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Abstract

Cereals are the major staples in most African countries, where food processing industries are emerging fast. New low-cost extruders allow small enterprises to enter the market for processed cereal products, including instant, fortified and flavored mixes. Before engaging in the marketing of these products, consumers' interest needs to be assessed. This study used a combination of affective tests and experimental auctions with 200 consumers in Touba, Senegal, to evaluate four new products with conventional millet four as control: instant millet flour, instant millet flour with added mango and carrot extract, and the previous product with added micronutrients from either synthetic or natural origin. During affective tests, consumers made little distinction between the five products for appearance, aroma, taste and overall appreciation. The experimental auctions showed that, without providing additional information on the products, there is no difference in WTP between them. However, after that information is provided, consumers are willing to pay a modest premium for instant flour, and a large premium for added mango and carrot extract and for added micronutrients, but not for micronutrients from natural sources. Income increases overall WTP, while education increases WTP for instant flour. We conclude that there is a potential market for instant and fortified millet flour in Touba, but likely in the higher income and education groups. The increased cost needs to be compared to the premiums consumers are willing to pay. In the next step, the new and promising products could be tested in pilot markets, with target consumers.

Measuring consumers' interest in instant fortified millet products - a field experiment in Touba, Senegal

1. Introduction

The objective of the Feed the Future Food Processing and Post-Harvest Handling Innovation Lab (FPL) is a sustainable reduction of post-harvest losses in Feed the Future countries through technologies and innovations that link farmers to markets, with focus on Kenya and Senegal. To reduce post-harvest losses, the project works with hermetic storage technologies such as the Purdue Improved Cereal Storage PICS) bags, improved drying methods and low-cost grain moisture meters. To link farmers to markets and increase marketing opportunities, the project aims to increase and diversify food processing markets for cereal and legume products at the rural and urban levels, and to create a sustainable market-driven model for nutritionally-enhanced foods. Research activities focus on the improvement of existing technologies and products, as well as development of new ones. Through innovative mechanisms for dissemination, these activities will improve quality, safety, and nutritional options for consumers, leading to increased market opportunities for producers.

One of the processing technologies the project is developing and evaluating is extrusion technology to produce ready-to-eat (RTE) or instant fortified cereal products. This technology has been used extensively in the production of cereal RTE snacks due to its ease of operation and ability to produce a variety of textures and shapes which appeal to consumers (Brennan et al., 2013). The technology can also be used to develop products with higher nutritional quality such as soy-based breakfast cereals (Yeu et al., 2008). However, the effects of extrusion cooking on nutritional quality are ambiguous and to obtain a nutritionally balanced extruded product, careful control of process parameters is essential (Singh et al., 2007). In Mexico, optimized

extruded maize flour (EMF) from quality protein maize (QPM) had similar physico-chemical and functional characteristics than commercial nixtamalized maize flours (Reyes-Moreno et al., 2003).

Purdue University has developed a mini- extruder, much cheaper than the standard industrial models, which is now commercially available (US$18,700, by Technochem International, Inc), for a medium capacity (with a 7.5 HP electric motor, it can process approximately 45.4 kg of grain (100 pounds) per hour, at an energy cost of approximately 3.375 kWh (Dr. Sanjeev Agarwal, Technochem International, Inc., Pers. Comm.), making it suitable for small and medium enterprises in developing countries.

In most developing countries, cereals are the major food staples, such as millet in Senegal (REF) and maize in Kenya (De Groote and Kimenju, 2012). Focus group discussions conducted with low and medium income women in both countries conducted in 2015 indicated a strong interest in affordable instant cereal products with improved nutritional qualities. Participants from both groups were interested in instant cereals, the poor because it saves energy, the medium income groups because it save time (if they cook themselves) and can easily be done by the home help without much training requirements. In South Africa, low cost instant sorghum porridge powders have been brought to the market, at a cost of approx. US$1.20 for 1 kg, and are very popular.

Before bringing improved cereal products to the market in low-income countries, it is important to evaluate consumer acceptance of these product. In Africa, HarvestPlus has been conducting consumer acceptance studies for fortified crops such as orange fleshed sweet potatoes (Tomlins et al., 2007), while the International Maize and Wheat Improvement Centre (CIMMYT) conducted similar studies with Quality Protein Maize (QPM) in East Africa (De Groote et al., 2014). HarvestPlus also organized the first combination of sensory evaluation with economic experiments, in particular choice experiments, with provitamin A biofortified maize (Meenakshi et al., 2012) and orange-fleshed sweet potatoes (Chowdhury et al., 2011). CIMMYT first tried to estimate consumers' willingness to pay (WTP) of proVA maize with the

Becker-DeGroot-Maschak mechanism (a simulated auction) with proVA maize and found the mechanism convenient for work in rural areas (De Groote et al., 2011). Further, CIMMYT and its partners expanded this work on consumer acceptance of biofortified food crops, now combining affective tests (with representative consumers, not a trained panel like in sensory evaluations) and the BDM mechanism, in particular on proVA biofortified maize in Ghana (De Groote et al., 2010b) and QPM in Tanzania (De Groote et al., 2010b) and Ethiopia (Gunaratna et al., 2016 (online)). From these experiences, practical ways to evaluate consumer acceptance and WTP for new products combining affective test and economic experiments can now be derived.

Unlike these previous research, the products under study here are processed cereal products. Small and medium enterprises (SMEs) would be interested in producing instant cereal products with improved nutritional quality if they can make profit, Therefore, before producing and marketing these products, consumers' acceptance and their willingness to pay needs to be assessed. In particular, the premium consumers are willing to pay for instant vs. regular cereals, and for fortification with vitamins and minerals (artificial or from natural sources) needs to be estimated and compared to their respective production cost, and included in the total production cost, with cost of raw ingredients, packaging, marketing and so forth.

