

Full Length Research Paper

Sensory evaluation and consumer acceptability of orange-fleshed sweet potato by lactating women and their children (<2 years old) in Kaffrine, Central Groundnut Basin, Senegal

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This study evaluated the sensory properties and consumer acceptance of boiled, fried, and mashed orange-fleshed sweet potato (OFSP), by rural lactating women (n=80) and their children <2 years old (n=77). Sensory evaluation and acceptability were performed using a 7-point hedonic scale. Intake parameters (food intake and eating rate), and vitamin A content in the OFSP were measured. The relationships between the sensory descriptors and the type of OFSP preparations was analysed using principal component analysis (PCA) plot. Frying and boiling the OFSP decreased the vitamin A content by 50%, but an acceptable level of retinol was maintained. For all sensory attributes, mothers preferred fried OFSP over boiled, while their children gave high acceptability scores to both boiled and mashed OFSP. The success of the OFSP cultivar, which is newly introduced in Kaffrine, and its high acceptability are promising for the prevention of maternal and child vitamin A deficiency in the rural areas of Senegal.

Key words: Orange-fleshed sweet potato, sensory evaluation, consumer acceptance, Senegal.

INTRODUCTION

Sweet potato (*Ipomoea batatas* (L.) Lam.), a hardy crop that produces storage roots, has the potential to combat increasing food shortages as it provides a high yield of

edible energy per unit area and per unit time, while also supplying substantial amounts of vitamins and minerals (van Oirschot et al., 2003). In the Senegal River Valley,

sweet potato is produced annually and is mainly grown in the northern regions following two cropping systems, namely, conventional and flood recession cropping (ISRA/ITA/SAED, 2009). Annual production of sweet potato is approximately 35000 tons (FAOSTAT, 2016) and mostly consists of white- and yellow-fleshed varieties. In many Senegalese households, sweet potato has replaced potatoes and provides variety in the diet (ISRA, 1986). However, the production of orange-fleshed sweet potato (OFSP) is recent and rare, and generally, the crop is intended for export. In the Central Groundnut Basin of Senegal, especially the Kaffrine region, OFSP has not been introduced in the region until recently. In 2014, OFSP cultivars were introduced in northern Senegal through a development project for combating undernutrition (USAID, 2017) because of its high content of β -carotene (Hotz et al., 2012a, b). This project improved the diet quality and the nutritional status of children under five and women, but its impact on vitamin A status was not evaluated. Several studies have shown the beneficial effects of OFSP consumption in improving vitamin A reserves and status (van Jaarsveld et al., 2005; Low et al., 2007; Hotz et al., 2012a). Undernutrition and micronutrient deficiencies (MNDs) are prevalent in Senegal. The first national MNDs survey carried out in 2011 showed iron, zinc, folate, and vitamin A (VA) deficiencies were common among children and women, and particularly in the rural central region of Senegal (Agne-Djigo et al., 2012; Ndiaye et al., 2015, 2017). The main strategies implemented in Senegal to prevent vitamin A deficiency are vitamin A supplementation every six months for children aged 6 to 59 months, large-scale fortification of refined vegetable oil with vitamin A, and promotion of breastfeeding (DAN, 2016a). Despite these preventive interventions, undernutrition and MNDs remain (Fiorentino et al., 2013; DAN, 2016b; ANSD, 2017). Thus, the prevention of these problems requires a holistic and sustainable approach that integrates food availability and accessibility, women's empowerment, advocacy and the promotion of micronutrient-rich foods (Masset et al., 2012; Ruel and Alderman, 2013). To address the promotion and consumption of carotenoid-rich foods such as OFSP, this study implemented a community farm of 5 ha through a Development Research Project (PRD) in Sagna, a village with 1478 inhabitants located in the Kaffrine region of central Senegal, and introduced an OFSP cultivar to this region for the first time. In Senegal, sweet potato is usually boiled and consumed as vegetables, but the fried form is also used as taste, snack or accompaniment. As the sensory properties and degree of acceptance of OFSP have not been established in this area, the aim of this

study was to conduct sensory evaluation and acceptability tests of boiled, fried, and mashed OFSP preparations by mother-child (<2 years old) pairs in Kaffrine.

