Combining sensory evaluation and mental models in the assessment of consumer preferences for and choice of healthy products: Experience from a field experiment in Kenya

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Abstract

This paper combines Just-About-Right (JAR) sensory evaluation and means-end chain (MEC) analysis to examine consumer evaluation of the sensory attributes of conventionally bred biofortified orange-fleshed sweetpotato (OFSP). It specifically examined the role of information on biofortification process on consumers' expected and actual sensory evaluation of OFSP attributes and the mental models associated with the decision to consume OFSP. It is based on data collected via a field experiment with 501 rural consumers. Each consumer was randomly placed into one of the 3 treatment groups and received: i) general information about biofortification (Control), ii) general and positive information (Treatment 1) and iii) general and negative information (Treatment 2). The study finds, among others, that information on vitamin A (i.e., nutrition), taste and texture were, overall, discriminated by the kind of information provided (i.e., treatment), with texture being considered to be at an inappropriately lower level. Nutrition attribute was, however, considered to be at a higher than appropriate level. The results of the MEC were in line with those of sensory evaluation, with mental constructs (and models) being strongly discriminated by treatment type. It concludes that information consumers receive affect the expected and actual sensory evaluation OFSP attributes and mental models of OFSP consumption. We highlight some implications of these findings.

Key words: Rural consumers, Sensory evaluation, JAR, MEC analysis, Mental models, Biofortified foods, Field experiment, Kenya

1. Introduction

Despite years of economic development in Africa, malnutrition still remains a major problem in most countries of the continent. The most affected are rural households which continue to suffer from inadequate access to essential micronutrients, mostly due to the inadequate supply of these nutrients in their diets. The problem is acute in rural areas because diets such areas tend to be comprised of mostly staple cereals. Thus recent efforts in many countries of sub-Sahara Africa has targeted the incorporation of essential micronutrients in staple crops through conventional breeding, a process known as biofortification. These efforts have targeted maize and sweetpotato (for vitamin A), beans (for iron) and potato (for zinc), with successes recorded in sweetpotato and maize. Pilot studies conducted in a number of African countries have demonstrated the efficacy of these biofortified crops in tackling micronutrient deficiency. At the same time, though, there is evidence that biofortification process can alter some of the sensory characteristics of a product (De Groote et al, 2014). To date, however, there is still limited understanding of the drivers of acceptance of these conventionally bred biofortified foods. The few existing studies have to date largely focused mainly on the willingness to pay for such foods. These studies include Stevens and Winter-Nielson (2008), Chowdhury et al (2011), De Groote and Kimenju (2011), and Meenakshi et al (2012). They notably how consumers' sensory evaluation of biofortified foods changes with the provision of information about changes in a products resulting from biofortification, and also the role consumers' personal values play in the acceptance of conventionally bred biofortified crops. Specifically, little is known about the effect of information on biortification process on consumers' sensory evaluation and acceptance of biofortifed foods and the mental models associated with consumption of such foods.

This study used a field experiment that encompassed actual cooking and tasting of vitamin A-fortified orange-fleshed sweetpotato (OFSP) to examine the effect of information about biofortification process on consumers' expected and actual sensory evaluation and mental models associated with OFSP consumption among rural sweetpotato producing and consuming households in western Kenya. The study focused on OFSP because there is ample evidence from proof-of-concept and pilots studies that its production and consumption can significantly contribute to reduction of vitamin A deficiency (Hortz et al, 2012a, Hortz 2012b; de Brauw et al, 2015; Jones and de Brauw, 2015). Western Kenya is the main sweetpotato growing region of

