

Full Length Research Paper

Consumer acceptability of four products made from beta-carotene-rich sweet potato

S. M. Laurie^{1*} and S. M. Van Heerden²

¹Agricultural Research Council-Roodeplaat Vegetable and Ornamental Plant Institute (ARC-VOPI), Pretoria, South Africa.

²Agricultural Research Council-Animal Production Institute, Sensory Analysis Unit, Pretoria, South Africa.

Accepted 13 February, 2012

Beta-carotene-rich (orange-fleshed) sweet potato is one of a few new crops, which is an excellent source of energy and important nutritive substances that can contribute to improve the nutrient status of communities. The crop is being promoted in the developing world as a source of provitamin A towards alleviating vitamin A deficiency (VAD). The purpose of the study was to determine the consumer acceptability of four products made from β -carotene-rich sweetpotato namely chips, doughnuts, juice and sweet potato leaves (cooked green vegetable dish). Consumer testing (n=950) was conducted in six target sites in Limpopo, Mpumalanga, North West and KwaZulu-Natal Province of South Africa. The product acceptability was high varying between 85 and 95%, with the highest acceptability for doughnuts. The results further indicated that on average 92% of the consumers liked the colour of the four products, 87% of the consumers would buy the products and 88% indicated that they will make the products at home. The older respondents were more willing to buy and make these products as opposed to younger consumers. Consumers in different regions and in different age groups showed interest in the products. It is therefore recommended that these products are introduced to the formal as well as the informal sector.

Key words: Consumer panel, hedonic scale, processing, orange-fleshed sweet potato, provitamin A.

INTRODUCTION

Vitamin A deficiency (VAD) has far reaching consequences and is one of the three most common deficiencies in the world and in sub-Saharan Africa. The VAD contributes up to 25% of child mortality due to related diseases such as malaria, diarrhea associated diseases, acute respiratory infections and vaccine preventable diseases (Micronutrient Initiative, 2004). It can cause retarded growth and development, causing slow progress at school, night blindness and even total blindness, susceptibility to diseases and in severe cases death. The elderly, children, pregnant and lactating women are the most affected. However, as societies

become exposed to outside influences, food patterns and their food habits change. As culturally accepted nutritious products and methods of preparation with information about such product become known, the nutrient status of a community could improve. Beta-carotene-rich sweet potato (also known as orange-fleshed sweetpotato) is one of a few new crops, which is both an excellent source of energy and important nutritive substances that can contribute to improve the nutrient status of the community (Burri, 2011). The crop is promoted by various organizations in Sub-Saharan Africa through the Sweetpotato Action for Security and Health in Africa (SASHA) and worldwide through the Sweetpotato Initiative for Profit and Health (SPHI) (International Potato Center, 2009).

In South Africa, the Agricultural Research Council (ARC) and Medical Research Council (MRC) are leading research institutions involved in research and promotion

*Corresponding author. E-mail: slaurie@arc.agric.za. Tel: 27128419639. Fax: 27128080348

efforts of beta-carotene-rich sweetpotato in a crop-based approach to address vitamin A deficiency (Faber et al., 2002; Laurie and Faber, 2008; Laurie et al., 2008). Improved orange-fleshed sweet potato varieties are being developed at the ARC (Laurie et al., 2004; 2009). Tomlins et al. (2007), in a consumer study in Tanzania, found that beta-carotene-rich sweet potato was more acceptable to consumers than cream-fleshed sweet potato. The advantages of sweet potato are well-documented for example, high yield, hardiness, low demands on soil nutrients and cultivation input, storability and versatility for use in processing (Woolfe, 1992). Processing adds variety to the form in which food is taken and thereby provides an additional way of consumption. Processing also lengthens the period of availability of a food, creating the potential for income generation and it also provides a way of using surplus produce (Hagenimana et al., 2001; Kapinga et al., 2007).

