Measuring consumers' interest in instant fortified pearl millet products: A field experiment in Touba, Senegal

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Abstract

BACKGROUND: In Africa, food-processing industries are emerging fast, especially for cereals. New low-cost extrusion cookers give small enterprises an opportunity to enter the market for processed cereal products, in particular 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 pearl millet flour as the control: instant pearl millet flour, instant pearl millet flour with added dry mango and carrot powder (naturally fortified), and the previous products with added conventional chemical micronutrient fortificants.

RESULTS: During affective tests, consumers made little distinction between the five products in appearance, aroma, taste and overall appreciation. The experimental auctions showed that, without providing additional information on the products, there was no difference in 'willingness to pay' (WTP) between them. However, after that information is provided, consumers were willing to pay a modest premium for instant flour, and a large premium for added mango and carrot extract and for added micronutrients, but were not willing to pay a premium if those micronutrients came from natural sources. Income increased overall WTP, while education increased WTP for instant flour.

CONCLUSION: We conclude that there is a potential market in low-income African countries for instant and fortified cereal food products, 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."

INTRODUCTION

Cereals are major food staples in many African countries, where food processing industries are emerging fast [1]. New low-cost extrusion cookers 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, however, it is important that consumers' interests and preferences are properly assessed.

The Food Processing and Post-Harvest Handling Innovation Lab (FPL) project, supported by USAID Feed the Future, aims to sustainably reduce post-harvest losses through technologies and innovations that link farmers to markets, with a focus on Kenya and Senegal (https://ag.purdue.edu/ipia/fpl/Pages/default.aspx). 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.

One of the processing technologies the project is applying and evaluating is high-temperature short-time (HTST) extrusion cooking to produce ready-to-eat (RTE) instant (powder-based) cereal products, fortified with plant food ingredients rich in micronutrients (natural fortificants) as well as synthetic micronutrient fortificants. The HTST extrusion cooking technology has been used extensively in the production of

RTE cereal snacks due to its ease of operation and ability to produce a variety of textures and shapes which appeal to consumers [2]. The technology can also be used to develop food products with higher nutritional quality such as breakfast cereals containing soy [3].

Purdue University has developed a mini single-screw extrusion extruder, much less expensive than the standard industrial models. It is now commercially available (Technochem International, Inc) with a capacity of 45 kg of grain per hour, suitable for small and medium enterprises in developing countries.

In many developing countries, cereals are the major food staples, in particular rice and pearl millet in Senegal [4] and maize in Kenya [5]. In both countries, project research teams conducted focus group discussions with low and medium income women in 2015. The results indicate a strong interest in affordable instant cereal products with improved nutritional qualities. Participants from both groups were interested in instant cereal foods: the poor because it saves energy, the medium-income groups because it saves time (if they cook themselves) and it can easily be done by the home help without much training. In South Africa, low-cost instant sorghum porridge powders have been brought to the market at a cost of approximately US$1.50 for 1 kg, and are very popular.

Before bringing improved cereal food products to the market in low-income countries, it is important to evaluate consumer acceptance of these products. In Africa, HarvestPlus (a program to reduce malnutrition through biofortification of staple food crops) has been conducting consumer acceptance studies for biofortified crops

such as orange-fleshed sweet potatoes [6], while the International Maize and Wheat Improvement Centre (CIMMYT) conducted similar studies with Quality Protein Maize (QPM) in East Africa [7]. HarvestPlus organized the first combination of sensory evaluation with economic experiments, in particular choice experiments, with provitamin A biofortified (proVA) maize [8] and orange-fleshed sweet potatoes [9]. CIMMYT first tried to estimate consumers' WTP for proVA maize with the Becker-DeGroot-Maschak (BDM) mechanism (a simulated auction) with proVA maize and found the mechanism convenient for work in rural areas [10]. Further, CIMMYT and its partners expanded this work on consumer acceptance of biofortified food crops, now combining affective tests (with representative consumers) and the BDM mechanism. This combination was used on proVA biofortified maize in Ghana [11, 12], and QPM in Tanzania [11] and Ethiopia [13].

Unlike these previous studies, 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 WTP needs to be assessed. In particular, the premium consumers are willing to pay for instant versus regular cereal products, and for fortification with vitamins and minerals needs to be estimated and compared to their respective production cost, and included in the total production cost, with the cost of raw ingredients, packaging, marketing and so forth.

The objective of this study was therefore to i) assess consumer acceptance of

the new, instant cereal products through affective tests; and ii) estimate consumers'

WTP for the different product traits tested: instant, added flavor, added micronutrients

and added micronutrients from natural sources.

METHODS

Overview

Two methods are commonly used to assess consumers' interest in new food

products: affective tests and experimental auctions. Affective tests involve sensory

evaluation of the new products by representative consumers, in contrast with trained

panels [14]. Experimental auctions are organized to elicit consumers' WTP for the

products. More recently, consumer studies have combined the two methods to obtain

both consumers' evaluation and WTP. The combination of sensory evaluation with

experimental auctions to evaluate consumers' preferences is a common practice in

developing countries.