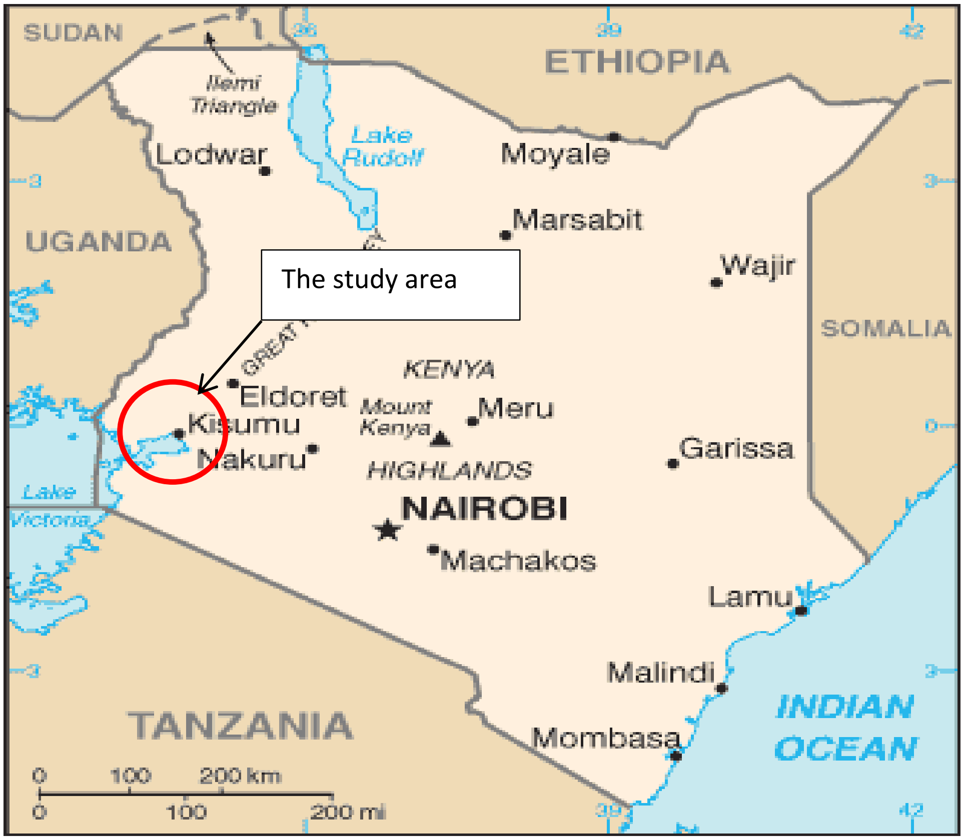
Kenya and is currently targeted for scaling up of OFSP production and consumption by farm households.

The rest of the paper is organized as follows. Section 2 provides a brief discussion of the study context. In Section 3 we present the methodology and discuss the empirical set up of the field experiment. Section 4 presents and discusses the study findings while Section 5 concludes and highlights major policy implications of the study findings.

2. Study context

This study was conducted in five counties of western Kenya, namely, Migori, Nyamira, Homabay, Kisumu and Siaya. The area suffers from high levels of poverty and has some of the highest levels of food insecurity in the Kenya (Low, 1997; Barrett et al, 2008; Suchdev, 2012). Poverty and food insecurity have led to high incidences of malnutrition, especially micronutrient deficiency (Hagenimana et al, 2001; Nabakwe et al, 2005; Tumwegamire et al. 2005; Foote et al, 2013). These studies show that micronutrient deficiency is not only prevalent in the region but also persistent. Further, proof-of-concept study conducted in some districts of the region have demonstrated that targeting households with an integrated intervention that combines agriculture (i.e., the production of OFSP) and nutrition (especially nutrition education) components can help reduce vitamin A deficiency (VAD) (Bouis et al, 2013).Western Kenya is therefore currently being targeted with two large a food-based agricultural intervention that aims to alleviate the high incidence of micronutrient deficiency. The first project known as Scaling Up Sweetpotato Through Agriculture and Nutrition (SUSTAIN), aims to improve production and consumption of vitamin A rich orange-fleshed sweetpotato (OFSP) by households with children under five years of age.

Map 1: Map of Kenya showing the area where the study was conducted



The second project, the Agriculture Value Chains Development project, brings together a consortium of partners to implement complementary activities that aim to improve the value chains of commodities that most farm households in the region rely on. Production, consumption and sale of OFSP is one of the main pillars of the project.

3. Study methods

3.1 Empirical methods

This study used data collected as part of a field experiment. The experiment was conducted as follows:

Step 1: Upon recruitment, the participant was asked for his/her informed consent to participate in the study. A consenting respondent was then randomly assigned to one of the three treatment groups. One group (the *control*) received only the general information on the agronomic properties of the biofortified sweetpotato variety, whereas the other groups in addition to the agronomic information received either detailed information[2] on vitamin A (Treatment 1: *approach*), or detailed information on the negative sensory attributes of OFSP in relation to white-fleshed sweetpotato (WFSP) and yellow-fleshed sweetpotato (YFSP) (Treatment 2: *avoidance*). The experiment was conducted in the home environment of the participants because this provides the context where food preparation and eating takes place.

Step 2: The participant was provided with two medium-sized roots of OFSP and asked to wash and boil them using portable[3] water with their own fuel until readiness (about 25 minutes) according to instructions provided by the enumerator.

Step 3: After the enumerator had verified that the roots were ready (i.e., cooked) by piercing through using a sharp knife, the participant was read for/given the information according to his/her treatment category. In addition to the verbal information, the participant was shown a set of images specific to his/her treatment. The images used were selected to be aligned with and to reinforce the meaning of the verbal information, and to convey aspects related to production and product properties, food availability and emotions. Experiences from photo-elicitation interviewing indicate that images stimulate deeper meanings and emotions than abstract verbal and written ideas (Clark, 1999; Clark-Ibáñez, 2004; Clark-Ibanez, 2004).

