe. Food Policy. 2008;33:352-361.
10. De Groote H, Kimenju SC. Comparing consumer preferences for color and nutritional quality in maize: application of a semi-double bound logistic model on urban consumers in Kenya. Food Policy. 2008;33:362-270.
11. De Groote H, Kimenju SC, Morawetz UB. Estimating consumer willingness to pay for food quality with experimental auctions: the case of yellow versus fortified maize meal in Kenya. Agricultural Economics. 2010;41:362-370.
12. Tschirley DL, Santos AP. Who eats yellow maize? Preliminary results of a survey of consumer maize preferences in Maputo, Mozambique. MSU International Department of Agricultural Economics Development, Department of Economics Working Paper No 53. Michigan: Michigan State University, 1995.
13. Tothova M, Meyers WH. Predicting the acceptance for high beta-carotene maize: an ex-ante estimation method. Long Beach, California: American Agricultural Economics Association, 2006.
14. Cooke LJ, Wardle J. Age and gender differences in children's food preference. Br J Nutr. 2005;93(5):741-746.
15. Faber M, Kruger S. Dietary intake, perceptions regarding body weight, and attitudes toward weight control of normal weight, overweight, and obese Black females in a rural village in South Africa. Ethnicity & Disease. 2005;15(2):238-245.
16. Faber M. Complementary foods consumed by 6-12 month old rural infants in South Africa are inadequate in micronutrients. Public Health Nutr. 2004;8(4):373-381.
17. DeMan JM. Principles of food chemistry. 3rd ed. Maryland: Aspen, 1999: p. 237.
18. Mkhambathini Local Municipality. Local economic development (LED) strategic plan. Pietermaritzburg: UMgungundlovu District Municipality, 2007.
19. Resource Targeting List. Pretoria: Department of Education, 2010.
20. Stone H, Sidel JL. Sensory evaluation practices. 3rd ed. California: Elsevier Academic Press, 2004: p. 247-277.
21. Guinard J-X. Sensory and consumer testing with children. Trends Food Sci Tech. 2001;11:273-283.
22. Kimmel S, Sigman-Grant MJ, Guinard J-X. Sensory testing with young children. Food Technology. 1994;48:92-99.
23. Heymann H. Three-day advanced sensory analysis workshop. Agricultural Research Council (ARC). Irene, Pretoria, 1995.
24. Merton RK, Fiske M, Kendall PL. The focused interview: a manual of problems and procedures. 2nd ed. New York: Free Press, 1990: p.137.
25. Cochran WG, Cox GM. Experimental designs. 2nd ed. New York: John Wiley, 1992: p. 611.
26. Muzhingi T, Gadaga T, Siwela AH, et al. Yellow maize with high β-carotene is an effective source of vitamin A in healthy Zimbabwean men. Am J Clin Nutr. 2011;94:510-519.
27. Schroeder JW. Corn gluten feed: composition, storage, handling, feeding and value.1997 [homepage on the Internet]. c2010. Available from: http://www.ag.ndsu.edu/pubs/ansci/dairy/as1127w.htm.