The objective of this study is therefore to i) assess consumer acceptance of the new, instant cereal products through affective tests; ii) estimate consumers' WTP for the different attributes tested: instant, added flavor, added micronutrients and added micronutrients from natural sources.

2. Methods

2.1. *Overview*

In this study, 200 consumers, men and women, from a regional capital, Touba in central Senegal, tasted and evaluated porridge from instant and fortified millet flour, in comparison to plain traditional millet, for the major sensory characteristics: appearance, aroma, taste and overall. The major product traits under evaluation were instant vs. regular cooking, added flavor, nutritional supplements, and natural vs.

synthetic supplements.

Participants received a show-up fee, after which they were asked some socioeconomic questions, followed by affective tests with cooked products to determine their acceptance, and an economic experiment to determine their willingness to pay (WTP) for the packed finished products (flours), conducted either with or without information on the content of the products (Figure 1).

2.2. *The products*

To attain the research objectives, the attributes of interest were carefully distributed over five different products, all made from millet, the major cereal in Senegal (Figure 2. Codes): A) traditional millet flour (MF), decorticated; B) instant decorticated MF; C) instant decorticated MF, flavored with mango and carrot extract; D) instant decorticated MF, flavored with mango and carrot extract, and fortified with a synthetic premix of minerals and vitamins; E) instant decorticated MF, flavored with mango and carrot extract, and fortified with natural products. Because the extracts contained sugar, the sugar content of all products was uniformly set at 10%.

2.3. *Selection of site and participants,*

The city of Touba was selected because it is representative of smaller cities targeted by the project to test new approached in food processing. In collaboration with Purdue University and the Institut de Transformation Alimentaire (ITA), SMEs in Touba have been successful in developing and marketing new food products. For this study, 100 male and 100 female participants were randomly selected. The study took place from February 28 to March 3rd. For four consecutive days, on average 50 consumers per day were invited to participate in the experiment.

2.4. *Show-up fee, informed consent and socioeconomic survey*

Participants were individually welcomed and presented with a small show-up fee of 3000 FCFA (US$1=600 FCFA at the time of the study), to express our gratitude, help with transport fees, and to assure that they have the cash to participate

in the experiment. The amount is set at roughly twice the estimated average WTP for the products, estimated at 1000 FCFA, plus a small transport allowance, a total of 3000 FCFA ($5) .

Participants were then explained by one of six enumerators the planned activities of the day, assured that they can stop and leave at any time, and asked to give their informed consent. The enumerator signed the form as a witness. To assure double blinding, four enumerators conducted the organo-leptic tests and the experiment without information, while two other enumerator conducted the experiment with information.

Next, a set of demographic and socioeconomic questions was asked to determine their age, education, wealth, income, and so forth. The questionnaire was programmed with CSPro and entered in tablets, and all data were entered directly by the enumerators into the tables.

2.5. Affective tests

Next, consumers were asked to evaluate the products with affective tests. Each participant was provided with about 50 g of each product, cooked in the standard manner and presented in the same fashion and at the same temperature. Consumers were asked to taste and evaluate each product in a given order, which was randomized to avoid first sample and order bias. They were asked to provide a hedonic score on a 5-point Likert scale for different sensory characteristics (dislike very much, dislike, neither like nor dislike, like, like very much). The sensory characteristics used are appearance, aroma, texture in hand, flavor, texture in mouth, taste and overall (not an average, but a separate overall evaluation). The products were identified with a neutral symbol, randomly assigned (A: circle, B: square, C: triangle, D: diamond, E: rectangle) (Figure 3, second column). The tests were conducted double blind: neither the enumerator nor the participants knows the content of the different products at this stage.

2.6. Economic experiments to determine WTP - information treatment

After the affective tests, the WTP of consumers was elicited with experimental auctions. For these auctions, participants were presented the same five products, but now in dry flour format, packed in clear plastic bags with 250 g of flour each, with a plain white rectangular label inserted in the bag, labeled with symbols or symbols plus text printed in black ink, depending on the information treatment.

To distinguish the WTP for the products based on their taste and sensory evaluation vs. the ease of cooking (instant vs traditional) and the nutritional content (micronutrient) and origin of the micronutrients (synthetic or natural),sensory characteristics from the WTP for the improved nutritional quality, the participants were randomly divided into two equal groups. Participants from Group 1 first conducted the experiment without any additional information on the content of the products, which were now presented with a label with the same symbol used in the affective test. Therefore, their bids reflected the WTP for the sensory characteristics. After the first round of experiments, the same participants (of Group 1) were given the information on the content of the products, and the experiment was repeated. Because doing the exercise twice might incur participant fatigue and bias the results, the other half of the participants, Group 2, went straight from the affective tests to the auctions with information. All information about the products was provided on the labels, together with the same symbols used during the affective test (Figure 3, last column).

The text on labels contained a simple description of the product translated into French: A) Decorticated millet flour; B) Instant decorticated millet flour; C) Instant decorticated millet flour - flavored with mango and carrot extract; D) Instant decorticated millet flour - flavored with mango and carrot extract, fortified with micro-nutrients; and E) Instant decorticated millet flour - flavored with mango and carrot extract, fortified with micro-nutrients from natural sources. The labels were translated into the local language, Wolof, by the enumerators, and some time was provided for the participants to ask questions. The benefits of the instant product in terms of time and energy saved was explicitly explained, but not the benefits of the

micronutrients.

2.7. *Economic experiment*

During the economic experiments, participants' WTP for the different products are elicited using the Becker-DeGroot-Marschak (BDM) mechanism (Becker et al., 1964). This procedure mimics an auction, where the participant bids against a random price, drawn from a random distribution. If the bid is higher than the random price, the participant buys the product at the random price, if the bid is lower, there is no transaction. This mechanism is incentive-compatible, meaning that the optimal bidding strategy of the participant is to bid its true WTP (unlike, for example, first-price sealed envelope auctions). The most convenient way is to use a random uniform distribution, around the mean expected value, from 0 to twice that value, with increments equal to the lowest currency value used in the local market, which are coins of 50 FCFA. These numbers were printed on pieces of paper and put in an envelope or bag.