Step 4: The enumerator sliced one of the two boiled OFSP roots in half to allow for visual observation of the inside. The participant was then instructed to taste the sliced OFSP root. Efforts were made to ensure actual tasting was done while the roots were still warm (i.e. had not cooled done completely), which otherwise would affect sensory properties.

Finally, the participant was told that they were allowed to keep the second unsliced root as reward for their time devoted to the experiment.

[2] See Appendix 1 for detailed description of the three information treatments.
[3] The water used was the same as what the participants families typically use for cooking food.

The biofortified OFSP roots used in this study were obtained from a multiplier of sweetpotato planting materials (i.e., vines) located in one of the study counties. The variety of sweetpotato used was VITAA which is known for its deep orange color, indicating higher density of beta carotene, a pre-cursor for Vitamin A.

3.2. Consumer evaluation of sensory attributes

The expected and actual appropriateness of six sensory attribute characteristics (sweetness/sugary; smell; color; texture/softness; taste; and crumbliness/easy to handle) was scored on a 5-item nominal Just-About-Right (JAR) scale ranging from 'much too little' to 'much too much'. JAR scales are typically used for product evaluation and can be very useful to product developers in informing the direction that the advanced product development should take. Their main weakness is that scales are not normally distributed (Gere, Sipos, and Héberger, 2015).

The use of JAR scales based on pre- and post-tasting was used in this study to try investigate how the level of a sensory attribute relative to the assessor's ideal level is affected by the information treatment regarding the biofortification process. In using the JAR scales to assess sensory evaluation of OFSP, the standard white and yellow varieties of sweetpotato (which are grown by most households) were adopted as evaluative comparisons.

The sensory attributes were selected based on the results of a study van Oirschot, Rees and Aked (2003) and Tomlins et al. (2004; 2007). The former study reported that softness and moistness of OFSP varieties were related to a shorter storage time under tropical conditions. Taste (liking) was included as a sensory attribute because information about the product technology may influence evaluations of the taste itself (Caporale and Monteleone, 2004).

The nutrition/nutritious attribute were assessed on a separate, but identical, JAR scale to allow a straightforward comparison between this attribute and the sensory attributes (see Largerkvist et al (2016) for details). The use of identical scales was also important in the context of the study to reduce the complexity and cognitive burden on respondents.

The JAR expected and actual likings data were both analyzed in three steps. First, to test the effect of the information provision between treatments, an independent-sample Kruskal-Wallis test was employed. It specifically tested whether the samples originated from the same distribution. Secondly, a series of Mann-Whitney tests was used to examine whether pairwise samples originated from the same distribution. Finally, a series of related-samples Friedman tests were employed within treatments to test whether expected and actual likings originated from the same distribution.

3.3 Means-End Chain (MEC) analysis

In order to understand how biofortification influences the consumer's mental models associated with consumption of biofortified foods, the means-end chain (MEC) theory, which draws from economic psychology, was used. Mental models are defined as cognitive structures that influence consumer behavior and include attitudes, emotions and feelings, actions, symbols, goals, personal values, images, memories of past events, visions of anticipated events, and sensory images (Christensen & Olson, 2002). MEC theory posits that an individual's decision to consume a product is driven by the characteristics of the product and the benefits the product offers; and that the benefits of purchasing or consuming the product are, in turn, associated, in that individual's mind, with a range of personal life goals the individual wishes to fulfill in life (Reynolds and Gutman, 1988).

The MEC theory is essentially a hierarchy of an individual's perceptions of a product's features/characteristics, known as *attributes* (A), how the features in turn relate to product's benefits/outcomes, also known as *consequences* (C), and, ultimately, how the consequences are associated with core/personal life goals that motivate the consumption of the product i.e., *values* (V). The mental connection (link) of an attribute to the consequences and ultimately values (i.e., the A-C-V link) forms a *causal implication* (Mulvey et al, 1994; Arsil et al, 2014), and is, in our case, a representation of an individual's mental model associated with the decision to consume boiled OFSP roots. A series of these implications forms an implication matrix (Murvey et al, ibid).

Since the mental constructs are deeply seated in an individual's mind, they are usually extracted using laddering interviews which uses a series of "why is that important to you" questions to reveal the structure of the mental models, i.e., how the various mental constructs in an implication are linked together. It is a widely used in examining the content of mental models and how they relate to consumers' decision-making process or actions (Lagerkvist et al., 2012; Dellaert et al., 2014; Hansson and Lagerkvist, 2015). In this study, a combination of soft and hard laddering techniques[4] was used to assess how the provision of information on biorfortification influences the mental association of attributes, consequences and values related to decision to consume OFSP.

