

Acceptance of a complementary food prepared with yellow, provitamin A-biofortified maize by black caregivers in rural KwaZulu-Natal

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Abstract

Objectives: The objective was to assess the sensory acceptability and consumer perceptions of soft porridge made with yellow, provitamin A-biofortified maize by black African female infant caregivers from rural KwaZulu-Natal.

Design: This was a cross-sectional study.

Setting: The study was conducted at Edendale Hospital, located in the uMgungundlovu District, KwaZulu-Natal province. The hospital serves a high proportion of people from rural areas in this district.

Subjects: Sixty black African female infant caregivers participated in the study.

Outcome measures: The sensory acceptability of soft porridge made from two varieties of provitamin-A biofortified maize and one variety of white maize were evaluated by black African female infant caregivers ($n = 60$) using a five-point facial hedonic scale. Some of the subjects ($n = 21$) participated in focus group discussions to assess consumer perceptions.

Results: There was no significant difference in the sensory acceptability of the biofortified maize porridge and the white maize porridge, irrespective of caregiver age (p -value > 0.05). The caregivers expressed a willingness to give their infants porridge made with provitamin A-biofortified maize if it was more affordable, readily available and beneficial to health.

Conclusion: The biofortified maize soft porridge was found to be as acceptable as the white maize soft porridge to black African female infant caregivers from rural KwaZulu-Natal. Provitamin A-biofortified maize has the potential to be used as a complementary food item that would contribute to the alleviation of vitamin A deficiency.

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Introduction

The prevalence of childhood malnutrition is escalating worldwide, especially in developing countries, resulting in more than 33% of child deaths.¹⁻³ In South Africa, the average incidence of severe acute malnutrition in children under five years was 4.4 cases per 1 000 children in 2012/2013. KwaZulu-Natal had a reported incidence of 13 cases per 1 000 children, which was the second highest nationally.⁴ Although macronutrient malnutrition is a major concern, micronutrient malnutrition is usually overlooked. Vitamin A deficiency (VAD) is one of the most common micronutrient deficiencies in developing countries.^{5,6} Diets are high in starch, such as maize, and low in animal-sourced food in poor communities. These diets lack diversity, are nutritionally insufficient and may lead to VAD.^{7,8} VAD doubled between 1994 and 2005 in South African children.⁹⁻¹¹ A more recent study, the National Health and Nutrition Examination

Survey (SANHANES-1), reported that VAD prevalence was 43.6% at national level. Compared to the National Food Consumption Survey-Fortification Baseline (NFCS-FB), these results showed a 20% decrease in the national prevalence of VAD in children aged five years and younger.¹²

The South African government has implemented various strategies to address VAD. These include fortification, vitamin A supplementation and dietary diversity. However, these strategies have not been effective for various reasons.^{13,14} Biofortification is an emerging complementary strategy that involves enhancing staple crops with vitamins and minerals through conventional breeding and genetic modification techniques.^{8,15-17} The sensory attributes of provitamin A-biofortified maize are important as they affect the acceptance of the biofortified maize by consumers.^{18,19} Many rural communities perceive yellow maize as being unfit for human consumption, but

suitable for animal feed or food aid.^{20,21} Appropriate nutrition in the early stages of an infant's life is important for optimal growth and development. Six months after birth, breastfeeding alone cannot meet the infant's nutritional requirements and complementary food is required.^{2,3} Infants from rural communities are generally given soft white maize porridge as the first, and in most cases, only, complementary food.²² Unfortified soft white maize porridge is devoid of vitamin A, and its use as the main complementary food increases the risk of VAD in infants. The use of provitamin A-biofortified maize, instead of unfortified white maize as a complementary food could improve vitamin A intake in vulnerable children.^{23,24} Previous studies have indicated a low acceptance of provitamin A-biofortified maize by consumers because of its undesirable sensory attributes.^{8,25,26} However, it has been found that usually mothers are willing to try new foods if they are beneficial to their infants' health and culturally acceptable.³ This study aimed to assess the acceptance of soft porridge made with provitamin A-biofortified maize as a complementary food by caregivers.

Method

Maize grain

Dried grain from three maize varieties: two yellow provitamin A-biofortified varieties [provitamin A (PVA) pool A and PVA pool B] and one white variety (reference) were used in this study. The white maize variety was not biofortified and therefore lacked vitamin A as it was not commercially purchased. Instead, the maize grain from all three varieties was produced in the same season (2011/2012), and under the same production conditions by plant breeders at the Ukulinga Research Farm of the University of KwaZulu-Natal.