Beta-carotene-rich sweet potato have been added to products such as beef patties (Saleh and Ahmed, 1998), noodles (Collins and Pangloli, 1997) and in the production of sweetpotato flour for use in baking products (Bechoff et al., 2009; Low and Van Jaarsveld, 2008) and ready-to-eat sweetpotato breakfast cereal (Dansby and Bovell-Benjamin, 2003) to provide a source of provitamin A. Several products were made from beta-carotene-rich sweetpotato in African countries which were involved in the Vitamin A for Africa Initiative. In Uganda dried chips, flour and juice (Kapinga et al., 2007) were produced as well as baby weaning food (Tumwegamire et al., 2004). At household level, product development included chapatti (similar to pancakes), mandazi (similar to doughnuts), fried chips, cakes and crackies (Tumwegamire et al., 2004; Kapinga et al., 2007; Owori et al., 2007). In Kenya mandazi's, chapatti, crackies, onion bites, crisps and buns were produced (Hagenimana et al., 1999; Kapinga et al., 2007). Substitution of wheat flour with sweetpotato in mandazi's, made the product more profitable to vendors.

The total carotenoid content of mandazi's produced in Kenya was $1\ 616 \pm 90$ μg β -carotene equivalent per 100 g product from cultivar pumpkin containing 2900 ± 500 μg β -carotene per 100 g fresh root (Hagenimana et al., 1999). Furthermore in some areas of Tanzania, sweetpotato leaves were widely consumed (Kapinga et al., 2007). Sweetpotato leaves contain in the range of 2,700 μg β -carotene per 100 g fresh sample (Woolfe, 1992). Food acceptability depends on a complex set of attributes, which are mostly difficult to quantify. A range of methods has been developed in order to translate qualitative perceptions into numerical values which allow statistical analysis (Holland and Campbell, 2005). Aiming at answering "Which is liked?" hedonic methods are considered appropriate (Kroll, 1990), using a panel representative of the users or target group to consume the product and have been used successfully with

children as well (Kroll, 1990). The objective of this study was to determine the consumer acceptability in South Africa for four products made of beta-carotene-rich sweetpotato. The products can serve as an additional means to consume beta-carotene-rich sweetpotato, adding variety to the form of consumption

MATERIALS AND METHODS

Study population

Consumer tests were conducted at three sites in the Limpopo Province and one each in Mpumalanga, Northwest and KwaZulu-Natal Provinces. These sites were known to the ARC since multi-environment cultivar trials were conducted there during 2001 to 2003 (Laurie and Magoro, 2008). In contrast to the other areas, Northwest Province is not traditionally a sweetpotato growing area but the crop was being introduced there. They were generally of middle to low income, residing in rural areas. Central venues for the evaluation of the products for example, schools, were arranged by local agricultural extension officers and they invited their farmer groups to attend the sessions. Arrangements were made with schools to allow learners to come for the sessions as well. The six regions in the study were:

- Region 1 Ditshilo near Mafikeng (North West)
- Region 2 Thembaletu - KwaMhlanga (Mpumalanga)
- Region 3 Bushbuckridge north of Hazyview (Limpopo)
- Region 4 Tompi Seleka College near Marble Hall (Limpopo)
- Region 5 Tshiombo near Thohoyandou in Venda (Limpopo)
- Region 6 Vulindlela near Pietermaritzburg (KZN)

The aim was to obtain a total sample size of 1000 people equally distributed among male/female and adult/children.

Sweet potato production

Resisto, a variety with a very dark orange flesh and excellent eating quality (Laurie, 2008) containing 9980 ± 1167 μg β -carotene per 100 g cooked sweet potato (Van Jaarsveld et al., 2005) was chosen. Stock plants of virus-tested origin were used to propagate cuttings and production of storage roots commenced in December 2002. Production practices entailed chemical control of weeds and insects, application of fertilizer mix 2:3:4 (30) at 500 kg/ha pre-plant and top dressings of LAN (125 kg/ha at 5 and 7 weeks after planting) and KNO_3 (125 kg/ha at 11 weeks after planting), 296 mm water applied with sprinkler irrigation and the rainfall was 317 mm. Sections of the sweet potato production were harvested at six intervals from April 2003 until July 2003, as needed to prepare the products as per visits organized with the communities. The time laps from harvesting until sensory analysis of the products was mostly 5 days.