MATERIALS AND METHODS

OFSP samples, preparations, and carotenoids contents

The OFSP was from healthy cuttings of the Kande variety (Kapinga et al., 2010) provided by the Senegalese Institute of Agricultural Research (ISRA). Healthy cuttings were planted in the farm in Sagna and grown using a drip irrigation system. After two cycles of culture (dry and wet seasons), the introduction of Kande was considered successful (Sylla et al., 2017). Mature OFSP roots were harvested 5 months after planting as recommended for this variety (Kapinga et al., 2010). For at least 2 months after harvest, the OFSP roots remained available for food consumption by the populations of Sagna and its surrounding area. The storage time before sensory evaluation and consumer acceptability tests was approximately 5 days.

The OFSP roots were sorted to remove diseased and insect-damaged roots, and the acceptable samples were peeled and chopped into roughly equal sized pieces of 30 to 50 g each. A portion of the roots was immersed in tap water and boiled (approximately 20 min) until the texture, as assessed by a knife, was considered tender and suitable for eating. Boiled OFSP were cut into smaller pieces and used for sensory testing by the mothers and older children (≥ 1 year). For children <1 year of age, the boiled OFSP were mashed. The remaining portion of the raw OFSP roots was fried (10 min) in refined vegetable oil until the texture, as assessed by a knife, was considered correct for eating. Fried OFSP was used for sensory evaluation by the mothers (Figure 1).

Raw, boiled and fried OFSP samples were assessed for total carotenoid contents by colorimetric assays using an i-Check device (iCheck™ carotene BioAnalyt GmbH, Germany) (Schweigert et al., 2010). All samples were analysed as ready-to-eat samples instead of based on their dry matter content. The β -carotene content in each preparation was estimated to account for 90% of the total carotenoid content (Rodriguez-Amaya and Kimura, 2004; Bengtsson et al., 2008). The retinol activity equivalent (RAE) was estimated using a bioconversion factor of 12 mg of β -carotene to 1 mg of retinol activity (FAO/WHO, 2004).

Participants, design, and ethics approval

A sample size of at least 70 subjects per targeted group is required by the ISO method (ISO, 2017) to determine the degree of liking (DOL) from a 7-point hedonic scale with a probability of error of 0.05 and power ≥ 0.80 . Overall, 160 subjects (80 mothers and 80 children <2 years old) living in Sagna and the surrounding area were selected to participate in the test. Ethical approval was obtained from the Ethical Committee of the University Cheikh Anta Diop of Dakar. An information session was conducted in the local language with the mothers to obtain their verbal consent. On the same day, Child's hearty appetite pre-test was performed using boiled OFSP. In addition, to be eligible for the study, the children had to appear healthy and have a weight-for-length z-score > -2 .

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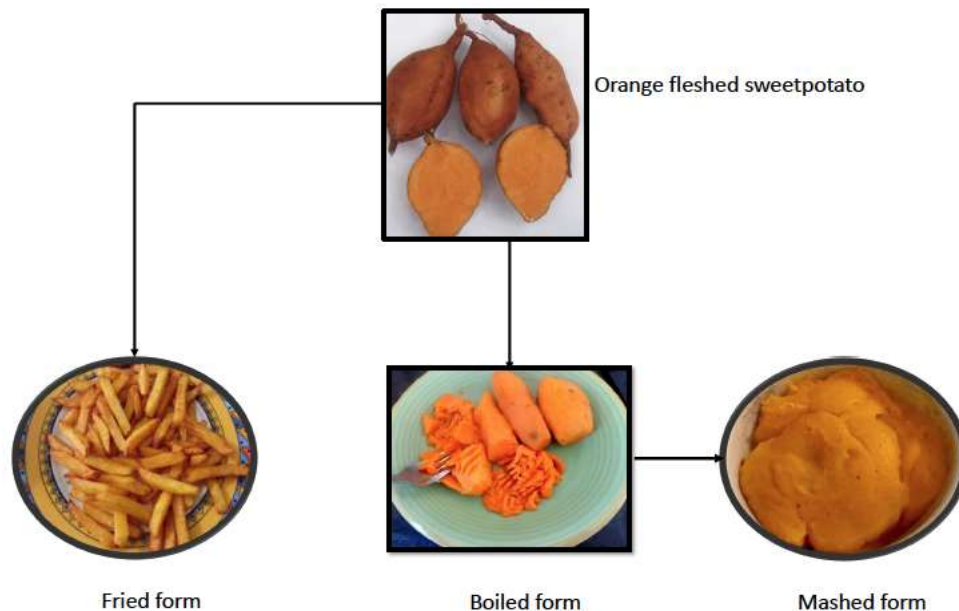