Breeding of provitamin A-biofortified maize

Provitamin A-biofortified maize inbred lines, i.e. the parents of hybrids, were developed through pedigree breeding from 2008-2011. During phenotypic selection, emphasis was placed on grain colour intensity, such that lines exhibiting a deep orange colour were advanced to the next generation. The deep-orange grain colour positively correlates with provitamin A content in maize grain. The breeding experiments resulted in three groups of hybrids (synthetic populations) classified according to grain colour intensity: Group A (deep orange), Group B (medium orange) and Group C (light orange). For convenience, the three synthetic populations were designated as pool A, B and C. The synthetic populations and a reference white maize variety were grown at Cedara Research Station, near Pietermaritzburg, to bulk the grain. Standard cultural practices for maize production were followed. The maize was harvested manually and left to dry under ambient conditions ($\pm 25^{\circ}\text{C}$) for 21 days at Ukulinga Research Farm. The maize was then threshed by hand and the grain stored in a cold room at 5°C at Ukulinga Research Farm until it was required for the research.

Maize milling

After the maize grains had been cleaned following a standard method, they were milled with a pilot roller mill (Model MK[®] 150, Roff

Industries, Kroonstad). This type of miller has a three-break system and yields super meal, maize grits and fine meal. Super meal was collected from the last two break systems for the purpose of the study. This maize meal passed through a $459\ \mu\text{m}$ aperture screen.

Preparation of the porridges

A standardised recipe was used to prepare soft maize porridge, a commonly used complementary food. The porridges were prepared on the day of data collection in the food-processing laboratory at the University of KwaZulu-Natal by a black African woman living in a rural area in the uMgungundlovu District where the site, Edendale Hospital, is located. This ensured that the porridges were prepared in the same way in which the study participants traditionally prepared soft porridge. Thereafter, the porridges were transported to the research site in air-tight containers.

Sensory evaluation

Sixty black African female infant caregivers residing in the rural areas of uMgungundlovu District, and attending either the paediatric outpatients department clinic or the Khanyisa Clinic at Edendale Hospital (a referral hospital for 16 rural clinics) were randomly selected to participate in the study, which was conducted over one day. A pilot study was carried out using 10 participants. The pilot study participants were excluded from the main study. In order to prevent the panellists from influencing one another's responses, the panellists were seated a few metres away from one another, and were asked not to communicate during the sensory evaluation session.

Sample labelling was randomised by assigning each of the porridge samples a unique three-digit code obtained from a table of random numbers.²⁷ The serving order of the porridge samples was randomised using a table of random permutations of nine.²⁷ Every participant received one heaped tablespoon from each sample in a polystyrene cup. Each sample was warmed to $\pm 45^{\circ}\text{C}$ in a microwave oven before serving. The panellists were provided with a cup of water to rinse the palate between samples, and a sensory evaluation questionnaire for each sample was administered in the local language, *isiZulu*. The questionnaire, which made use of a five-point facial hedonic scale (1 = very bad to 5 = very good), as well as the sensory attributes, was explained to the participants by the research assistant in *isiZulu*. The participants were given minimal information about provitamin A-biofortified maize prior to the evaluation or during the explanation of the consent form in order to prevent bias. Participants were assisted by the research assistants when required.

Focus group discussions

Focus group discussions were conducted to determine the sensory and consumer perceptions of the black female infant caregivers regarding the provitamin A-biofortified maize. Twenty-one participants were randomly selected from the caregivers who participated in the sensory evaluation to participate in the focus group discussions. Participants were divided into three groups of seven. The accepted sample size for a focus group discussion is between seven and

12 subjects.^{28,29} The focus group discussions were free flowing and were directed by a focus group guide consisting of eight questions which were mainly open ended. Information saturation was reached after completing the three focus group discussions. The focus group discussions were facilitated in *isiZulu* and were recorded using a digital voice recorder. The discussions were translated verbatim into English by the focus group discussion facilitator, and were then cross-checked by an *isiZulu*-speaking person against the English translation.

Ethics approval

Ethical approval was obtained from the University of KwaZulu-Natal, Humanities and Social Science Ethics Committee (HSS/0180/012M). Approval to conduct the study was also received from the Edendale Hospital Ethics Committee and the Department of Health. Written consent was obtained from the panellists before their participation in the study. The consent form was read to illiterate participants and they were able to sign the consent form with assistance.