The laddering interview was conducted after the (expected and actual) sensory evaluation of OFSP. The interviewer started the interview by reading the statement below to the respondent:

> "*You have now had a chance to taste the boiled OFSP root part of which you see here before you. We are here interested in what comes to your mind and what you would think of when considering the following question:* ***Why would you be interested in eating the boiled OFSP root such as this one displayed before you now?"***

Based on the response to this question, characteristics (*attributes*) that would make the respondent to consume OFSP roots were listed, and the interviewer proceed with the interview using a series of "why is [*mentioned construct*] important to you" questions. The information collected was analyzed using MECAanalyst software. A description of the steps of analysis of this kind of data is in Okello et al (2014).

3.3 The study area and sampling procedure

The respondents interviewed were participants of a total of 30 Community Units[5] (CUs) which were targeted by a project. The CUs spanned all the five administrative counties where the project is being implemented. The selection of the survey respondents was done as follows. First, 10 CUs were randomly sampled from among the targeted 30 CUs using probability proportionate to size sampling technique. That is, more CUs were selected from counties that are large, and vice versa. This random selection process yielded the following: three CUs in Siaya county, one in Kisumu,

[4] Soft laddering technique typically allows the respondent to trace his/her mental models with little interruption and to follow as much as possible his/her own flow of speech (Voss et al, 2007), while in hard laddering technique, the interviewer controls the flow to ensure that the respondent verifies the structure and associations between constructs (Barrena and Sanchez, 2009).

[5] Community Units are health administrative structures under the Government of Kenya community health outreach system

one in Nyamira, three in Homabay and two in Migori. Next, names of all the villages in each of the selected CU were compiled and 50 villages randomly sampled from the total tally of villages using probability proportionate to size sampling technique. In each of the randomly sampled villages, a complete list of all the households with children less than 5 years old was drawn with the help of community health workers and local leaders.

Respondents of the sensory evaluation were randomly selected from each of the village lists using probability proportion to size technique. This procedure resulted in 97 households being interviewed in Siaya county, 115 in Kisumu, 143 in Homabay, 41 in Nyamira and 105 in Migori. The respondents comprised 501 adult women[6]. The survey was conducted in February and March 2015. Data was collected using a pre-tested questionnaire via personal interviews. The data collection team comprised 8 trained enumerators and two survey supervisors.

In the case of laddering interviews, the respondents were obtained by randomly sampling one household from the list of all the households in each village each day. This was done without consideration of the treatment to which the respondent had been assigned, but the respondent's treatment group was recorded during the interview, in order to help in posing laddering question and in the placement of the respondent to the correct treatment group during data analysis. This process led to a random sample of 45 respondents, among whom 16 were from the *control* group, 16 from the *approach* group, and 13 from the *avoidance* group.

4. Results

4.1 Characteristics of the respondents

A majority of the women (90.4%) farmed for the whole 2014 calendar year and also had no reported salaried work, while 9.4% farmed for 1-11 months during 2014 and also reported to have had salaried work during this time. A smaller share of the women (8.6%) where pregnant at the time of the interview, while the majority were not (91%) or did not want to report on this (0.4%).

[6] All the respondents were women because caregivers of children under five years of age were, in this study, exclusively, women.

The demographic profile of consumers assigned to each treatment group is included in Table 1. It shows that all participants were regular consumers of sweetpotato. Yellow-fleshed sweetpotato is the most frequently cooked variety (share=51%), while the share of white-fleshed sweetpotato was 42%. Only 5% of the respondents indicated that the most frequently consumed sweetpotato in their households was orange-fleshed. The low consumption of OFSP is due to the fact that this variety was largely unavailable in the study communities, hence the introduction/promotion by the project. Indeed, 75% of the respondents reported that their household grows sweetpotato in addition to other crops, but only about 5% reported that they had ever grown OFSP. The average amount of sweetpotato produced per household was about 500 kilograms per year. About one-half of the production was consumed at home.

Table 1. Demographic characteristics of the sample (n=501).

Highest level of education completed	Share (%)
Non-school or incomplete primary	39.3
Primary	49.3
Post-primary	10.4
Marital status	
Single	2.0
Married	87.6
Other	10.4
Main occupation	
Farming (crop/livestock)	65.3
Other	34.7
Experience (years) of growing sweet potato	
0-5	52.9
6-10	20.8
>10	24.9

The characteristics of laddering respondents, categorized by treatment group, are presented in Table 2. They show that the laddering interview respondents were similar in all the characteristics considered, namely, education, age, farming experience and the number of children less than 5 years of age, among others. The table also shows that the respondents were mostly aged between 26-31 years and, on average, had more than 5 years of experience in growing sweetpotato.