Figure 1. Different forms of OFSP preparations

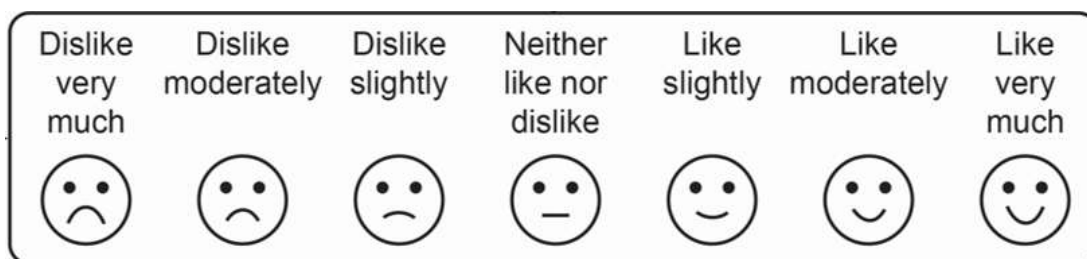


Figure 2. Seven-point facial hedonic scale.

Participant’s profile

Before starting the test, short interviews to profile each mother and their consumption of recently harvested OFSP from the farm were conducted using a simple questionnaire that included questions on their age, occupation, level of education, consumption of OFSP during the preceding 2 weeks, the origin of the OFSP usually consumed, usual preparation methods, and what they perceived as the personal benefits of consuming OFSP. Mothers completed, on behalf of their children, a similar questionnaire. The questions included the usual preparation methods for OFSP given to the child and what the mothers perceived as the benefits for their child from consuming OFSP.

Sensory evaluation

During the test, women were asked to choose the most common and their preferred methods of cooking OFSP (boiled or fried). The sensory test was carried out in an appropriate site by qualified personnel. Before starting test of the mothers, samples from the different preparation methods were randomly chosen, and boiled OFSP was given prior to the fried OFSP. Preparations were served

on plates as ready-to-eat food. After each test, the mothers were asked to assess their appreciation of the appearance, flavour, and texture using the 7-point hedonic scale (Figure 2) from 1 (“dislike a lot”) through 4 (“neither like nor dislike”) to 7 (“like a lot”) according to Tomlins et al. (2007). They were also asked to report boiled or mashed OFSP appearance, flavour, and texture for their children using the same hedonic scale.

Overall acceptability

Before the acceptability test, the emotional state of the children was assessed by the criteria defined by the WHO’s gross motor development study (Wijnhoven et al., 2004), which classified children’s emotional state in relation to 2 parameters: (1) sleepy or completely awake and (2) calm, restless or crying. If the child was not in an adequate emotional state during a waiting time of 30 min, he was excluded.

One hundred grams (100 g) of each of the two OFSP preparations (boiled and fried) were given to the mothers, and 50 g (boiled or mashed) were given to the children by their mothers 60 min after the last breastfeed. The mothers were instructed to continue feeding until their children ate all the food or refused

Table 1. β -carotene content and vitamin A intake of raw, boiled, and fried orange fleshed sweet potato (OFSP).