To ensure participants understood the procedure, it was first described and it was emphasized, using a numerical example, that it was in the participant's best interest to reveal his or her true WTP. Next, a test round was first conducted, as this improves understanding and reduces bias (Morawetz et al., 2011). For the test round, participants were asked to bid for two small packets of biscuits. One product was then selected randomly as binding, by letting the participant draw a random number from a set of prices (50, 100, 150) around the average value of the test round product. The test round experiment was conducted with real money, and if the participant won the auction, he or she purchased the test product at the random price.

The main round with the main product followed the test round. The participant was asked to make a bid for each of the five products, one product was selected as binding, the participants drew a number from a uniform random distribution (from 50 FCFA to 600 FCFA, in increaments of 50 FCFA), to approximately twice the value of the product, 300 FCFA). If the bid was higher than the random price, the participant purchased the product at the random price.

2.8. *Analysis*

Affective tests used a five-point Likert scale, so the resulting variables are ordinal in nature (Stevens, 1946), and an ordinal regression is the preferred method of analysis (Coe, 2002; McCullagh, 1980). This model is also called the 'proportional odds' model by statisticians (McCullagh, 1980) and the 'ordered logit' model by economists (Greene, 1991; Train, 2003). In its basic form respondents are asked to score two products, distinguished by a binary variable x, using a set of ordered categories. Let y be the score and $v_k = P(y \leq k)$, or the probability that a score y falls at or below a certain level k. The logarithm of the odds of v_k, also called the logit, is then modeled as a linear function of the independent variables, formally:

$$Logit(v_k) = Ln\frac{P(y \leq k)}{1-P(y \leq k)} = \alpha_k + \beta' x \quad . \qquad (1)$$

The coefficient β represents the change in the log odds (the logarithm of the odds) for a unit change in the explanatory variable x. If x is binary, β is the change in the log odds, and its exponent e^{β} represents the odds that one product is rated higher than the other, over the odds that the other product is rated higher, also called the odds ratio (Bellon et al., 2006).

The model can be expanded to analyze the scores for different products j, each with a vector of attribute vector $\boldsymbol{x}_j$, by respondent i. The scores of different products by one respondent could be correlated, so an individual effect u_i needs to be added (De Groote et al., 2010a), and the model becomes:

$$Logit\ (v_{ijk}) = \alpha_k + \boldsymbol{\beta}'\boldsymbol{x}_j + u_i \qquad (2)$$

If the respondents are randomly selected, the standard procedure assumes that u_i is randomly distributed, also called the random effects model. Such models have been used to analyze farmer participatory evaluation of new technologies (De Groote et al., 2010a) and consumer evaluation of maize products (De Groote et al., 2014).

The effects of consumer characteristics $\boldsymbol{z}_i$ can also be included in the analysis using both direct effects (vector $\boldsymbol{\gamma}$) and cross effects (matrix A) (De Groote et al., 2011), resulting in:

$$Logit\ (v_{ijk}) = \alpha_k + \boldsymbol{\beta}'\mathbf{x_j} + \boldsymbol{\gamma}'\mathbf{z}_i + \mathbf{x}_j'A\ \mathbf{z}_i + u_i \quad (3)$$

This model was estimated with the *xtologit* model with random effects with the software Stata, version 13.1. Design factors include enumerator and order.

For the analysis of WTP, the dependent variable is WTP_{ijk} or consumer *i* 's willingness to pay for product *j,* a quantitative variable on a ratio scale, and can be analyzed using a linear model. The WTP for the different attributes can be included as binary variables in a random effects model:

$$WTP_{ij} = \alpha + \boldsymbol{\beta}'\mathbf{x_j} + u_i + v_{ij} \quad (4)$$

Because the main interest here was the WTP for specific attributes, in this model $\boldsymbol{x}$ represent a vector of attributes, not products like in the ordinal regression. The attribute vector consisted of following binary variables: instant (vs. conventional), flavored (yes/no), fortified (yes/no), fortified with natural ingredients.

Finally, the effect of consumer characteristics was analyzed by adding a vector $\mathbf{z}$ with age, gender and education level, to the model:

$$WTP_{ij} = \alpha + \boldsymbol{\beta}'\mathbf{x_j} + \boldsymbol{\gamma}'\mathbf{z}_i + \mathbf{x}_j'A\ \mathbf{z}_i + u_i + v_{ij} \quad (5)$$

The WTP models were estimated with the module *xtreg* in Stata version 13.1.

3. Results

3.1. Consumer characteristics

Both women and men were well represented in the sample, but most participants had low incomes and wealth, and education levels were generally low (Table 1). More than half of the participants (54%) were women and average age was 40.5%, ranging from 17 to 88 years. Two thirds of participants did not receive any formal education; average schooling was 2.5 years. The average family size of the participants was 10 people.

The participants were selected from peri-urban areas, and most were urban. A quarter of participants owned land, but only 5% of them indicated farming was their main occupation. Only 6% of participants owned cattle, but 35% owned poultry. Almost half (42%) of participants ran their own business. a quarter owned farm land.

While many participants did not provide income details, most were able to report an annual income, with the average reaching almost 1 million FCFA ($1,600) per year.

3.2. Affective tests

After the socioeconomic questionnaire, consumers were asked to taste and evaluate using affective tests the five products, which were presented in small cups, freshly prepared, in random order and double-blinded. Participants were asked to score them, on a five-point scale, for five attributes and overall (Figure 4). The results show that consumers generally appreciated the different products but made little, if any, distinction between them. Almost all evaluations were positive, and all products mostly received scores of "good" (49%) or "very good" (40%) for all criteria. Only product E received a few more negative scores, in particular for appearance and aroma (the natural source of micronutrients was hibiscus, which added a distinct red color and specific flavor).