In the US, several such studies have now been conducted, for example, on

different types of meat [15-17]. In Europe, the method is also popular, for example, for

studying consumers' interest in food quality such as in specialty foods [18] or organic

foods [15]. The sensory evaluation is usually conducted with a 9-point hedonic scale [19],

while the experimental auction is usually a variation of a variation of the Vickrey

auction [20]. In a Vickrey auction, the winner is the highest bidder, but he or she only

pays the second-highest bid price (or the 5th or nth price in variations), making the

auction incentive-compatible.

In Africa, this type of consumer study is fairly recent. Experimental auctions have been used in combination with taste sessions, for example, in East Africa for assessing consumer interest in improved milk quality in Kenya [21] and Ethiopia [22], and in West Africa for rice with improved quality in Benin [23] and Senegal [24]. However, these studies did not include formal sensory evaluation.

Combinations of formal sensory evaluations with experimental auctions in Africa were first conducted with biofortified crops. The first experiment was with orange maize, biofortified with provitamin A, and combined home use test, choice experiments, and information on health benefits [8]. A similar experiment was conducted in Ghana, now with a central location test and different types of experiments (choice experiment, Vickrey 5th auction and BDM)[12]. The experience of this study showed how BDM, which is conducted individually, was easy to use with respondents with little or no education, and particularly suited for rural dispersed populations. It was therefore selected to estimate WTP for quality protein maize, in combination with both central locations affective tests [7] and modified home use tests, with adults [25] and with both mothers and children [13] , with all experiments including an information component.

The current study builds on the experience of consumer experiments in both developed and developing countries that combine sensory evaluation with economic experiments. It used the BDM as this is the most convenient auction mechanism as it is a one-on-one procedure more convenient for consumers with little or no education, in contrast to group auctions. As in previous studies, it uses information as a factor.

Unlike the studies in West Africa, it uses formal affective tests so their effect on WTP can be analyzed. Further, this is the first time the method has been applied to test processed food products in Africa, and to measure consumers' WTP for specific traits, in particular instant products.

In this study, 200 consumers, men and women 18 years or older, from Touba, a regional capital in central Senegal, tasted and evaluated porridge from instant and fortified pearl millet flour, produced using a mini-extrusion cooker, in comparison to plain traditional pearl millet, for the major sensory attributes: appearance, aroma, taste and overall appreciation. The major product traits under evaluation were instant versus regular cooking, added flavor, nutritional supplements, and natural vs. synthetic supplements.

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

The products

To attain the research objectives, the product traits of interest (instant, added flavor, added micronutrients and added micronutrients from natural sources) were carefully distributed over five different products, all made from pearl millet, a major cereal in Senegal (Figure 2). The following products were included: A) traditional
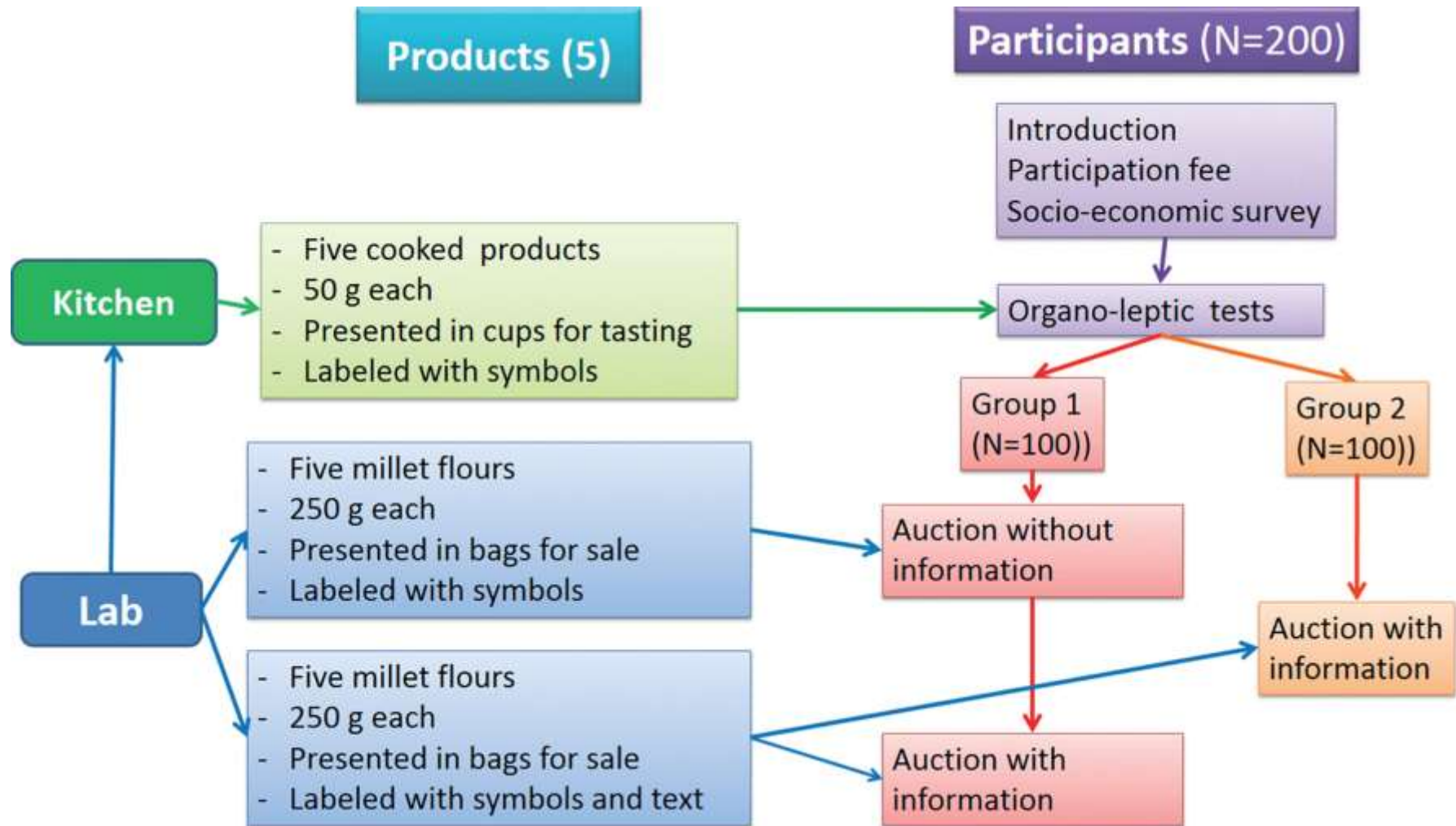
Figure 1. Study design