Parameter	OFSP form		
	Raw	Boiled	Fried
Total carotene contents ($\mu\text{g}/100\text{ g FW}^{\text{a}}$)	111.1	50.1	55.4
β -carotene contents ($\mu\text{g}/100\text{ g FW}$)	10000.0	4508.8	4988.1
Vitamin A intake ($\mu\text{g RAE}/100\text{ g FW}$)	275.0	137.2	124.9

^aFW: fresh weight

β -carotene contents were calculated as 90% of the total carotenoid contents

RAE: retinol activity equivalent; 1 retinol activity equivalent = 12 μg β -carotene with a bioavailable fraction = 33%

further food. Consumption time of each meal, as well as the quantity consumed by the women and children, was recorded (iBalance 2500 bowl scale, My Weigh, AZ, USA). For mothers, 50 ml of water was provided after the first meal, and there was a 30 min break between the first and second meal according to the approach used by Aaron et al. (2010). For sensory evaluation, after each meal test, the mothers were asked to assess their overall DOL using the 7-point hedonic scale. They were also asked to provide, with the help of interviewers, proxy ratings of their child's overall DOL. The sensory testing of children required an indirect approach in which the mothers interpreted the behaviour of the toddler as he/she tasted the food using nonverbal cues (for example, turning the head away, spitting out the food, pushing away or reaching for the spoon, and accepting the spoonful with an open mouth) and rated the child's acceptance using the same 7-point hedonic scale. The index of acceptability (IA) of women and their children was also calculated according to Fernandes and Salas-Mellado (2017) by

using the equation: $IA (\%) = \frac{\text{score} \times 100}{7}$ where score

represented appreciation reported by the mothers based on the 7-point hedonic scale. Food should have a minimum score of 70% IA to be considered acceptable (Spehar et al., 2002).

Statistics analysis

Data were computed using Epi-Info version 3.5.1, and statistical analysis of the data was conducted using Stata/Special 14 software (Stata Corporation, Texas, and USA). The results are presented for all mother-child pairs that completed the study and are expressed as the mean \pm standard deviation (SD) or as a percentage (%). For the consumption data and hedonic evaluation, independent Student's *t*-tests and paired *t*-tests were used to determine the differences between the types of food preparations. The relationship between the sensory descriptors and type of OFSP preparation was illustrated by the principal component analysis (PCA) plot prepared using R software version 3.4.3 (R Core Team, Vienna, Austria, 2018). All statistical analyses were performed using a significance level of 5%.

RESULTS

Maternal and child characteristics

A total of 80 mothers and 77 children completed the acceptability test. Three children were excluded because they were asleep during the test. The majority of mothers

were more than 20 years old and multiparous. Over 18% reported having an occupation and nearly 72% of them had attended school. The child's mean age was 12 months, and half of them were between 12 and 16 months of age. The gender among the children was quite balanced.

OFSP β -carotene content and vitamin A intake

The β -carotene contents of raw, boiled, and fried OFSP were 10000, 4508.8, and 4988.1 μg β -carotene/100 g, respectively (Table 1). Boiled and fried OFSP had lost 55 and 50% of their β -carotene content during processing, respectively, relative to the raw OFSP. The vitamin A (VA) contents in 100 g of raw, fried, and boiled OFSP were 275, 137, and 124 μg RAE/100 g, respectively, which account for 32.3, 16.1, and 14.6% of daily VA recommended safe intake (RSI) for lactating women. Among children aged 7-24 months, consumption of 100 g of boiled OFSP accounts for 31% of their daily VA RSI.

Attitudes of the mother-child pairs towards OFSP

The short interviews showed that nearly, 59% of the mothers usually consumed OFSP from 2 to 6 days per week, 35% once per day, and only 5% once per week (Table 2). Children typically consumed OFSP from 2-6 days per week (59%) and preferred the boiled (64%) and mashed (31%) OFSP. The most common preparation method was boiled (> 60%); however, OFSP was sometimes consumed fried (27%) or raw (10%). The OFSP consumed by the mothers and their children was mainly from the PRD's farm. The mothers generally mentioned the high vitamin A content of the OFSP as the primary health and nutritional benefit. Overall, 96% of the mothers were willing to buy OFSP and give it to their children (Table 2).

Sensory attributes

The scores for the sensory attributes for both boiled and

Table 2. Mother-child pairs profile on attitudes towards OFSP.