Since the scores are ordered categorical data they were analyzed with ordinal regression (Equation 2). However, no statistical differences were found between the scores for the different products, and for none of the different attributes (Table 2). As a result, the effect of demographic and socioeconomic characteristics (Equation 3) was not further analyzed.

3.3. Willingness to Pay - means, by gender

After the affective test, participants were asked to state their WTP for the five products, now packed in clear plastic bags of 250 g, using the incentive-compatible BDM mechanism to assure revealed preferences, either with or without additional information.

Participants of the first group, randomly assigned, were first asked to make their bids without receiving any additional information on the content of the products (Figure 5, first bars in blue). These bids showed no differences in WTP for the different products, except for a small difference between products A and C, and this for women only. However, there was a large difference between WTP from women

(254 FCFA on average) and men (310 FCFA).

After this exercise, the participants of group 1 were provided with the information on the content of the products, on labels containing both the symbol and the content information (Figure 3). The results (yellow bars in Figure 5), show little or no change in WTP for products A to C after given the information, but they do show a substantial premium for the products with added micro-nutrients (products D and E). There is, however, little or no difference between products D and E, indicating consumers do not express a willingness to pay a premium for micronutrients derived from natural sources. Further, men showed a small premium for product B (instant flour) while women did not.

The participants of group 2 went straight from the affective tests to the WTP exercise with information (red bars in Figure 5). The WTP of this group was similar to those of group 1 with information, except that there was now a clear premium for instant flour for both men and women. So for both men and women, there is a clear increasing trend in WTP from A to D, but not between D and E, and the trend looks stronger among men.

3.4. Willingness to pay - statistical analysis with pairwise t-test

To check if consumers were willing to pay a premiums for the products' characteristics, pairwise tests were conducted, comparing the improved products (from B to E) to the basic product (A), and that for the three sets of bids (Group 1with and without information, and Group 2 with information) (Table 3). For ease of interpretation, the premiums were also calculated as a percentage over the WTP for product A.

Consumers in group 1, before they were given information on the content of the products, did not express any systematic increase in WTP for any of the improved products. This was to be expected, since their WTP was only based on the affective tests, and which no differences were observed. All premiums in this group were small and not significant, except for product C (instant MF with mango and carrot extract), for which consumers were willing to pay a small premium (6%). Upon further query,

however, this premium was only observed for women (and amounted to 20% when calculated for them alone). This could therefore be a random effect, and would need to be confirmed by a repeat experiment.

The same participants from group 1, after the first BDM exercise, were provided the information on the products and offered a second chance to make bids. , now increased their bids for all products except for product B (plain but instant flour), with large and significant differences . These premiums amounted to 13% for the flavored flour, and to 19-21% for those with micronutrients. There was no premium, however, if micronutrients come from natural sources.

The participants of group 2 received the information on the products immediately after the affective tests, and were then asked to bid on the different products. In this group, the premiums for all the improved products were found to be large, positive and significant. The premium for instant flour was 27%, for flavoring with mango and carrots it was 54%, and for micronutrients it went up to 75%. The premium for micronutrients from natural ingredients, however, was slight smaller (68%, although not statistically different from the previous one), indicating no premium for "natural ingredients".

There was no statistical difference between the average WTP for the different products between groups 1 after information and group 2.

3.5. Willingness to pay - regression analysis

For a statistical analysis of the WTP for the different traits, a random effects model was estimated with the different traits as binary variables (Equation 4). Four traits are examined (Figure 2): instant flour (products B to E), added flavor from mango and carrots (C to E), added micronutrients (D and E) and micronutrients from natural sources (E). The constant therefore represents the mean of the omitted category, product A, and the coefficients represent the premiums for the different traits, in comparison to product A.

The results for the participants in group 1, before they received information, show they were not interested in paying a premium for the improved products: none

of the coefficients in the regression are significant (Table 4, first block). This is expected, as participants did not score the improved products higher and did not have any information on their content. After they received the information, however, the bids of the participants in this group increased significantly for flavor (to 20 FCFA or 8% over the constant, the WTP for product A) and micronutrients added (25 FCFA or 9%). The coefficient for instant (11 FCFA or 4%), was positive but not significant in this group. Further, the coefficient for natural sources was not significant.

The bids participants of group 2, who went straight to the auction with information, where generally higher than those of the previous group. In particular, the analysis showed a large and significant premium for instant flour (26 FCFA, or 10% over the constant). The premium for flavored with mango and carrots was also higher (28 FCFA), while that for micronutrients was slightly lower (21 FCFA).

3.6. WTP - regression, long model

To analyze the effect of demographic and socioeconomic characteristics of the participants on their WTP for the new products, these factors were included in the long model (Equation 4) was (Table 5). As in the previous model, there were no significant differences in WTP for the traits for the participants of Group 1 without information. After information, however, as the previous model, the WTP analysis shows large and significant premiums for flavor and micronutrients, but not for natural source of micronutrients. In the long model, however, the premium for instant flour was small, and now not significant, because of the cross-effect with education, discussed below.

Few of the socioeconomic variables were significant, however. In Group 1 without information, the effect of gender was large, but only marginally significant ($p=0.09$) (Table 5, first model). Otherwise, the effects of consumers' socioeconomic characteristics were only significant in Group 2 with information. In this group, of the direct effects only income affected WTP, with a positive coefficient of 0.01, indicating WTP increases by 1% with income (Table 5, last model). In the cross effects, the only significant cross-effect was that of education on WTP for instant flour. For every extra

year of education, WTP for instant food increased by 2 FCFA. Including the cross-effect for education in the model, however, reduces the main effect for instant flour to the extent it becomes insignificant. This might indicate that only people with education value instant flour.