pearl 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 micronutrients (iron); E)

instant decorticated MF, flavored with dried mango and carrot powders, and fortified

with a natural product, hibiscus, which also added a distinct red color and specific

flavor. The detailed composition is presented in Table 1. Because the powdered dried

mango naturally contained sugar and because the traditional pearl millet porridge is

normally sweetened by consumers, the sugar content of all products was uniformly

adjusted to 100 g kg -1 (dry basis), the same level as contributed by the mango

powder.

Selection of site and participants

The city of Touba was selected because it is representative of medium-size

cities in predominantly rural areas targeted by the project to test new approaches in

food processing. In collaboration with Purdue University and the Institut de

Technologie Alimentaire (ITA), SMEs in Touba have been successful in developing

and marketing new food products. For this study, a two-stage random-sampling

design was used. A list of the suburbs around Touba was obtained from the Mayor of

Touba's office, and five were drawn randomly. In each selected suburb, a list of all

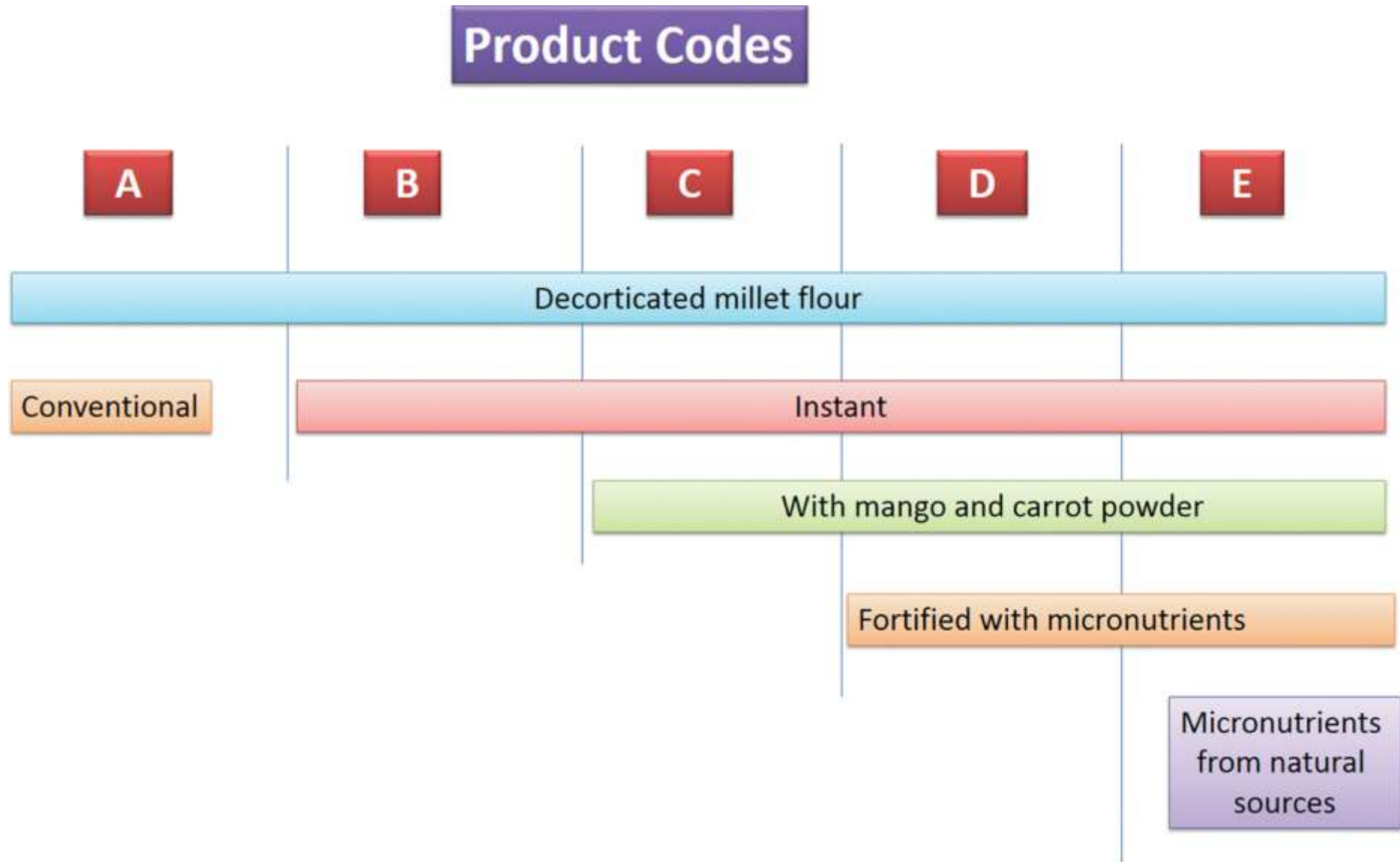adult men and women was drawn, and 40 names were randomly drawn, with an