Parameter	Mothers (n=80)	Children (n=77)
OFSP consumption during the preceding 2 weeks	46.2 (37)	53.2 (41)
Usual OFSP consumption		
Every day	35.1 (13)	24.4 (10)
2-6 days per week	59.5 (22)	58.5 (24)
1 day per week	5.4 (2)	17.1 (7)
Form of OFSP consumption		
Raw	10.8 (4)	ND
Fried	27.0 (10)	4.8 (2)
Boiled	62.2 (23)	64.3 (27)
Mashed	ND	30.9 (13)
Source of OFSP		
Project farm	87.8 (36)	87.8 (36)
Market	7.3 (3)	7.3 (3)
Elsewhere	4.9 (2)	4.9 (2)
Benefits of OFSP		
Rich in vitamin A	60.0 (36)	63.3 (38)
Health/Nutrition	35.0 (21)	40.0 (24)
Rich in energy	5.0 (3)	ND
Increase milk production	3.3 (2)	ND
Willing to buy OFSP and give it to their children	96.0 (77)	ND

Data expressed in percentage (frequency).

ND: Not detected.

Table 3. Scores of acceptability and degree of liking (DOL) by mothers and children based on types of OFSP preparations.

Mothers	Boiled (n=80)	Fried (n=80)	p-value
Appearance	6.3 ± 0.9	6.9 ± 0.3	<0.001
Flavour	6.3 ± 0.8	6.8 ± 0.4	<0.001
Texture	6.3 ± 0.8	6.8 ± 0.4	<0.001
Overall acceptability	6.3 ± 0.7	6.9 ± 0.3	<0.001
IA (%)	90.5	98.0	<0.001
IA ≥ 70%	98.7	100	0.320
Children	Boiled (n=41)	Mashed (n=36)	p-value
Appearance	6.3 ± 0.8	6.5 ± 0.7	0.369
Flavour	6.3 ± 0.9	6.6 ± 0.6	0.176
Texture	6.3 ± 0.9	6.6 ± 0.5	0.131
Overall acceptability	6.2 ± 1.1	6.2 ± 1.2	0.984
IA (%)	88.2	88.1	0.984
IA ≥ 70%	96.6	93.8	0.591

Data are means ± standard deviation. IA= index of acceptability
p <0.05=means are significantly different.

fried OFSP were mostly greater than 5 and were evaluated as “moderately like” to “like very much” (Table 3). Nearly, 95% of the mothers liked moderately or liked a

lot the boiled OFSP, and 99% of them liked moderately or liked a lot the fried OFSP. Nevertheless, the DOL ratings for the flavour (P < 0.001), texture (P < 0.001), and