Table 2. Demographic characteristics of the laddering respondents

Demographic characteristic	Overall N=45	Control N=15	Approach N=16	Avoidance N=14	P-value
Average education (years)	8.13 (2.98)*	8.53 (3.44)	7.50 (2.83)	8.56 (2.51)	0.568
Age (years)	29.28 (8.74)	30.20 (10.10)	30.25 (8.43)	26.00 (6.60)	0.454
Total # children < 5 years of age	1.35 (0.74)	1.20 (0.86)	1.50 (0.63)	1.33 (0.71)	0.536
% who are primarily farmers	57.50	53.33	50.00	77.78	0.392
% pregnant	12.50	20.00	6.25	11.11	0.528
% with salaried work	22.50	26.67	25.00	11.11	0.664
Years of SP farming	8.00 (7.48)	5.93 (5.32)	10.19 (9.39)	7.56 (6.33)	0.287

* Numbers in parenthesis are standard deviations

4.2 Results of the sensory evaluation

Table 3 presents the results of the sensory evaluation prior to tasting of the OFSP roots, i.e., based on expectations. Therefore the sensory evaluation is based on the available treatment-specific information, prior beliefs, and visual appearance of the displayed product. Therefore mental representation and processing of these stimuli likely played a role in the formation of expected JAR scores (Carporale and Monteleone, 2004). As Table 3 shows, the expected sensory evaluation of sweetness, nutrition and taste differed between information treatments. There is however no evidence to support the hypothesis that expected JARs of texture and crumbliness differed between treatments.

Results from the pairwise tests show that the information effect for nutrition was significant between *control* and *approach* treatments/groups suggesting that information about VAD and biofortification process influenced expectations on the appropriateness of the nutrition attribute of OFSP. Interestingly, in the *approach* group, a larger share of the participants found the nutrition/nutritious attribute to be excessive (i.e., much too much). This treatment group also found the sweetness attribute to be at an upper/higher level of acceptability. Thus, contrary to expectations, the main effect of information on VAD and biofortification process (i.e., nutrition attribute of OFSP) was to decrease the consumer acceptability of OFSP. This finding is not surprising since majority (95%) of the participants had no prior experience with OFSP and neither had they benefited from prior nutritional messaging that includes specific information on the benefits of vitamin A to the body. This explains why the *approach* group found the information provided to be complex.

Table 3. Comparative tests of the expected sensory evaluation of the appropriateness of sensory attributes of boiled OFSP roots

Treatment	Feature	Kruskal-Wallis test[a]	Mann-Whitney[b]		
			(Approach vs. Control)	(Avoidance vs. Control)	(Approach vs. Avoidance)
Control (n=158)	Sweetness/sugary	0.002			
	Smell	0.076			
	Color	0.095			
	Texture/softness	0.490			
	Taste	0.004			
	Crumbliness	0.792			
	Nutritious	<0.001			
Approach (n=172)	Sweetness/sugary		0.014		
	Smell		0.438		
	Color		0.121		
	Texture/softness		0.219		
	Taste		0.300		
	Crumbliness		0.505		
	Nutritious		<0.001		
Avoidance (n=171)	Sweetness/sugary			0.387	0.001
	Smell			0.168	0.023
	Color			0.697	0.034
	Texture/softness			0.683	0.486
	Taste			0.026	0.002
	Nutritious			0.011	0.013

[a] Test of equal proportions across treatments by each attribute.
[b] Test of the null hypotheses that the two samples originate from the same distribution.

The pairwise tests between the *control* and *avoidance* groups indicate that the information about the negative attributes of OFSP had discriminatory effect only on the expected taste and nutrition/nutritious. Specifically, the *avoidance* group also found expected nutrition to be at an inappropriately high level. On the other hand, a comparison of the results between the *approach* and *avoidance* treatment groups shows that there was difference in assessment of the appropriateness of the sensory attributes except for texture/crumbliness. The findings show that the JAR balance between the attributes was in the opposite directions between these groups. The *approach* treatment group consistently expected the sensory attributes to be more towards the upper end of the scale. Overall, the finding that nutrition information was perceived to be at higher than appropriate level by all the treatment groups is quite interesting. It indicates that information about vitamin-A fortification, even if only brief and comes in the form of mere mention without being thoroughly explained, is taken to mean that the nutrition is too much or, in other words, too complex.

Table 4 presents the results of actual JAR sensory evaluation of OFSP attributes after tasting the boiled root. It indicates that there was actually less discrimination between samples after tasting the OFSP. A significant difference in the responses to the JAR scales across the three samples remained only for the nutrition/nutritious attribute. In addition, texture appeared to be significantly different across samples, contrary to what was observed for the expected liking rating (i.e., before tasting).