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

Table 1. Composition of the products

Product code	Product Description	Composition in kg (% in brackets)					
		Pearl millet flour[a]	Sugar	Mango powder	Carrot powder	Hibiscus powder	Iron fortificant
A	Traditional porridge	19 (90)	2.1 (10)				
B	Instant porridge	22.5 (90)	2.5 (10)				
C	Instant flavored porridge	21.5 (86.2)		3.15 (12.5)	0.355 (1.4)		
D	Instant flavored porridge with micronutrients	20 (86.2)		2.88 (0.13)	0.33 (1.3)		0.005
E	Instant flavored porridge with micronutrients from natural sources	20.25 (81)		3.15 (12.6)	0.355 (1.4)	1.25 (5)	

extra ten as reserve. The selected people were contacted and invited to participate in the study. The study took place at the beginning of 2016 in a guest house in Touba, at the outskirts of the city, over four days, with one long morning session per day. The randomly-selected participants were invited to come in the morning on a specific date, and were told they would receive a small allowance. The actual evaluation and experiment took place in a large, central hall where five enumerators were seated at individual tables to conduct the affective test with one consumer at a time, while two enumerators were similarly set up to conduct the experiments. Food was prepared in a separate kitchen and, to accommodate the organization of the enumerators, in small batches for about five consumers at a time. When food and enumerators were ready, participants were invited into the hall, individually or in small groups. They were registered, had the procedure briefly explained to them, then they were asked to give their informed consent and provided with their show-up fee. Participants who were invited but who did not show up were replaced by people from the reserve list in the order that they were drawn. On average, 50 consumers per day participated in the study.

Show-up fee, informed consent and socio-economic 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 based on the prices of

instant infant products in the local shops, plus a small transport allowance, giving a

total of 3000 FCFA ($5).

One of six enumerators then explained the planned activities of the day to the

participants, who were assured that they could stop and leave at any time, and were

asked to give their informed consent. The enumerator signed the form as a witness.

To assure double blinding, four enumerators conducted the affective tests and the

experiment without information, while two other enumerators conducted the

experiment with information.

Next, a set of demographic and socio-economic questions was asked to

determine their age, education, wealth, income, and so forth. The questionnaire was

programmed with the software CSPro [26] onto electronic tablets (Kindle Fire,

produced by Amazon, Seattle, USA), which were subsequently used by the

enumerators to enter each item of data immediately as it was collected.

Affective tests

Next, consumers were asked to evaluate the products with affective tests.

The conventional porridge was prepared by mixing ambient temperature water

with normal flour to form a slurry. This was then poured into boiling water with stirring.

The mixture was then brought to boil with vigorous stirring and then simmered by 30

minutes with occasional stirring. The instant porridge was prepared by stirring boiling

water into the instantized flour.

Each participant was provided with about 50 g of each product, served at a temperature of about 50 °C. The five products were presented simultaneously on one tray, in systematic random order, and each participant was asked to evaluate each product in the established order.