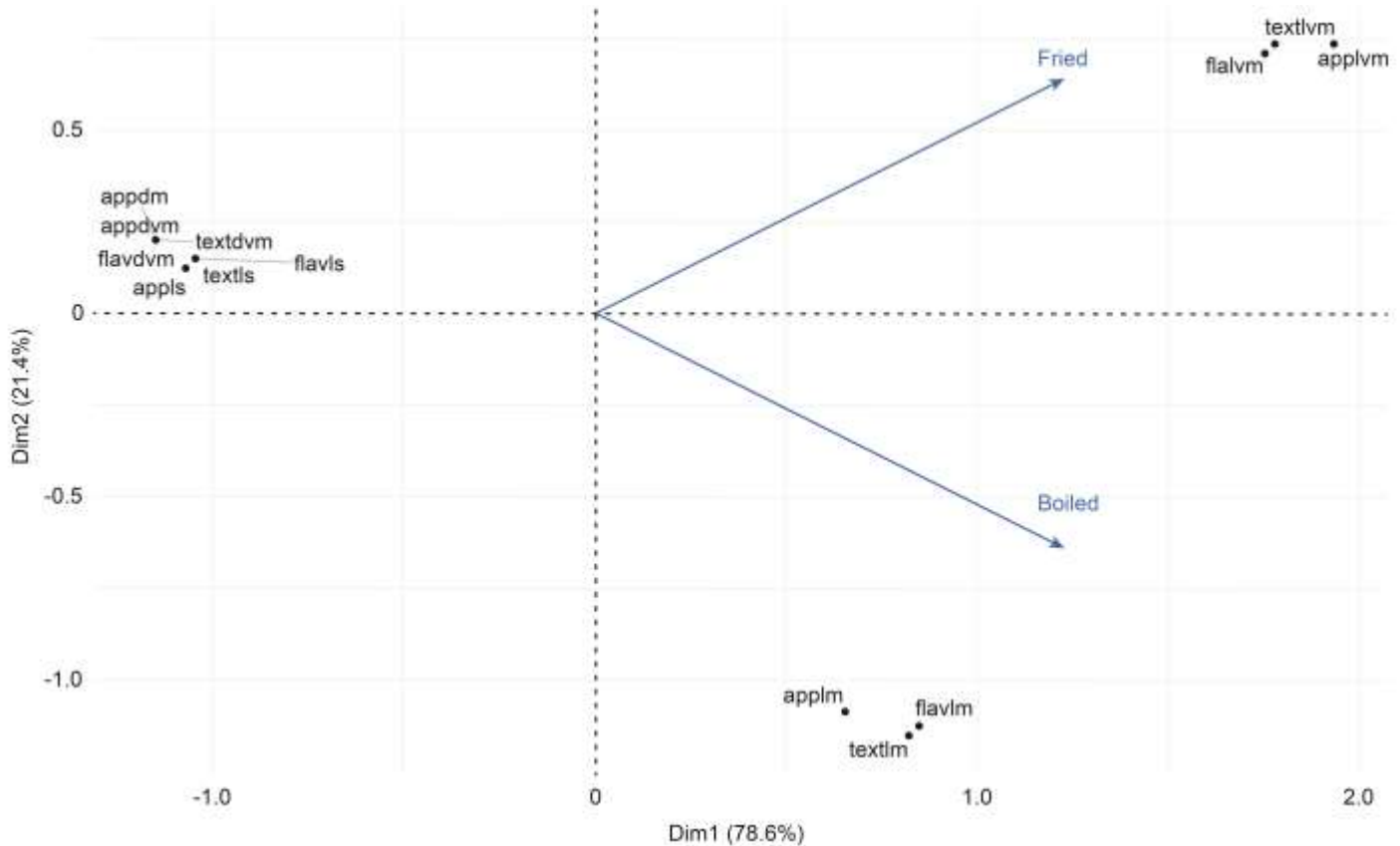


Figure 3. PCA plot of sensory descriptors and OFSP preparations among mothers.

appearance ($P < 0.001$) of fried OFSP were significantly higher than those of boiled OFSP. The relationships between the sensory descriptors and the OFSP preparations are illustrated in the PCA plots (Figures 3 to 4). The mothers reported very different sensory characteristics between the different OFSP preparations (Figure 3). Based on the paired t-tests, the sensory attributes of appearance, flavour and texture were better correlated with frying than with boiling. Frying (Figure 3; top right-hand quadrant) was most associated with “like very much” for texture, flavour, and appearance, while boiling (Figure 3; bottom right-hand quadrant) was more associated with “like moderately”.

All the children ≥ 1 year old received boiled OFSP and the others received mashed OFSP. For the sensory evaluation, the average scores for all attributes of the two types of preparations were generally greater than 5 (Table 3). Approximately, 91% of the mothers reported that their children liked moderately or liked a lot either boiled or mashed OFSP. Comparison using Student t-test, showed no significant difference between the boiled and mashed OFSP in their appearance, flavour, and texture parameters (Table 3). However, PCA (Figure 4) showed that the mashed OFSP (bottom right-hand quadrant) was more associated with “like very much”,

while boiling (top right-hand quadrant) was more associated with “like moderately”.

Intake parameters of the different OFSP preparations

No differences were observed between the OFSP preparation methods and the quantity of food consumed by the mothers (boiled = 96 ± 11 g; fried = 97 ± 10 g) and the children (mashed = 26 ± 15 g; boiled = 26 ± 15 g). However, there was a significant difference between feeding duration and eating rate among mothers for different preparations. The mean eating rate of the fried OFSP (11.5 ± 5.1 g/min) was significantly lower than that of the boiled OFSP (18.7 ± 7.4 g/min) ($P < 0.001$). In addition, the feeding duration for boiled OFSP (5.8 ± 1.9 min) was 4 min faster than that of fried OFSP (9.7 ± 3.4 min) ($P < 0.001$).