Results from the pairwise tests show that the information effect for nutrition was strongly significant between the *approach* and *control* groups, with participants in the *approach* group indicating, again, that OFSP had excess levels of nutrition. Texture was also different between these two groups, with the *control* group finding too little texture, while the *approach* group found it more balanced.

The appropriateness of the nutrition attribute also differed between the *control* and the *avoidance* groups where, again, the level was found to be too much in the latter group. Nutrition and texture were also the only two attributes for which the JAR scores differed between the *approach* and *avoidance* treatment groups. The JAR rating for the nutrition treatment group was more towards the “too much” level while the smell, color, texture and taste attributes were rather to the opposite end of the JAR rating scale.

Results further show that the extent of sweetness, nutrition, color, and taste for OFSP were considered to be above the ideal levels across the samples. Furthermore, smell and crumbliness and, to a lesser extent, texture were considered to be below the ideal/desired levels. The latter findings are in line with a priori expectations. Indeed, they corroborate the narrative of the negative OFSP design attributes which was drawn from the criticisms of OFSP as found in the literature.

Results of the Friedman tests in the last column of Table 4 show that there were treatment-specific differences between actual and expected likings. They show that the *control* group showed less differences, and that sweetness, color and taste were the only attributes for which participants found the actual tasting to accentuate their assessment of the “too much” or “much too much” ratings.

Table 4. Comparative tests of actual sensory evaluation of the appropriateness of sensory attributes of OFSP after actual tasting of boiled OFSP root

Treatment	Feature	Kruskal-Wallis test[a]	Mann-Whitney[b] (Approach vs. Control)	Mann-Whitney[b] (Avoidance vs. Control)	Mann-Whitney[b] (Approach vs. Avoidance)	Friedman test[c]
Control (n=158)	Sweetness/sugary	0.306				<0.001
	Smell	0.347				0.491
	Color	0.405				0.001
	Texture/softness	0.030				0.592
	Taste	0.670				<0.001
	Nutritious	<0.001				0.012
Approach (n=172)	Sweetness/sugary		0.599			0.002
	Smell		0.326			0.042
	Color		0.379			<0.001
	Texture/softness		0.065			0.99
	Taste		0.648			0.005
	Nutritious		<0.001			0.008
Avoidance (n=171)	Sweetness/sugary			0.318	0.136	<0.001
	Smell			0.682	0.158	0.012
	Color			0.684	0.188	<0.001
	Texture/softness			0.475	0.011	0.078
	Taste			0.671	0.373	<0.001
	Crumbliness			0.915	0.324	0.095
	Nutritious			0.009	0.021	0.011

[a] Independent-samples test of equal proportions across treatments by each attribute.
[b]Test of the null hypotheses that the two samples originate from the same distribution.
[c] Related-samples test: the expected liking and liking after tasting follow the same distribution.

A similar pattern was observed for the nutrition attribute, although the excess levels were not so pronounced. The *approach* group, on the other hand, rated the color attribute more to the top JAR level after tasting than before tasting. Tasting the OFSP root accentuated the upper levels of all sensory attributes except for texture and crumbliness for this group. Interestingly, the JAR rating for the *avoidance* group changed after tasting for the all sensory attributes, although the changes for texture and crumbliness were only weakly significant.

Overall, the results of the sensory evaluation indicate that information about nutritional benefits was deemed too much across all the treatment groups. This may be interpreted to mean that information about the nutritional benefits of OFSP is perceived to exceed the expectations. In addition, the results of this section therefore corroborate past studies that suggest that color and taste are some of the positive attributes of OFSP (Okello et al, 2014; Okello et al 2015) while texture and crumbliness are negative.

4.3 Results of MEC analysis

4.3.1 The mental models of the *approach* group

The implication matrix the *approach* group had two dominant attributes. These attributes are good taste and nutrition. As in the case of sensory evaluation, participants in this treatment group indicated that their liking of the taste of OFSP would be one of the leading reasons for deciding to consume OFSP in future. Indeed, 88% of the respondents associated their future decision to consume OFSP would be linked to (or driven by) good taste. In addition, an equal percentage (88%) of the approach group associated their likelihood to consume OFSP in future with nutrition, even though this sensory attribute was rated to being at higher than appropriate level. The other characteristics of OFSP that the *approach* group indicated would motivate them to consume OFSP in future were "early maturity (41% of the responses) and its "attractive color" (29% responses). These four dominant attributes were ultimately linked to three life goals namely "good health", "long life" and "independence" through pathways encompassing varied number of consequences. Further, "good health" was further associated with "happiness".