4. Conclusion

The results of the affective tests indicate that consumers did not distinguish between the sensory characteristics of the different products evaluated. As a result, participants who did not receive information on the products' content were not willing to pay a premium for the different quality traits. However, when participants were provided with that information, they showed an interest in paying a small premium (10%) for instant flour, and large premiums for added mangoes and carrots and for fortification with micronutrients. There was no added premium, however, if the micronutrients came from natural sources. Among participants, income had a positive effect on general WTP, but not for particular traits or quality. Education, on the other hand, increased WTP for instant flour.

Methodologically, several lessons were learned. First, the procedure of selecting the participants from the peri-urban areas led to large proportions of poor and uneducated participants. As the results indicate that WTP increases with income and WTP for instant flour increases with education, future research should focus on consumers with higher income and education levels, as these are more likely to be the final buyers of the improved products. In this respect, the goals of the project to developing sustainable businesses (based on customers who can afford the products) and improving the nutrition of low-income groups can be in conflict.

Second, the results from the participants of Group 1, after they were given information, were not as good as those from Group 2, who went straight to the experiment after the affective test. Results from Group 2 showed more significant factors and with more precision in the estimates. Our experience indicates that participant fatigue plays a role: five products is already a substantial number, so to first evaluate them with affective tests, then do a WTP exercise without information,

followed by another one with information, is asking a lot of concentration and effort.

Third, another problem with uneducated participants was that many could not read the information provided on the label. The information needed to be translated and explained in local language (Wolof). The enumerators were was not initially prepared for this, and some ad hoc training had to be organized. In the future, this information needs to be clearly written out, translated and practiced, so all participants receive the same information.

Since the results show how consumers are willing to pay a premium for better quality, in particular a small premium for instant flour and a large premium for added mangoes and carrot extract, and for micro nutrients, the next step in the research is to estimate the cost of the added quality traits and to compare them to premiums, and determine the products that are likely to find a market. Further, WTP for these products needs to be established among the target consumers, those with higher income and education, either through a repetition of this experiment in more upscale markets, or a pilot marketing project.

Finally, the project should consider how to balance its two seemingly conflicting goals: sustainable business development and reaching the poor. Since there is no point in reaching out to the poor in a non-sustainable way, the first goal should be pursued first, and profitable markets identified, likely first among consumers with higher incomes and education levels. Once these markets have been explored and businesses are well established, appropriate affordable products for the poor can be developed and tested.

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Table 1. Descriptive statistics of the participants

Group	Variable	Appearance			Aroma			Texture			Taste			Overall		
		Coef.	SE	P	Coef.	SE	P	Coef.	SE	P	Coef.	SE	P	Coef.	SE	P
Products	Product B	-0.07	0.31	0.824	0.03	0.26	0.914	0.24	0.33	0.464	0.05	0.31	0.870	0.54	0.33	0.103
	Product C	0.38	0.31	0.225	-0.17	0.26	0.504	-0.03	0.32	0.920	0.38	0.31	0.223	0.59	0.33	0.075
	Product D	-0.30	0.31	0.330	-0.05	0.25	0.856	-0.21	0.32	0.514	-0.18	0.31	0.567	0.13	0.33	0.690
	Product E	0.20	0.31	0.521	-0.37	0.25	0.140	0.21	0.32	0.513	-0.11	0.31	0.721	0.15	0.33	0.647
Intercepts	/cut1	-10.59	0.87	0.000	-6.01	0.42	0.000	-13.37	1.48	0.000	10.55	0.89	0.000	12.05	1.23	0.000
	/cut2	-7.99	0.75	0.000	-4.92	0.39	0.000	-9.81	1.23	0.000	-7.83	0.79	0.000	-9.95	1.15	0.000
	/cut3	-7.06	0.72	0.000	-4.36	0.37	0.000	-8.05	1.16	0.000	-6.86	0.77	0.000	-8.79	1.11	0.000
	/cut4	1.52	0.46	0.001	0.65	0.31	0.039	0.59	0.79	0.458	0.84	0.58	0.145	0.18	0.71	0.801
Model	sigma2_u	24.589	4.93		11.6	1.87		40.756	11.6		32.2	6.42		40.11	9.27	
	N observations	987			987			987			987			987		
	N participants	201			201			201			201			201		
	Wald chi2(4)	2.09			6.98			1.11			3.84			5.08		
	Log likelihood	-618.6			-826			-595.4			-641			-574.5		

Table 2. Analysis of consumers' scores for different attributes and overall, using ordinal regression with random effects (base category is product

Group	Variable	Mean	Std. Dev.	N	None (% of respondents)	Minimum	Maximum
Demographics	Male	0.46	0.5	201		0	1
	Age	40.5	14.3	201		17	88
	Years of education (years)	2.5	4.3	200	66.7	0	16
	Family size	9.9	6.0	195		1	40
Land	Owned	0.9	3.1	174	75.6	0.000	25.000
(ha)	Cultivated	0.5	2.1	180	81.1	0.000	20.000
	Uncultivated	0.2	0.9	180	81.1	0.000	8.000
	Other crops	0.4	1.9	175		0.000	20.000
Livestock	Cattle	0.3	1.7	200	93.5	0	14
	Sheep	1.1	3.3	200	78.6	0	30
	Goats	0.3	1.3	200	93.5	0	10
	Horses	0.1	0.6	201		0	5
	Donkeys	0.1	0.4	200		0	2
	Chicke	10.4	37.2	199	64.7	0	300
Income	Livestock sales	193,920	2,274,698	174	76.6	0	30,000,000
(FCFA/year)	Crop sales	13,795	69,236	173	79.6	0	500,000
	Salary	62,055	298,853	146	65.7	0	3,100,000

Business	67,897	283,139	141	60.2	0	2,600,000
Other sources	279,752	2,454,680	167	72.6	0	31,200,000
Total	950,113	5,792,629	156	21.4	0	65,000,000