Overall acceptability of the different OFSP preparations

The mothers' overall acceptability of OFSP was high for both boiled and fried preparations with mean values that

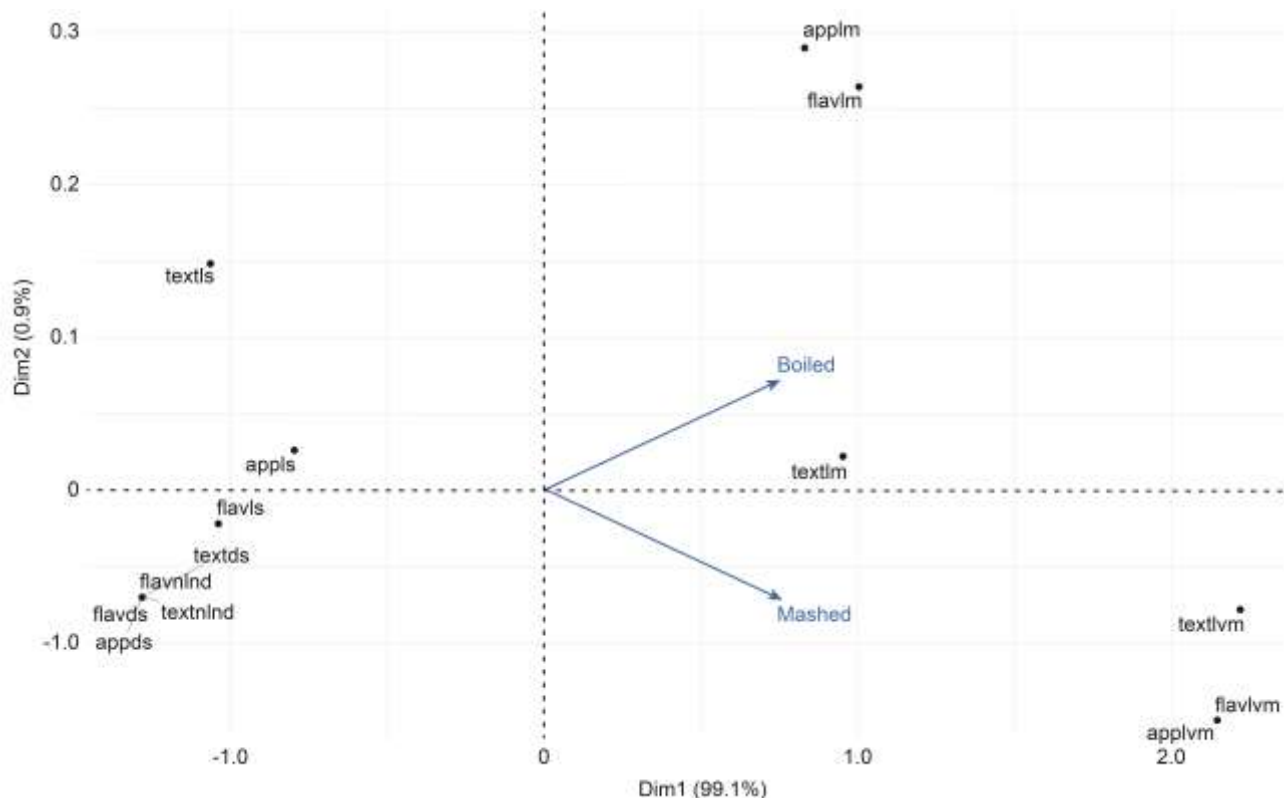


Figure 4. PCA plot of sensory descriptors and OFSP preparations among children.

were generally ≥ 6 (Table 3). However, there was a significant difference between the mean acceptability score of fried OFSP and boiled OFSP ($P < 0.001$). Based on mean overall DOL scores, all preparations were acceptable for consumption because the majority of mothers (>90%) reported a minimum IA score of 70%. Nevertheless, the IA values of fried and boiled OFSP were significantly different ($P < 0.001$), indicating that women generally preferred fried over boiled OFSP. Boiled and mashed OFSP were appreciated “moderately” to “very much” by the children with mean values of 6.2. The IA values were good ($> 88\%$), indicating the children appreciated both forms of preparation of OFSP.