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 score on a 5-point hedonic scale for different sensory attributes (dislike very much, dislike, neither like nor dislike, like, like very much). The 5-point scale is much easier to use by enumerators interviewing consumers with limited or no education than the standard 9-point scale, which is typically used by consumers filling in the response sheets themselves, and has been used in several recent consumer studies in Africa [13, 25]. The sensory traits used were appearance, aroma, texture in hand, flavor, texture in mouth, taste and overall appreciation (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 knew the content of the different products at this stage.

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 with the same five

Product	Labels with symbols only	Labels with symbols and information
A - traditional millet flour, decorticated	●	● Farine de mi 250 g Produit au Sénégal
Binstant 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, labels with symbols, and labels with both symbols and information

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. It was

explained that these were the same products they had just tasted, presented in the

same order and with the same labels as during the affective tests.

The WTP for the products is based on their taste and sensory evaluation but

also on other traits, in particular the ease of cooking (instant versus traditional), the

nutritional content (micronutrient), and the origin of the micronutrients (synthetic or

natural). To distinguish the WTP for the sensory attributes from the WTP for the

improved nutritional quality, the participants were randomly divided into two equal

groups. Participants in 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 attributes. 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).

The text on the labels contained a simple description of the product translated

into French: A) decorticated pearl millet flour; B) instant decorticated pearl millet flour;

C) instant decorticated pearl millet flour - flavored with mango and carrot extract; D)

instant decorticated pearl millet flour, flavored with dried mango and carrot, fortified

with micronutrients; and E) instant decorticated pearl millet flour, flavored with dried

mango and carrot, fortified with micronutrients 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 pearl millet

flours in terms of time and energy saved was explicitly explained, but not the benefits

of the micronutrients. The natural source of the micronutrients, hibiscus, was also

explained.

Experimental auction

During the experimental auction, participants' WTP for the different products

was elicited using the BDM mechanism [27]. This procedure mimics an auction, but

instead of bidding against other participants, the participant bids against a random

price. This random price is drawn randomly from a particular distribution during the

exercise. 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). Using a

random price allows the exercise to be conducted individually, unlike real 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 in this case were coins of 50 FCFA. These numbers were printed on pieces of paper and put in an envelope.

To ensure participants understood the procedure, it was described and then it was emphasized that it was in the participant's best interest to reveal his or her true WTP, using a numerical example. Next, a test round was conducted, as this improves understanding and reduces bias [28]. 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. Then, one product was selected as binding, by asking the participants to draw a number from one to five from an envelope. Next, the participants drew the random price: a number from a uniform random distribution (from 50 FCFA to 600 FCFA, in increments of 50 FCFA, to approximately twice the value of the product, 300 FCFA), from another envelope. If the bid was higher than the random price, the participant purchased the product at the random price. The participants could pay with their show-up fee or (as change was often a problem), with money from their pocket. Although technically allowed, no participants offered zero bids. As the enumerators took care to explain clearly that the bids were binding, illustrated by the test round, and people were provided with

sufficient money, people had no difficulties paying their bids when winning the

auction. A few invitees did decline to participate after they were told the procedure.

Analysis

Affective tests used a five-point hedonic scale, so the resulting variables are

ordinal in nature [29], and an ordinal regression is the preferred method of analysis [30, 31]. This model is also called the 'proportional odds' model by statisticians [30] and the

'ordered logit' model by economists [32, 33]. In its basic form, respondents are asked to

score two products, distinguished by a binary variable x, using a set of ordered

categories. Let $\hat{y}$ be the score and $\pi = \acute{U}\c{C}\acute{A}n\acute{A}\hat{D}\hat{A}$ for the probability that a score $\hat{y}$ falls

at or below a certain level ι. The logarithm of the odds of π, also called the logit, is

then modeled as a linear function of the independent variables, formally:

$$Logit *v_k += Ln\frac{P*y \le k+}{3 - P*y \le k+} = \alpha_k + \beta)x \,. \tag{1}$$

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 $\wedge^{\beta}$ 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 [34].

The model can be expanded to analyze the scores for different products $b\hat{A}$

each with a vector of attribute vector $\pmb{x}_b$ by respondent $a\hat{A}$ The scores of different

products by one respondent could be correlated, so an individual effect $\check{}_a$ needs to

be added [35], and the model becomes:

$$\check{S}[\ *\tilde{a}\acute{C}_{\tilde{a}}D\acute{M}\acute{A}_{\backslash} + \beta\varphi_{j}\acute{E}\acute{A}_{\tilde{a}} \tag{2}$$

If the respondents are randomly selected, the standard procedure assumes that $\check{}_{\tilde{a}}$ is randomly distributed; it is also called the random effects model. Such models have been used to analyze farmer participatory evaluation of new technologies [35] and consumer evaluation of maize products [7].