Processed products

Four products were chosen for the study based on high content of beta-carotene-rich sweet potato as well as on anecdotal data of the ARC on preference when promoting sweet potato processed products in rural communities. The four chosen products were: Beta-carotene-rich sweet potato juice, -chips, -doughnuts and the green leaves from beta-carotene-rich sweetpotato plants. The

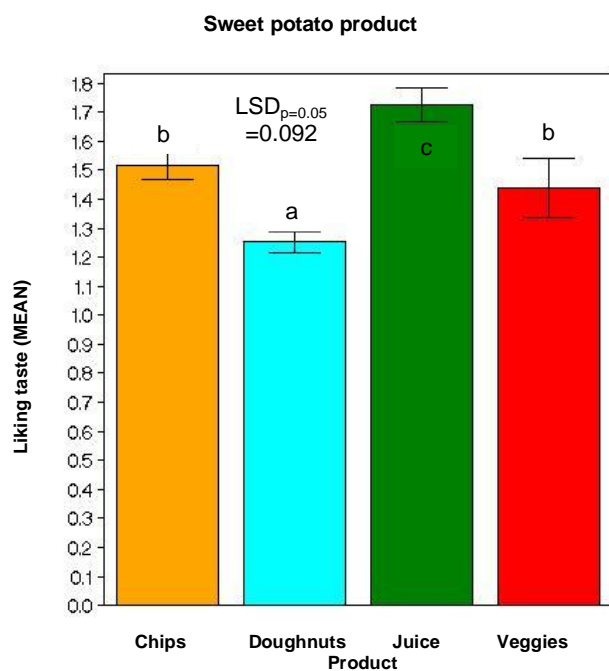


Figure 1. The mean taste score of four products made from beta-carotene-rich sweet potato evaluated over six regions.

products were prepared from a homogenized sample of sweetpotatoes that were harvested prior to each assessment session. Approximately 25 g of sweetpotato chips were served to each consumer in a small wax paper bag ($\pm 12 \times 12$ cm). The sweetpotato doughnuts (the size of a walnut, ± 30 mm) were served on a serviette. Sweet potato juice (50 ml) was served in a small polystyrene glass at room temperature. Consumer received 50 ml of the freshly cooked green leafy vegetable in a small plastic container with a spoon. Therefore, 200 doughnuts, 200 packets of chips, a pot of green vegetables and 10 litre of juice were prepared for each evaluation session.

Protocol of consumer testing

The protocol for consumer testing was based on Jellinek (1985), Meilgaard et al. (1991) and ASTM (1989). A score sheet was designed, first containing a 5-point hedonic scale with facial expressions (Meilgaard et al., 1991; Lawless and Heymann, 1998). The following verbal anchors were used: 'like a lot', 'like a little', 'neither like nor dislike', 'dislike a little' and 'dislike a lot', respectively. Secondly three 'Yes/No' questions were asked, namely: 'Do you like the colour of the product?', 'Will you buy this product?' and 'Would you like to make this product at home?'. The sheet was bilingual in English and the local language. Each panelist was allocated to a desk and the score sheet and facial expressions explained to the whole group. Panelists were informed that their honest opinion was important. One product was evaluated per session by the whole group, after which the next product were served and evaluated. The products were served in the following order: first the sweet potato juice followed by the chips, the doughnuts and lastly the beta-carotene-rich sweet potato leaves. In most cases the panelist themselves completed the score sheet, only a few elderly people were assisted. A segment of orange and a

sip of water (ASTM, 1989; Jellinek, 1985) were taken in between samples to cleanse the palate before tasting the next product. A sweet and a copy of the sweetpotato recipe pamphlet of the ARC were given to each as incentive after the sessions were completed.