Table 3. Premium for improved millet flours (results of pairwise t-tests)

Group/information	Product	Mean for Product A	**Premium** FCFA	%	Std. Dev.	df	P
Group 1, without information	A	262					
	B (instant)		9	3.3	61	76	.213
	C (B + mango and carrot)		16	6.0	68	79	.041
	D (C + micronutrients)		5	1.8	85	77	.618
	E (C + micronutrients from natural sources)		4	1.6	87	76	.673
Group 1, with information	A	278					
	B (instant)		11	4.3	84	96	.188
	C (B + mango and carrot)		34	13.1	93	95	.000
	D (C + micronutrients)		55	21.1	99	94	.000
	E (C + micronutrients from natural sources)		49	18.7	115	95	.000
Group 2, with information	A	274					
	B (instant)		27	10.1	116	97	.025

C (B + mango and carrot)	54	20.4	122	96	.000
D (C + micronutrients)	75	28.6	137	97	.000
E (C + micronutrients from natural sources)	68	25.8	140	70	.000

Table 4. Perceptions of consumers concerning GM technology (in % of respondents who agree or stronglyee agree, with avarge scores in italics)

		Mean for Product	**Premium**				
Group/information	Product	A	FCFA	%	Std. Dev.	df	P
Group 1, without information	A	262					
	B (instant)		9	3.3	61	76	.213
	C (B + mango and carrot)		16	6.0	68	79	.041
	D (C + micronutrients)		5	1.8	85	77	.618
	E (C + micronutrients from natural sources)		4	1.6	87	76	.673
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	C (B + mango and carrot)		54	20.4	122	96	.000
	D (C + micronutrients)		75	28.6	137	97	.000
	E (C + micronutrients from natural sources)		68	25.8	140	70	.000

Group	WTP_noin	No information (First group)			With information (first group, after exercise without information)			With information (second group, immediately after affective test)		
		Coef.	Std. Err.	P>|z|	Coef.	Std. Err.	z	Coef.	Std. Err.	z
Factors	Instant	7.99	11.48	0.487	3.54	11.81	0.765	7.93	14.98	0.597
	Flavored	7.04	9.76	0.471	21.57	10.77	0.045	31.57	13.43	0.019
	Micronutrients	-6.68	9.77	0.494	29.33	10.86	0.007	24.84	13.43	0.064
	Micronutrients from natural sources	4.09	9.88	0.679	-3.86	10.82	0.721	-19.27	14.91	0.196
	Male	82.70	48.31	0.087	58.46	45.45	0.198	42.76	52.30	0.414
	Age	-1.37	1.57	0.382	-0.74	1.47	0.614	-1.31	1.76	0.458
	Education (years)	-0.28	6.09	0.964	-1.04	5.71	0.855	-3.92	5.34	0.463
	Income (1000 FCFA)	0.03	0.04	0.441	0.05	0.04	0.190	0.01	0.00	0.004
	Education x instant	-2.55	2.08	0.221	1.27	2.07	0.540	6.53	2.11	0.002
	Constant	304.21	69.50	0.000	272.32	65.40	0.000	310.77	72.87	0.000
Model	Number of obs	360			376			367		
	Number of groups	77			77			78		
	R-sq: within =	0.0087			1			0.171		
	between =	0.0584			4.9			0.1341		
	overall =	0.0618			5			0.1397		

sigma_u	181.83	169.88		204.00
sigma_e	59.58	65.84		83.80
rho	0.90	0.87	ce due to	0.86
Wald chi2(8)	7.01	52.16		70
Prob > chi2	0.6361	0		0