The effects of consumer characteristics z_i can also be included in the analysis using both direct effects (vector γ) and cross effects (matrix $Œ\!Ð)$[10], resulting in:

$$\check{S}[\ *\tilde{a}\acute{C}_{\tilde{a}}D\acute{M}\acute{A}_{\backslash} + \beta\varphi_{j}\acute{E}\gamma\sigma_{\tilde{a}}\acute{E}\acute{x}_{i\flat}Œ\!\flat_{\tilde{a}}\acute{E}\acute{A}_{\tilde{a}} \tag{3}$$

This model was estimated with the $\phi\sigma[\ *\tilde{a}\acute{}$ 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 $Y\ V\acute{U}_{\tilde{a},}$ or consumer $\tilde{a}$'s willingness to pay for product $\hat{b}\!Ê$ obtained through the economic experiment. It is a money metric in local currency, and therefore a quantitative variable on a ratio scale [29], 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:

$$Y\ V\acute{U}_{\tilde{a}\flat}\acute{M}\acute{A}\ \acute{A}\ \beta\varphi_{j}\acute{E}\acute{A}_{\tilde{a}} + \varsigma_{\tilde{a}} \tag{4}$$

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

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

$$" \qquad Y\ V\acute{U}_{a}\acute{M}\acute{A}\ \acute{A}\ \beta\alpha_{j}\acute{E}\gamma q_{a}\acute{E}\acute{A}x_{b}\varphi Bz_{a}\acute{E}\acute{A} + \varsigma_{a} \qquad (5)$$

The WTP models were estimated with the module $\not{c}d\wedge * \acute{A}$n Stata version 13.1.

RESULTS

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 2). More than half of the participants (54%) were women and the average age was 40.5 years, ranging from 17 to 88 years. Two thirds of participants had not received any formal education and 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 the socio-economic survey results indicated that most were urban. Only a quarter of participants owned farm land; for only 5% of them farming was the main occupation. Only 6% of participants owned cattle, but 35% owned poultry. Almost half (42%) of participants ran their own business. 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.

Table 2. Descriptive statistics of the participants

Group	Variable	Mean	Std. Dev.	N	None (%)[a]	Min.	Max.
Demogra-phics	Female	0.54	0.5	201		0	1
	Age	40.5	14.3	201		17	88
	Education (years)	2.5	4.3	200	66.7	0	16
	Family size	9.9	6.0	195		1	40
Land (ha)	Owned	0.9	3.1	174	75.6	0	25
	Cultivated	0.5	2.1	180	81.1	0	20
	Uncultivated	0.2	0.9	180	81.1	0	8
	Other crops	0.4	1.9	175		0	20
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
	Chicken	10.4	37.2	199	64.7	0	300
Income (FCFA/year)	Livestock sales	193,920	2,274,698	174	76.6	0	30,000,000
	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

[a] Percentage of respondents whose level of education or ownership of assets was none.

Affective tests

After the socio-economic questionnaire, consumers were asked to taste and

evaluate the five products under study using affective tests. The products were

presented in small cups (about 100 cl), freshly prepared, in random order and

double-blinded. Participants were asked to score them, on a five-point scale, for five

attributes and overall appreciation (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 for this product was hibiscus, which added a distinct red color and

specific flavor.

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Because the scores were 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 3). As a result, the effect of demographic and socio-economic characteristics

(Equation 3) was not further analyzed.