Statistical analysis

Frequency tables were generated and used to assess distribution by region, gender, age group, region by age group and region by gender. The chi-square test for equal proportions was employed to detect associations between these. In order to investigate the comparative acceptability of the different products, scores were allocated according to the degree of liking: 1 = like a lot, 2 = like a little, 3 = neither like nor dislike 4 = dislike a little and 5 = dislike a lot. Analysis of variance (ANOVA) was conducted using SAS/STAT version 9.2. The student's protected t-least significance differences (LSD) was calculated at a 5% significance level to compare means. The frequencies (%) for categories 'like a lot' and 'like a little' were combined in one category as 'like', and likewise 'dislike a little' and 'dislike a lot' combined as 'dislike' to ease comprehension of taste acceptability. Percentages per categories 'Yes' and 'No' were calculated for colour, buy and will make the product.

The frequencies were then cross-tabulated into categories such as region and age group (>50 years, 20 to 49 years and 10 to 19 years) for like / dislike of product and yes / no for colour, buy and will make the product, by making use of GenStat 7.2 (Payne et al., 2007).

RESULTS

Overall acceptability of the beta-carotene-rich sweetpotato products

Based on the mean taste liking scores (Figure 1) the doughnuts made from beta-carotene-rich sweetpotato were most acceptable to consumers with a mean score of 1.25, followed by the chips (1.44) and the leaves (1.52), and lastly the beta-carotene-rich sweetpotato juice with a mean score of 1.72. Due to logistics and frost killing the top growth of the sweetpotatoes at the ARC, beta-carotene-rich sweetpotato leaves could only be served in regions 2 and 3.

Beta-carotene-rich sweet potato juice

Over the six regions (cf. Mean for Juice in Table 1), the results showed that 85% of the consumers liked the taste of the beta-carotene-rich sweet potato juice and 93% liked the color of beta-carotene-rich sweet potato juice 81% of the consumers indicated that they would buy the product while 84% of the respondents said they would like to make the product at home.

Beta-carotene-rich sweet potato chips

The mean results for beta-carotene-rich sweetpotato chips (Table 1) showed that 90% of the consumers liked the product as opposed to 6% who neither liked nor

Table 1. Consumer acceptability (%) for the four beta-carotene-rich sweet potato products per regions and the mean values over six regions.

Product and region	N	Taste			Color		Purchase		Prepare	
		Like	Unsure	Dislike	Like the color		Will buy the product		Would make at home	
					Yes	No	Yes	No	Yes	No
Juice										
1	140	67	9	24	88	12	66	34	68	32
2	114	92	4	4	98	2	87	13	94	6
3	150	90	3	7	91	9	82	18	90	10
4	196	87	9	4	96	4	86	14	84	16
5	172	91	5	4	95	5	83	17	86	14
6	158	82	6	12	90	10	78	22	85	15
Mean (N=930)		85	6	9	93	7	81	19	84	16
Chips										
1	141	83	9	8	86	14	79	21	77	23
2	113	91	5	4	94	6	85	15	90	10
3	157	74	19	7	83	17	80	20	82	18
4	193	91	6	3	90	10	88	12	84	16
5	170	98	1	1	91	9	94	6	92	8
6	153	90	5	5	88	12	85	15	88	12
Mean (N=927)		89	6	5	89	11	85	15	86	14
Doughnuts										
1	141	93	4	3	91	9	89	11	89	11
2	115	98	1	1	97	3	97	3	99	1
3	156	93	4	3	94	6	94	6	95	5
4	192	93	5	2	96	4	93	7	90	10
5	171	98	1	1	97	3	98	2	98	2
6	152	95	4	1	95	5	95	5	98	2
Mean (N=927)		95	3	2	95	5	94	6	94	6
Leaves										
2	80	98	1	1	99	1	91	9	99	1
3	155	88	4	8	85	15	86	14	87	13
Mean (N=235)		93	3	4	92	8	88	12	93	7

disliked it and 5% which did not liked the beta-carotene-rich sweetpotato chips. In terms of colour 89% of the consumers in the six regions liked the colour. Of all the respondents that participated, 85% indicated that they would buy the product and 86% would like to make the product at home.

Beta-carotene-rich sweetpotato doughnuts

95% of the respondents (cf. Mean for Doughnuts in Table 1) indicated that they liked the doughnuts, whereas 3%

did not like nor disliked the doughnuts and only 2% disliked the beta-carotene-rich sweetpotato doughnuts. The colour was also very acceptable and in addition, of all the respondents that participated 94% would buy the product and 94% indicated that they would like to make the product themselves at home.