DISCUSSION

The β -carotene content in the raw OFSP cultivar is consistent with results reported for the Kande variety (11030 $\mu\text{g}/100\text{ g}$) by Kapinga et al. (2010) and are relatively comparable to the contents found in other OFSP varieties (Kidmose et al., 2007; Bengtsson et al., 2008; Burri, 2011). However, after cooking, boiled and fried OFSP had lost half of β -carotene contents, but their contents remained consistent with reported values for cooked OFSP (Kidmose et al., 2007; Bengtsson et al., 2008; Burri, 2011). Bengtsson et al. (2008) found that

average losses of 22% for both boiled and deep fat fried preparations of several Ugandan OFSP varieties. These low losses compared to those found in this study may be due to the effect of high temperatures during OFSP cooking which were not measured in this study. In methods such as deep frying, prolonged cooking cause large losses of β -carotene (Kotíková et al., 2016). On other hand, the nature of the OFSP samples used for total carotene analysis could be explained the variations. Indeed, in this study, carotene content was calculated on a fresh weight basis, which is how OFSP is consumed by the population, instead of the dry matter of OFSP, which is what is used by others, to analyse the β -carotene content (Kidmose et al., 2007; Bengtsson et al., 2008; Burri, 2011), as β -carotene retention is normally overestimated when it is calculated on a dry-weight basis (Kotíková et al., 2016).

The acceptability tests showed that the mothers can consume 100 g of OFSP, while on average, the children ate up to 25 g per meal. According to Burri (2011), after adjusting the carotenoid concentrations in OFSP for cooking loss, storage, and poor bioavailability, based on an estimated requirement of 400 RE/d, children aged 7-24 months needed to consume 23.4 to 131.2 g OFSP/d to meet their daily VA recommended safe intake (RSI), while lactating women, with an estimated requirement of 800 RE/d, needed to consume 46.8 to 262.5 g OFSP/d.

Thus, promoting a minimum consumption of 200 g of OFSP for mothers and 100 g for children, which corresponds to two and three meals per day, respectively, will provide a large portion of the VA RSI.

In the present study, sensory evaluation and acceptability tests of different preparations (boiled, fried, and mashed) of Kandee OFSP to mimic the actual consumption of potatoes in Senegal, showed that boiled and fried OFSP have good sensory attributes among mothers. However, fried OFSP had better appearance, flavour, and texture than boiled OFSP, and this difference is probably due to the presence of fat in the preparation, as this ingredient positively contributes to both texture and flavour (Burri, 2011; Selvakumaran et al., 2017). Among the children, good sensory attributes were found for both boiled and mashed OFSP without any difference in their appearance, flavour, and texture parameters, indicating that after all, both preparations are boiled. These results suggested that mothers and their children have different perceptions of OFSP, especially with respect to the sensory properties, which is consistent with an earlier report by Tomlins et al. (2007).

All preparations were acceptable for consumption (Spehar et al., 2002), indicating a very good appreciation of this OFSP cultivar. Nevertheless, most mothers preferred fried OFSP over boiled OFSP, probably because, in Senegal, potato is traditionally consumed in boiled form as a vegetable rarely in fried form. Similar results suggesting that texture, flavour and taste can be used to predict consumption, overall acceptance and eating quality of OFSP, have been reported previously, and factors such as satiety and price are less important (Burri, 2011; Selvakumaran et al., 2017). In addition, the food matrix and the presence of fat influence carotenoid absorption and bioavailability (Bengtsson et al., 2008; Tumuhimbise et al., 2009). Among the children, the IA values obtained for both boiled and mashed OFSP were good (88%), indicating that both OFSP preparations were acceptable (Spehar et al., 2002). These results confirmed the values obtained by van Jaarsveld et al. (2005) in South Africa in school-aged children, and according to Tomlins et al. (2007) new OFSP varieties were generally accepted by young children.

Conclusion

This OFSP cultivar, which is being grown in the Kaffrine region for the first time, was acceptable to the mothers and their children <2 years old. The methods of cooking OFSP decreased the VA contents, but the levels of retinol activity remained acceptable. Boiled, fried, and mashed OFSP were well accepted, and high scores were reported for all the sensory attributes. Cooking OFSP with fat influenced positively OFSP consumption. The success of this cultivar and its acceptability are promising for the prevention of maternal and child VA deficiency in Kaffrine, Senegal.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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