More specifically, nutrition, taste and color were directly linked to the values through the pathways causal implications below:

{Nutrition/taste/color}>>appetite>>energy>> no disease>>work >>independence
{Nutrition/taste/color}>>appetite>>energy>>no disease>>work>>more food>>healthy
{Nutrition/taste/color}>>appetite>>energy>>no disease>>work>>more food>>healthy>>happy
{Nutrition/taste/color}>>appetite>>energy>>no disease>>work>> more food>>no stress>>long life
{Nutrition/taste/color}>>appetite>>energy>>no disease>>work>>more money>>diverse diet>>happy
{Nutrition/taste/color}>>appetite>>energy>>no disease>>work>>more money>>educate kids>>independent
{Nutrition/taste/color}>>appetite>>energy>>no disease>>work>>more money>>educate kids>>support me>>happy

The three dominant attributes in the above implications were linked to a total of ten attributes, some functional and others psychosocial (see Murvey 1994, pg 52 for a discussion on the various types of attributes). The functional attributes included “more energy” with which to produce “more food” hence make “more money” while the psychosocial included “no stress”.

The attribute “early maturity”, an agronomic characteristic, was in turn mentally associated with six attributes. Among them, having “more income” and “more food” were the main motivators of desire to (grow and) eat OFSP in future with an appetite to eat more OFSP, more energy, hence ability to work, which as before, are associated with having more food and income. The pathways by which this agronomic attribute of OFSP is linked to end goals are presented in the causal implications below

Early maturity>>more income>>diverse diet>> healthy
Early maturity>>more income>>educate kids>> independence
Early maturity>>more income>>educate kids>> support me>>happy
Early maturity>>enough food>> healthy
Early maturity>> enough food>>no stress>>long life

These results point to two main themes of the motivations to consume OFSP among *approach* group. The first entails the sensory aspects (taste, color) and nutritious and result in long life and good health with the latter resulting in happiness. The second relates to the agronomic aspects namely early maturity that is linked mentally to good health, independence social support during old age (i.e., “support me”), among other end goals.

4.3.2 Mental models of the *avoidance* group

The mental constructs associated with consumption of OFSP by the *avoidance* group was remarkably different from those of the *approach* group in many aspects. They were comprised of only five attributes, ten consequences and only three values. The attributes do not feature any of the agronomic characteristics identified by the *approach* group. This finding suggests that the negative sensory information provided to this group overshadowed the good agronomic aspects that formed part of the treatment narrative.

One major distinction in the mental constructs of the *avoidance* group relates to the attribute "tastes bad" which may have been influenced by the negative technology design narrative this group received. This attribute was mentally associated with end value "death" via a few consequences. The pathway by which the avoidance group mentally associated "bad taste" to "death", albeit with a break, is presented in the causal implication below:

Bad taste>>not eat enough>>no energy>> … >>get sick>>will die

The break in the above ladder may be due to the conflict/interaction between the negative information given via the narrative and the information the respondents received by actually experiencing the product (OFSP) (via tasting, touching, smelling and seeing). It may also be caused by the unfamiliarity of OFSP to the respondents, since many were seeing OFSP for the first time. Lind (2007) argues that consumer inexperience with the product can result in many incomplete means-end chains such as those obtained in this study.

Results also show that the proportion of the *avoidance* group participants who associated OFSP with good tastes and nutritious food significantly dropped sharply from 88% (for both sensory attributes) for the *approach* group to only 40% and 20% respectively. Together, these findings indicate that the negative information on design (i.e., effects biofortification process) received by this treatment group negatively influenced their perception of OFSP. The causal implication involving the attributes "nutrition" and "good taste" is in similar to those of the approach group but contain much fewer mental constructs. Notably the construct "no disease" is missing. The causal implications suggest that even with negative information the avoidance group still considered OFSP a valuable food that provides energy for work and ultimately providing good health and happiness.

{Nutrition/taste}>>appetite>>energy>>work>>more food>>healthy
{Nutrition/taste}>>appetite>>energy>>work>>more food>>healthy>>happy

5. Summary, conclusion and implications

This study used JAR scale to assess the effect of information on technology design (i.e., OFSP biofortification process) on consumers' expected and actual evaluation of the nutrition and sensory attributes of OFSP, and the MEC analysis examine mental models associated with the decision to consume OFSP. Results of the JAR expected sensory evaluation showed that *nutrition* information received as part of the experimental narrative was considered inappropriately high across all the treatment groups. Pairwise test between the *control* and the *avoidance* groups found that providing information about negative attributes of OFSP had discriminatory effect only in relation to expected *taste*. There was however less discrimination among treatment groups after actual tasting the OSFP sweetpotato except for nutrition and texture attributes. Across the treatments, the extent of sweetness, nutrition, color, and taste of OFSP were considered to be above the ideal levels after the actual tasting. However, smell and crumbliness, and, to a lesser extent, texture were scored below the ideal levels after tasting the boiled OFSP roots. Results also found treatment-specific differences between actual and expected likings. These results therefore indicate that consummers' perception the sensory and nutrition attributes of OFSP are influenced by the type of information about biofortification process they receive. Further, the results suggest that when consumers receive unelaborated information about Vitamin A and biofortification process, they will interpret the nutrition attribute of OFSP as being too much.