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
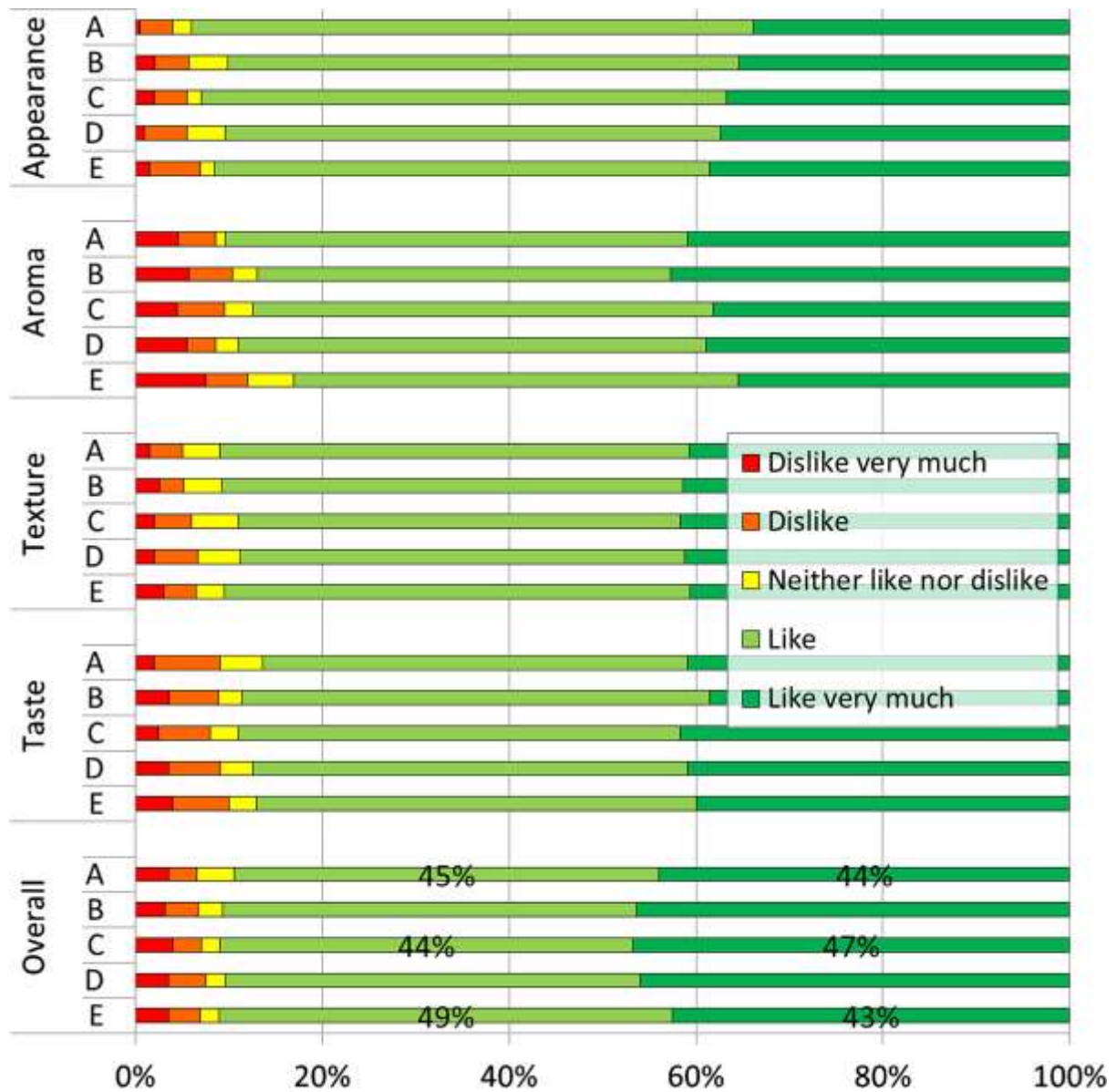
Figure 4. Results of the consumer affective tests, on a five-point hedonic scale, for attributes appearance, aroma, texture and taste, and overall appreciation (numbers are percentage of respondents who scored the specifi product at that level for that attribute)

Table 3. Analysis of consumers' scores for different attributes and overall appreciation, using ordinal regression with random effects (base category is product A, traditional porridge)

Group	Variable	Appearance			Aroma			Texture			Taste			Overall appreciation		
		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	/cut 1	-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
	/cut 2	-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
	/cut 3	-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
	/cut 4	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		

Note: The coefficients are …., they represent a comparison of the four improved products with the base, product A, traditional porridge

"

" 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). 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 (Figure 5), show only small changes in WTP for

" products A to C after the participants were given the information, but they do show a