Cooked leaves of beta-carotene-rich sweetpotato plants

According to the response (cf. Mean for Leaves in Table 1)

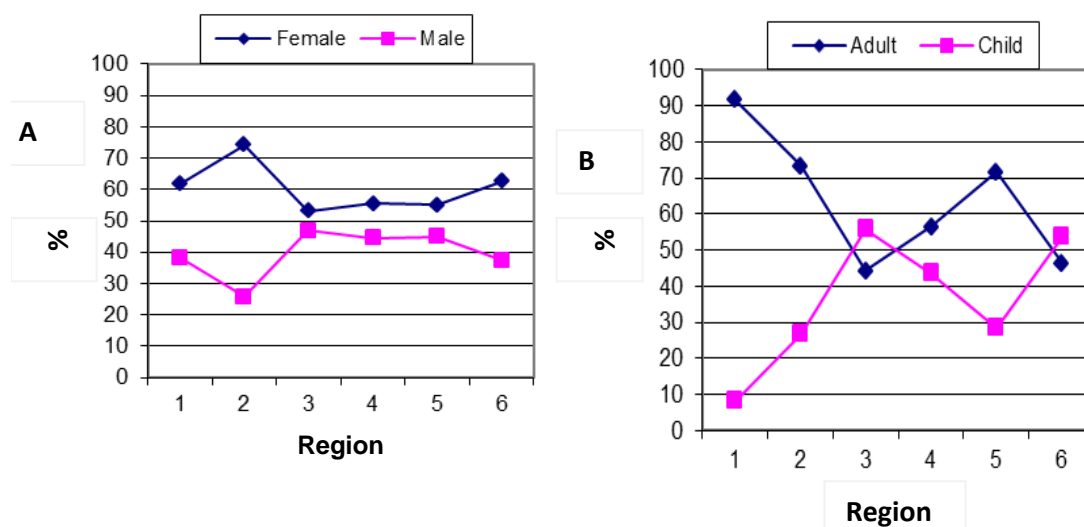


Figure 2. Frequency distribution of: **a** gender*region, and; **b** age group*region.

from regions 2 and 3, sweetpotato leaves were very acceptable with 93% indicated that they liked the vegetable dish cooked from the sweet potato leaves. The appearance, specifically colour, was liked by 92% of the respondents. Over the two regions, 88% of the respondents would buy the product and 93% indicated that they would like to make the product themselves at home.

Frequency distribution of respondent groups

Over the six regions (N=930) between 114 and 196 respondents took part in the assessment of the four products. In terms of gender the frequency procedure indicated that 59.67% female respondents and 40.35% male respondents (significant at $P<0.01$) participated. In terms of age group it was indicated that 59.67% were adult respondents and 40.33% were children (significant at $P<0.01$). The highest number of respondents attending was at regions 3 (19.96%) and 4 (18.95%), and the lowest attendance was in regions 1 (13.64%) and 2 (14.66%) (Significant at $P<0.01$). The interaction of region*gender and age group*gender were both significant ($P<0.01$). Fewer male respondents were involved in the survey at regions 1, 2 and 6 (Figure 2a). The adult consumers were more than the children in regions 1, 2 and 5 (Figure 2b).