Statistical analysis

Data from the sensory evaluation questionnaires were analysed using the Statistical Package for Social Science® version 15. Appropriate statistical techniques, including the analysis of variance, Tukey and Dunnett tests, were used to analyse the data. A p-value of < 0.05 was considered to be statistically significant.

Table I: Number and age of participants (n = 60)

Age group (years)	16-25	26-35	36-45	46-55	56-65
n (%) [*]	21 (35)	16 (27)	8 (13)	10 (16.7)	5 (8.3)

* Total sample, n = 60

Results

Sensory evaluation

Sample characteristics

The number and percentage of the black African female infant caregivers in the specific age groups is presented in Table I.

There was no significant difference between the different sensory attributes and the two types of biofortified maize, when compared to the reference variety (Table II).

There was no significant difference (p-value > 0.05) with regard to the acceptability of the evaluated maize porridges. The panellists rated the sensory attributes, including overall acceptability, of the different porridges as "good", with an average score of 4 (Table III). There was no statistically significant difference (p-value > 0.05) in the acceptability of the porridges across the age groups (Figure I). There was no significant relationship (p-value > 0.05) between the age of the caregivers and the overall acceptability of the porridges.

Table II: Sensory acceptability of the provitamin A-biofortified maize and the control white maize porridges

Porridge type	Sensory attributes				
	Taste	Texture	Aroma	Colour	OA
PVA pool A	4 [*] (1) ^{**}	4.1 (0.9)	4 (0.8)	4.2 (0.7)	4.2 (0.8)
PVA pool B	3.7 (1)	4 (0.8)	3.9 (0.9)	4.2 (0.7)	4 (0.8)
Reference	3.9 (1)	4.1 (0.8)	3.9 (0.9)	4 (0.9)	4.3 (0.8)

OA: overall acceptability, PVA: provitamin A
*mean, **standard deviation

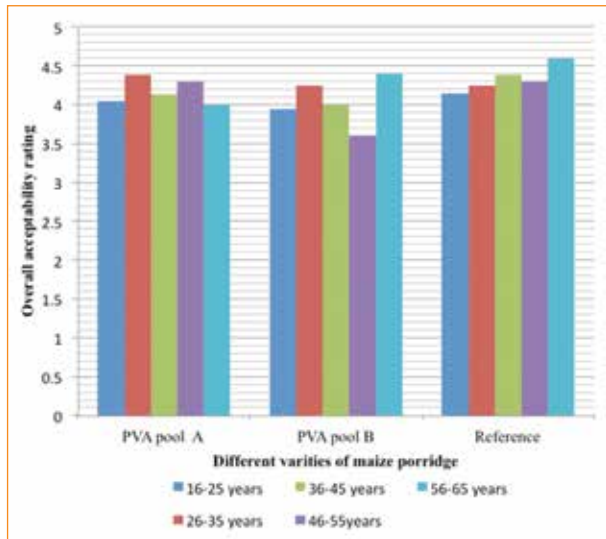
Table III: Number and percentages of panellists who gave different ratings for the sensory attributes that were evaluated (n = 60)

Porridge type	Rating	Taste	Texture	Aroma	Colour	OA
PVA pool A	Very bad	1 [*] (1.7) ^{**}	1 (1.7)	0 (0)	0 (0)	2 (3.3)
	Bad	4 (6.7)	4 (6.7)	2 (3.3)	2 (3.3)	0 (0)
	Average	7 (11.7)	3 (5)	15 (25)	5 (8.3)	8 (13.3)
	Good	31 (51.7)	33 (55)	27 (45)	35 (58.3)	27 (45)
	Very good	17 (28.3)	19 (31.7)	16 (26.7)	18 (30)	23 (38.3)
PVA pool B	Very bad	3 (5)	1 (1.7)	1 (1.7)	1 (1.7)	2 (3.3)
	Bad	5 (8.3)	1 (1.7)	2 (3.3)	1 (1.7)	2 (3.3)
	Average	9 (15)	8 (13.3)	15 (25)	3 (5)	8 (13.3)
	Good	28 (46.7)	36 (60)	28 (46.7)	38 (63.3)	29 (48.3)
	Very good	15 (25)	14 (23.3)	14 (23.3)	17 (28.3)	19 (31.7)
Control	Very bad	1 (1.7)	1 (1.7)	0 (0)	2 (3.3)	0 (0)
	Bad	3 (5)	4 (6.7)	4 (6.7)	1 (1.7)	1 (1.7)
	Average	12 (20)	3 (5)	12 (20)	9 (15)	8 (13.3)
	Good	25 (41.7)	33 (55)	25 (41.7)	30 (50)	25 (41.7)
	Very good	19 (31.7)	19 (31.7)	19 (31.7)	18 (30)	26 (43.3)