Table 5. WTP for instant millet flour - long model

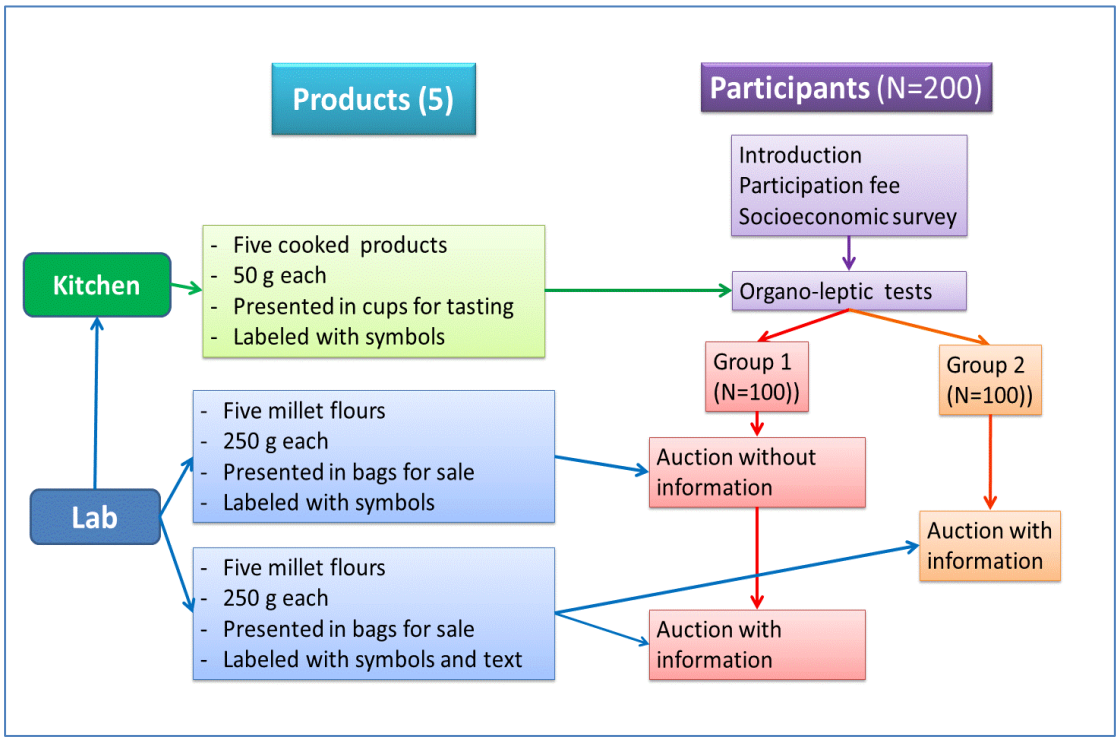

Figure 1. Study design

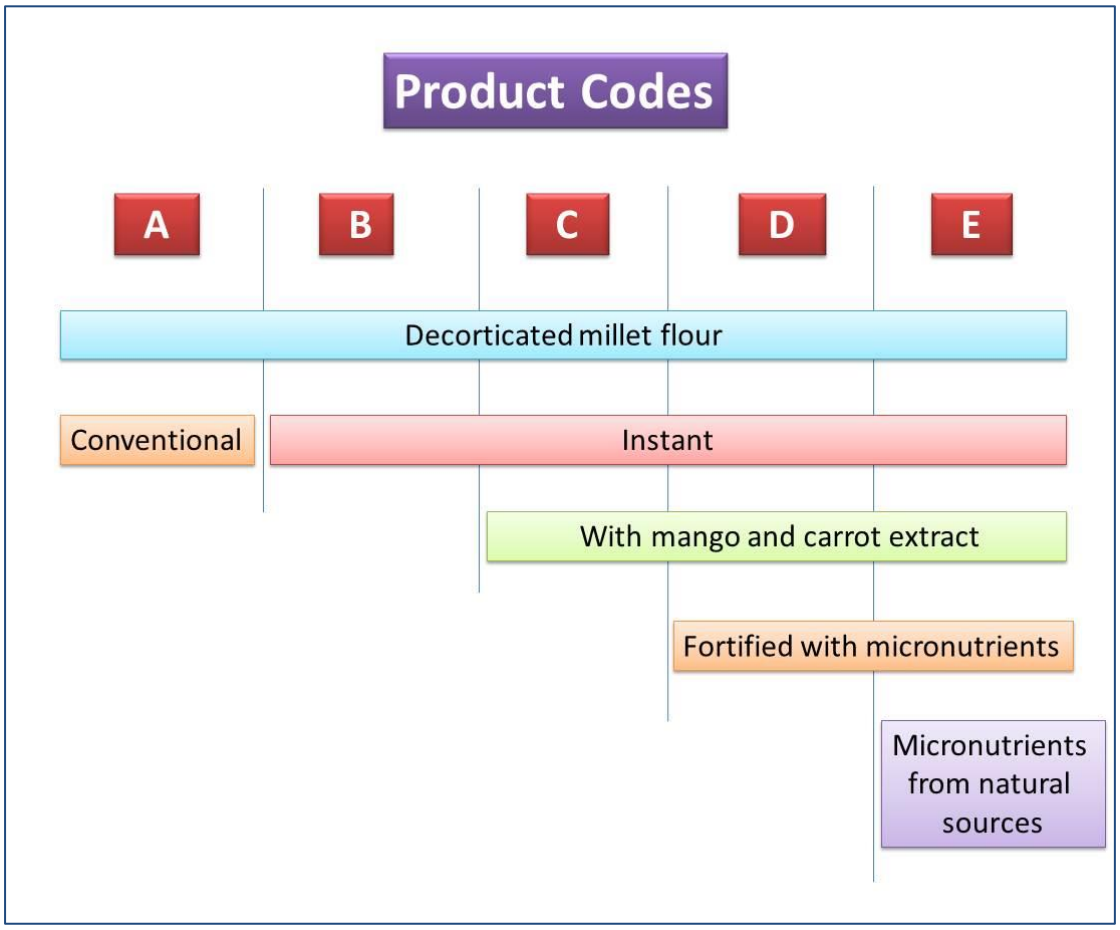

Figure 2. Product codes and the content of the different products

Product	Labels with symbols only	Labels with symbols and information
A - traditional millet flour, decorticated		 **Farine de mil** 250 g **Produit au Sénégal**
B instant decorticated millet flour		 **Farine de mil instantanée** 250 g **Produit au Sénégal**
C - instant decorticated millet flour, flavored with mango and carrot extract		 **Farine de mil instantanée avec extrait de mangue et carottes fortifiée avec des micro-nutriments** 250 g **Produit au Sénégal**
D - instant decorticated millet flour, flavored with mango and carrot extract, fortified with a synthetic premix of minerals and vitamins		 **Farine de mil instantanée avec extrait de mangue et carottes fortifiée avec des micro-nutriments** 250 g **Produit au Sénégal**
E - instant decorticated millet flour, flavored with mango and carrot extract, and fortified with natural products		 **Farine de mil instantanée Avec extrait de mangues et carottes Fortifiée avec des micro-nutriments extraits des produits naturels.** 250 g **Produit au Sénégal**

Figure 3. The different products, their codes, their labels with symbols, and their labels with both symbols and information