Acceptability of the beta-carotene-rich sweetpotato products by region

The generalized linear model (GLM) procedure indicated

significantly the higher mean taste liking scores for region 1 (lower acceptability) and lower scores (higher acceptability) at regions 2 and 5. Regions 1 and 6 had lower acceptability for the beta-carotene-rich sweet potato juice (Figure 3). The beta-carotene-rich sweetpotato chips were best accepted at region 5, while the doughnuts were best accepted at regions 2 and 5. The beta-carotene-rich sweetpotato leafy vegetables had a lower score (higher acceptability) at regions 2 than 3. The percentage acceptability for colour was in the same range over the six regions. Consumers from region 1 scored the lowest for the option to buy the juice (66% yes), chips (79% yes) and the doughnuts (89% yes) (Table 1). In terms of willingness to buy, the beta-carotene-rich sweetpotato juice had slightly lower acceptability than the other products since 81% of the consumers indicated willingness to buy the juice compared to >85% for the other products. Overall, the consumers from the six regions were willing to make the four beta-carotene-rich sweetpotato products, however the same trend as for the colour and willingness to buy attributes were noticed in that, region 1 scored the lowest percentage for willingness to make the juice, chips and beta-carotene-rich sweetpotato leaves. As for willingness to buy, the consumers in all six regions were the least willing (84%) to make the beta-carotene-rich sweetpotato juice and most willing to make the beta-carotene-rich sweetpotato doughnuts (94%).

Acceptability for beta-carotene-rich sweetpotato products by age group

According to the scores in Table 2, the age group 10 to

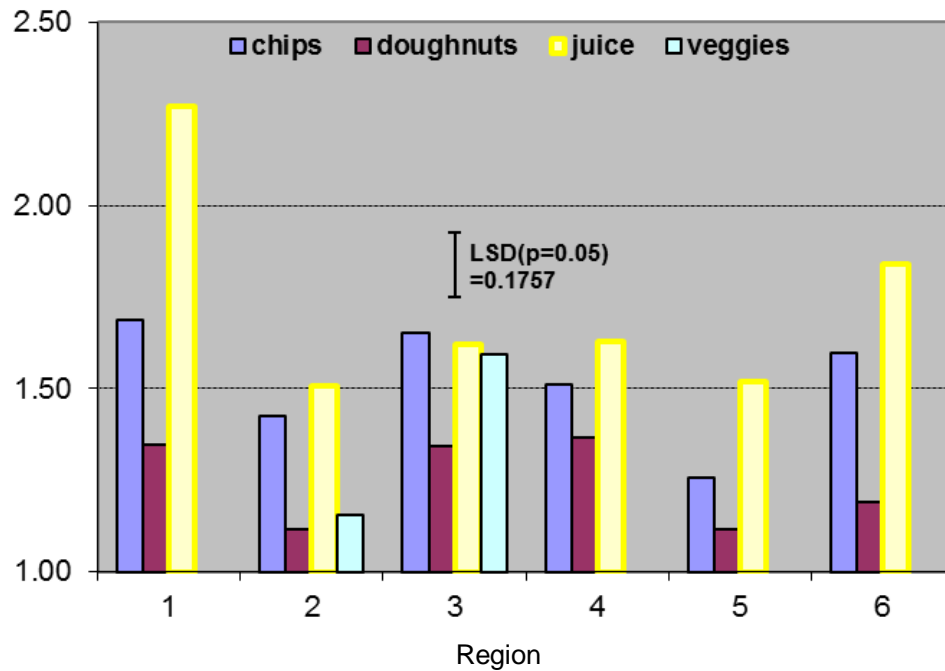


Figure 3. The mean taste liking scores over six regions for four products made from beta-carotene-rich sweet potato

19 years gave the lowest score (over four regions) for the taste of the beta-carotene-rich sweetpotato juice (74%) followed by the chips (84%), leaves (85%) and doughnuts (92%). This group was followed by the age group 20 to 49 years. The 50+ year old group scored the highest for all the attributes of the four products. The 50+ year group was more willing than the other age groups to buy the four products, 93% would buy the juice and beta-carotene-rich sweetpotato leaves, 90% would buy the chips, 97% would buy the doughnuts, and again also more willing to make the four products. All the consumers (100%) of this group were willing to cook the beta-carotene-rich sweetpotato leaves, 99% willing to make the doughnuts, 97% were willing to make the juice and 94% the chips. The youngest group was least willing to make the products, except for chips, where the 20 to 29 years group was least willing. The older group (50+) scored the highest on average for the liking of all the products (96 to 100%) followed by the middle group (20 to 49 years), and the 10 to 19 years group scoring 74 to 92%.