OA: overall acceptability, PVA: provitamin A

*Number of subjects, **Percentage of total number of participants

Acceptability rating: 1 (very bad), 2 (bad), 3 (average), 4 (good) and 5 (very good)



PVA: provitamin A

Figure 1: The effect of age on the overall acceptability of the maize porridges

Focus group

Overall, the caregivers had positive perceptions about the colour, aroma and texture of provitamin A-biofortified maize (Table IV). However, the taste of the provitamin A-biofortified maize was not readily accepted. The caregivers expressed a willingness to give their infants provitamin A-biofortified maize if it was more affordable than white maize, readily available and had a health benefit.

Discussion

Sensory acceptability of the porridges

Provitamin A-biofortified maize is an orange-yellow colour, to which consumers were not accustomed.³⁰ However, in the present study it seems that the sensory properties of the provitamin A-biofortified maize, including the yellow colour, had no negative effect on the acceptability of the porridges. The results indicated that there were no significant differences in the sensory acceptability of the biofortified maize porridge and the white maize porridge. The finding that there were no significant differences with regard to colour acceptance of the maize porridge is consistent with results obtained from a previous study in Zambia, in which Zambian participants rated the taste, aroma, texture and overall acceptability of the biofortified maize as being similar to that of white maize.³¹ Conversely, another study found that there was poor acceptance of the colour, flavour and aroma of yellow provitamin A-biofortified maize.²⁵ The acceptability of these sensory attributes varied with the food type, i.e. samp, thin porridge and *phutu*.²⁵ However, the current study evaluated only one food type, i.e. soft maize porridge. The texture of provitamin A-biofortified maize is another sensory attribute that has been found to be poorly accepted.¹⁶ Researchers reported that a finer texture was better accepted by consumers.²¹ Texture acceptability was not a challenge in the present study. The differences in the results pertaining to sensory acceptability of the biofortified maize in various studies can be attributed to the geographical location of

the consumers, consumer demographic profiles, the colour of the biofortified maize (yellow or orange), maize food type evaluated and consumer familiarity with biofortified maize.

Although many researchers have found that the sensory properties of white maize are preferred over those of yellow or orange biofortified maize, the results of this study differed. There was no significant difference in the acceptability of the white maize and provitamin A-biofortified maize. It is generally accepted that if a food is accepted by female caregivers, they will give it to the children in their care. The sensory evaluation findings of this study suggest that soft porridge made with provitamin A-biofortified maize could potentially be used as a complementary food by rural caregivers in the uMgungundlovu District of KwaZulu-Natal. More research needs to be conducted to determine whether or not the biofortified soft maize porridge would be acceptable for use as a complementary food to a much larger sample of caregivers from rural areas in other districts and countries in sub-Saharan Africa.

Focus group discussions

Participants believed that the yellow maize was suitable for infants as they perceived it to be nutritious. Some of them indicated a willingness to use provitamin A-biofortified maize soft porridge as a complementary food (Table IV). The participants in this study also had negative perceptions of yellow maize (Table IV), consistent with those reported in other studies.^{20,21,26} Orange biofortified maize has been found to be more acceptable to consumers than yellow maize.^{8,31,32} The stigma concerning yellow maize, including provitamin A-biofortified maize, could be reduced by educating consumers on the health properties of biofortified maize through the media and health workers. Consumer perceptions of yellow maize could be improved further if it was made readily available in supermarkets, as it would then be perceived as being fit for human consumption. Because less stigma is associated with orange maize, the colour of the biofortified maize could be developed through breeding techniques to be orange in colour. This would improve its acceptance.