Results of the MEC analysis also found treatment-specific differences in the mental models associated with the acceptance of OFSP. It showed, in line with the JAR evaluation results, that the attributes that motivate consumer acceptance OFSP include sensory/nutrition characteristics, which reflects the kinds of information received. In line with the information received, the *approach* group associated the decision to eat OFSP with the sensory attributes namely nutritious, taste and color. The *avoidance* group was, on the other hand, more negative about OFSP and highlighted "bad taste", as an attribute that would prevent them from eating OFSP. These sensory attributes were linked mentally to four personal values or life goals – healthy life, happiness, independence and long life – via a vector of consequences of consuming OFSP. Notably though, the agronomic information that formed the general information provided to all treatment groups greatly influenced the mental models associated with OFSP consumption.

This study concludes that the kind of information about biofortification process consumers receive' influences their evaluation (i.e., expected and actual liking) of OFSP's sensory attributes and also mental models of constructs relating to OFSP. The MEC analysis specifically concludes that the personal values that drive the consumption of OFSP are related to long life, happiness, being healthy, independence and the fear of dying. Specifically, the consumers are motivated to consume OFSP by the desire to have a long, independent, healthy and happy life.

The findings of this study has several implications. First, information of about the biofortification process needs to be elaborated and explained to recipients to avoid the tendency to interpret it as a nutrition "information overload" that can in turn cause the dislike of OFSP. Second, the findings highlight the perennial issue of "softness" or the low dry-matter content issue of the boiled OFSP roots that consumers who are used to the more dense white and yellow varieties are known to dislike. The findings imply the need to increase efforts to breed for varieties that are denser. Third, the consistency in the findings relating to nutrition provides product developers with information that should be taken into consideration in the development and promotion of advanced OFSP based products. They specifically imply the need for moderated and well-elaborated information on the nutritional benefits of OFSP, and that considers the context and educational level of recipients. Fourth, the finding that consumers would be motivated to consume OFSP by the desire to live long, be independent and have a happy life provides promoters with campaign these that can be used in combination with good health.

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Appendix 1: Product information given to each of treatment groups

Control: General information (read to all)
Orange-fleshed sweetpotato as a crop grows quite fast and some varieties can even mature in 3-4 months, which give food to the farmer and potential to sell the product faster than the other types of sweetpotato, which mature in 6 months. In addition, the new varieties are resistant to some of the diseases and pest that often affect the white and yellow types of sweet potato. This means that a farmer is able to harvest more from a given area of land.

Treatment 1 (Approach) information (in addition to general information):
Vitamin A is an essential nutrient crucial for maternal health and child survival. Vitamin A Deficiency leads to severe visual impairment and blindness, and significantly increases the risk of severe illness, and even death, from such common childhood infections as diarrhea disease and measles among children.

Plant source foods such as the orange flesh sweetpotato (OFSP) are an effective and sustainable strategy (or way) to address Vitamin A Deficiency among vulnerable populations in sub Saharan Africa. OFSP is a biofortified staple crop rich in provitamin A carotenoids, minerals such as iron and zinc and energy unlike vegetables. Biofortification is the idea of breeding crops to increase their nutritional value. OFSP has been developed through conventional selective breeding.

Vitamin A deficiency (VAD) remains a top public health problem in Kenya and many other sub Saharan countries. In Kenya, 84.4% of children under the age of five years are vitamin A deficient. One of the immediate causes of VAD is inadequate dietary intake of preformed vitamin A and food rich in provitamin A carotenoids such as the orange flesh sweetpotato (OFSP) by the vulnerable groups. Thousands of preschool children and pregnant women are currently at risk of VAD in Kenya. Pregnant women are more vulnerable to VAD during the last trimester when demand by both the unborn child and the mother is highest.

Treatment 2 (Avoidance) information (in addition to general information):
Orange Fleshed sweetpotato (OFSP) has been developed through a technology referred to as Biofortification. Biofortification is the idea of breeding crops to increase their nutritional value. In the process of improving the nutritional properties, some sensory attributes of OFSP are affected negatively.

For example, some consumers have felt that it becomes too soft when boiled and therefore does not feel like the white and yellow types they are used to. Others have felt that OFSP is not tasty as the white-fleshed and yellow-fleshed sweetpotato that you might be used to. Specifically, other consumers argue that OFSP is not as sweet (i.e. is less sugary) as the white and yellow types. There are also some consumers who say OFSP is only good for children due to its deep orange color, and not for grownups.