DISCUSSION AND CONCLUSIONS

Processing methods such as cooking is known to alter the sensory attributes of food for example, the colour, texture and flavor profile. The consumption of these vegetables often depends on the sensory appeal thereof. From the results of the present study it can be concluded

that a notable acceptability exists for the four beta-carotene-rich sweetpotato products in the six regions. This agrees with reports of products of beta-carotene-rich sweetpotato made in other countries. In Uganda, the baby weaning food was more acceptable to children and mothers than traditional maize weaning porridge (Tumwegamire et al., 2004), and preference ranking and pair wise comparison indicated preference for chapatti (similar to pancakes), mandazi (similar to doughnuts), fried chips, cakes and crackies made of beta-carotene-rich sweetpotato (Tumwegamire et al., 2004; Kapinga et al., 2007).

In implementation of vegetable gardens with the emphasis on beta-carotene-rich sweet potato from 2003 till present at various sites throughout South Africa, these products have been promoted (Laurie et al., 2008). Especially chips are often made due to the ease of the process and always are popular to participants of promotion events. In general all four products were well accepted with high preference on doughnuts made from beta-carotene-rich sweet potato, which was the most popular product. A reason for this finding, could be due to the fact that doughnuts are deep fried with oil, as many traditionally eaten foods are prepared with oil for example, frying tomato and onion, adding oil to pumpkin; and doughnuts (or also called "vetkoek") which are often sold at bus/train stations. Replacement of wheat flour with beta-carotene-rich sweetpotato can be a suitable vehicle to increase the consumption of beta-carotene-rich sweet potato. In rural areas, the use of leafy vegetables

Table 2. Acceptability (%) for different beta-carotene-rich sweet potato per age group (Percentage of respondents in each age group are given in parenthesis).

Product	N	All ages %	10 to 19 years (37%)	20 to 49 years (48%)	50+ years (15%)
Juice					
Like the taste	926	85	74	89	96
Like the color	954	93	86	96	99
Will buy the product	950	81	68	87	93
Will make the product	946	84	73	89	97
Chips					
Like the taste	899	89	84	91	99
Like the color	933	89	80	93	97
Will buy the product	925	85	81	87	90
Will make the product	925	86	79	66	94
Doughnuts					
Like the taste	894	95	92	96	97
Like the color	925	95	92	97	99
Will buy the product	924	94	91	96	97
Will make the product	930	94	90	96	99
Leaves					
Like the taste	221	93	85	95	100
Like the color	235	92	79	95	100
Will buy the product	235	88	82	92	93
Will make the product	234	93	81	96	100

is higher because households in remote rural areas have limited access to fresh produce markets and only have access through harvesting it in the field (Vorster et al., 2007). Consumption of beta-carotene-rich sweetpotato leaves are therefore expected mostly in rural areas. Poor households also tend to use leafy vegetables more because they lack the financial means to purchase vegetables and therefore produce their own.

According to the results of this consumer survey, a higher percentage of acceptability for the four products was found in the older group of consumers (50+ year group) who were more willing to buy and make these products than the other age groups. Vorster et al. (2007) found that knowledge of food preparation was rudimentary in the youth, while the elderly were the ones that had knowledge on traditional foods and food preparation methods.

This could explain these results. In the case of deep-frying of products, for instance doughnuts and chips, the amount of fat absorption is important due to nutritional concern of high fat intake, as well as the high cost of cooking oil (Hagenimana et al., 1998). In their study a

linear relationship was found between dry matter content of the raw sweetpotatoes and the level of oil uptake, therefore, using the right variety will be very important in preparation of these products.

A survey in the most prominent sweetpotato production areas during 1996 to 1998 found that sweet potato were mostly boiled and very few processing methods were conducted except for making chips (Thompson et al., 1999). Promotion of the processed products of beta-carotene-rich sweetpotato will add variety to the form in which beta-carotene-rich sweetpotato are consumed.

ACKNOWLEDGEMENTS

The authors thank the International Potato Center and Agricultural Research Council for provision of research funds, the ARC technicians and officials Department of Agriculture for organizing and conducting the tasting sessions, participants from the six sites, personnel from the Sensory Unit for data entering and the ARC Biometry Unit for analysis of data.

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