Several studies have indicated that biofortified maize would be purchased if it was sold at a lower price; consistent with the findings of the present study.^{8,19,25,33} Other authors have indicated that consumers were willing to pay more for orange maize, whereas a discount was needed for yellow maize.^{16,31} This study indicated that provitamin A-biofortified maize would be purchased and used as a complementary food if it was more affordable, contained health-promoting properties and was readily available. Research should expand to investigate the use of provitamin A-biofortified maize in other complementary food items, such as *phutu* (crumbly maize porridge) with *maas* (sour milk) or with vegetable or meat stew.

Conclusion

The sensory evaluation results of this study indicated that yellow, provitamin A-biofortified maize soft porridge was as acceptable as white maize soft porridge to infant caregivers from the rural areas

Table IV: Caregivers' perceptions towards the soft porridges made with provitamin A-biofortified maize

Question	Theme	Concept	Quotes	Discussion
Consumer familiarity with yellow maize	Consumer perceptions of yellow maize	<ul style="list-style-type: none"> Yellow maize was a familiar food consumed in bygone times White maize is regarded as a modern food Stigmatisation 	<p>"You can never find yellow maize in any supermarket or spaza shop."</p> <p>"<i>Bokide</i> was used to feed the animals."</p> <p>"In the old days, you could get it. Now, you cannot find it."</p> <p>"People feed the animals with it."</p> <p>"Yellow maize is for poor people and is used to feed animals."</p>	<p>Modernisation and market availability influences preferences, and the consumption and utilisation of yellow maize. The fact that it is unavailable in supermarkets suggests that white maize is of better quality, subsequently overshadowing that of yellow maize. Nutrition education on the health benefits of provitamin A-biofortified maize, in comparison to white maize, should be conducted to create a positive image and to change consumer perceptions. Social marketing techniques with respect to provitamin A-biofortified maize could increase consumer acceptance.</p> <p>The study subjects perceived yellow maize as being suited to poor people, because of the way in which it was introduced during times of drought. It was given as food aid. It is also perceived to be an animal food because it is only available in animal stores, and not in supermarkets. The stigmatisation of yellow maize jeopardises its acceptability.</p>
A description of the appearance of the yellow maize	The physical attributes of yellow maize which are appreciated	<ul style="list-style-type: none"> Described as being of an egg yolk colour Yellow maize is said to have a rough and coarse texture The smell of the yellow maize is not different to that of the white maize 	<p>"The colour of the yellow maize is beautiful and bright."</p> <p>"The yellow maize is a nice colour."</p> <p>"It tastes different from the white maize."</p> <p>"It tastes okay."</p>	<p>The colour, texture and appearance of the maize were satisfactory to consumers. However, the taste of the provitamin A-biofortified maize was less acceptable, although it was perceived to be nutritious when compared to the yellow maize meal from "bygone times". Caregivers mentioned that although the yellow maize had an unusual taste, it was something to which they could become accustomed. Provitamin A-biofortified yellow maize is a rich yellow colour, similar to that of egg yolk, and could have stimulated and influenced the belief that provitamin A-biofortified yellow maize is nutritious.</p>
	The physical attributes of yellow maize which are not appreciated	<ul style="list-style-type: none"> The yellow maize has an unusual taste 	<p>"It is fine and I could get used to the taste."</p> <p>"Children would not have a problem with it."</p>	
Willingness to use yellow maize porridge as a complementary food	Willingness	<ul style="list-style-type: none"> Colour Perceived nutrition Affordability 	<p>"If it is good for my baby's health, I would buy it."</p> <p>"I would buy it if it was cheap."</p>	<p>The colour is attractive enough to entice children into liking it. Mothers believed that the change in taste indicated that the yellow maize was nutritious. Price was the main determinant of whether or not they would buy it.</p>
	Food-preparation methods	<ul style="list-style-type: none"> Baby foods, such as soft porridge, <i>phutu</i>, pap and beans 	<p>"I can use it to make porridge, pap, sgwaqane and <i>phutu</i>."</p>	<p>There was no distinct difference in the way in which the yellow maize would be used, compared to white maize, with regard to food for babies. However, mothers indicated that if yellow maize had a specific primary benefit, this would possibly inspire them to purchase and consume it.</p>

of the uMgungundlovu District of KwaZulu-Natal. The caregivers were willing to give their infants porridge made with provitamin A-biofortified maize if it was affordable, readily available and had health benefits. With nutritional education and proper marketing strategies, the negative stigma attached to yellow maize could be minimised. Overall, it appears that provitamin A-biofortified maize has the potential to be used as a complementary food item.

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References available on request.