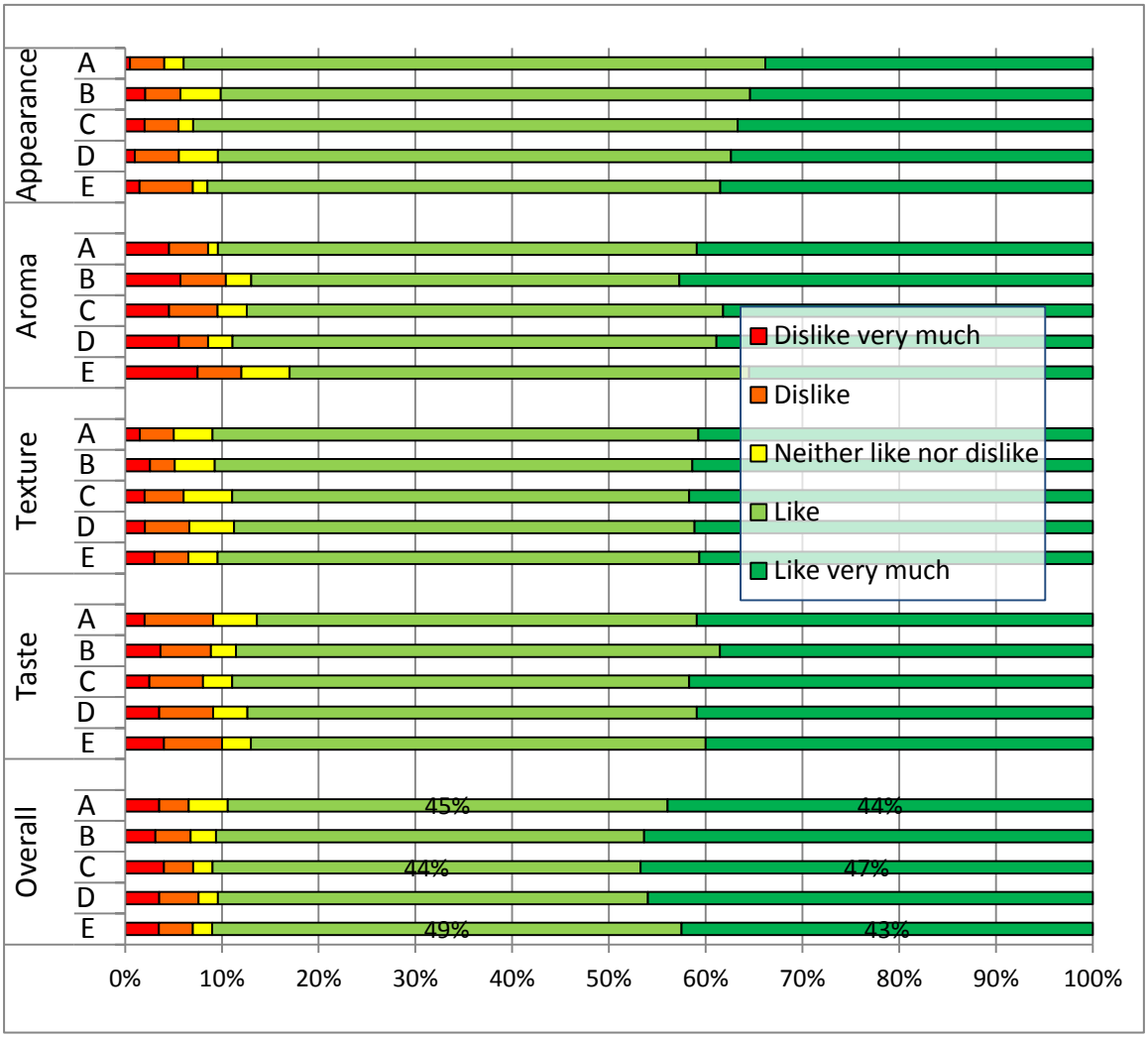

Figure 4. Consumer affective tests, on a five-point Likert scale, for attributes appearance, aroma, texture and taste, and overall appreciation

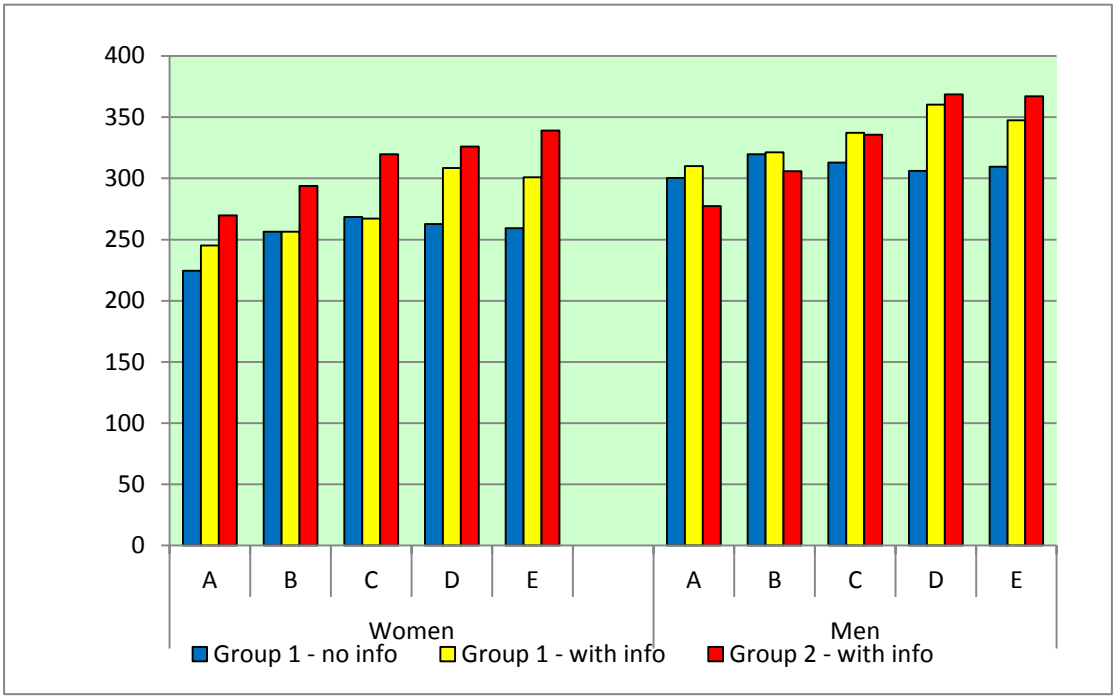

Figure 5. WTP for different millet flour products (A: conventional millet flour, B to D: instant millet flour, C to E