" substantial premium for the products with added micronutrients (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. 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 (Figure 5). 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
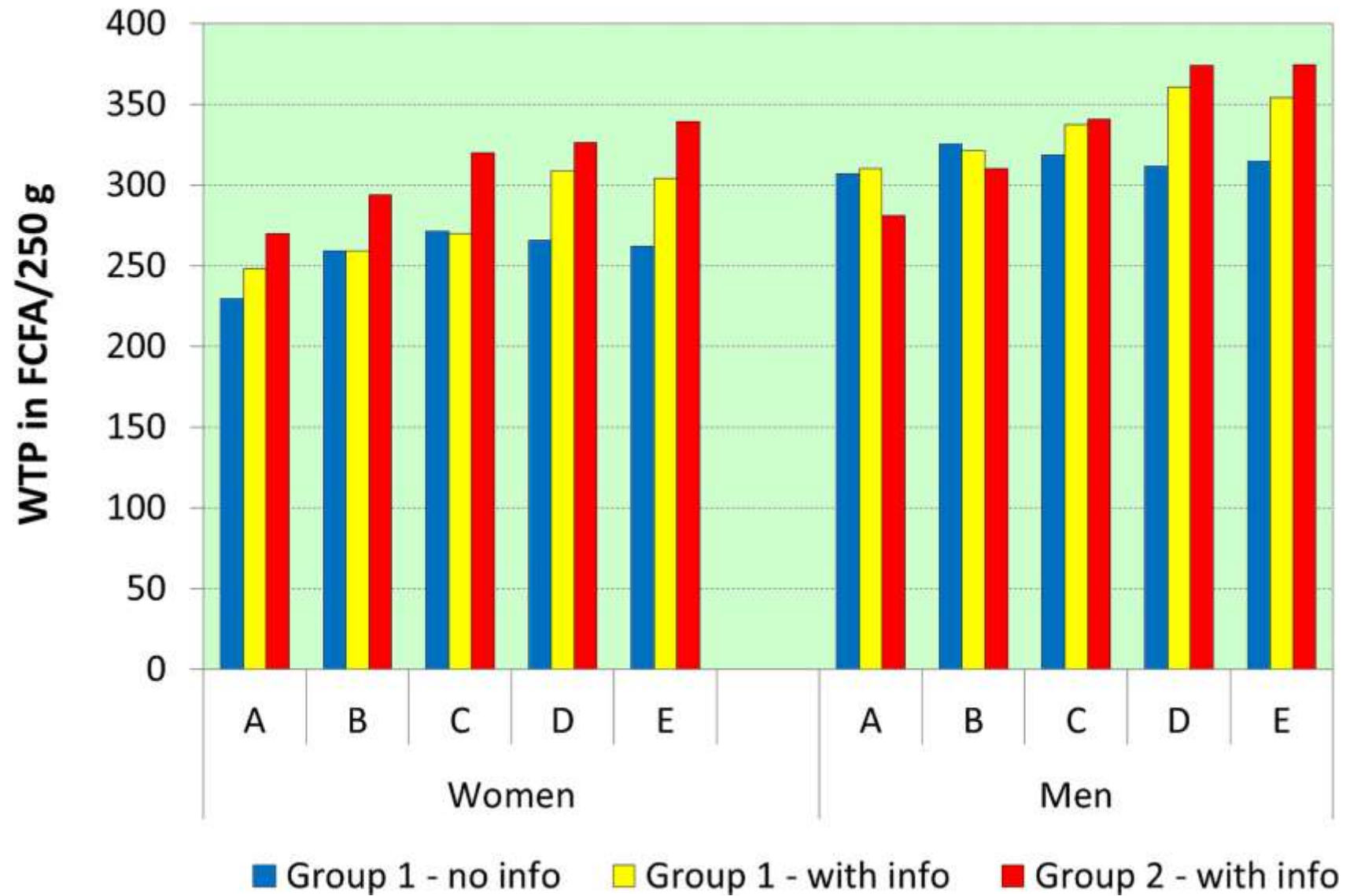
"

Figure 5. WTP for different pearl millet flour products (values in FCFA/250 g) (product codes as described in Figure 2)

" men.

"

" **Willingness to pay – statistical analysis with a pair-wise t-test**

" To check if consumers were willing to pay a premium for the traits of the new

" products, their mean WTP of the different products was calculated and compared to

" that of the control (Table 4), Participants of the group without information, for

" example, were willing to pay 261 FCFA for 250g of product A, the base product

" (traditional, decorticated millet flour), 270 FCFA for product B (the instant version of

" that product), an increase of 9 FCFA or a premium of 9% for the trait "instant".

" Consumers in this group were willing to pay 275 FCFA for product C (the instant

" product with added mango and carrot powder), and so forth.

" To test if the differences between products are significant, we do not compare the

" means directly, but use pair-wise t-tests. This test was used systematically to

" compare the improved products (from B to E) to the basic product (A), for the three

" sets of bids (Group 1 with and without information, and Group 2 with information)

" (Table 4). 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 systematic increases in WTP for the improved

" products. This was to be expected, since their WTP was only based on the affective

" tests, in which no differences were observed. All premiums in this group were small

"

Table 4. Mean Willingness-to-Pay (WTP) for improved pearl millet flours (250 g) and premiums as compared to WTP for traditional millet flour (results of pair-wise t-tests)

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" and not significant, except for product C (instant MF with mango and carrot powder),

" 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 with the information on the products and offered a second chance to make

" bids. In this second round, they 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 came 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 slightly smaller

" (68%). However, the premiums for the last two products, D and E, were not

" statistically different from each other, indicating consumers are not willing to pay a

" premium for micronutrients from natural sources compared to micronutrients from

" other sources. There was no statistical difference between the average WTP for the

"

"

"   different products between Group 1 after information and Group 2.

"

"   **Willingness to pay – regression analysis**

"   For a statistical analysis of the WTP for the different traits, a random effects

"   model was estimated with the four different traits as binary variables (Equation 4):

"   examined 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)

"   (Figure 2). The constant therefore represents the mean of the omitted category,

"   product A (traditional millet porridge), and the coefficients represent the premium

"   consumers are willing to pay to the different traits, compared to product A. They

"   represent the monetary value the trait has to the consumers, in particular after they

"   have received the information on those traits.

"   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 5, 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. Furthermore, the coefficient for natural sources was not significant.

"

"

Table 5. Analysis of consumers' willingness to pay (WTP) for improved pearl millet flours (in FCFA/250 g), using the short regression model (Equation 4)

Group	Variable	Group 1, without information			Group 1, with information			Group 2, with information		
		Coef.	Std. Err.	P>|z|	Coef.	Std. Err.	P>|z|	Coef.	Std. Err.	P>|z|
Traits	Instant	11.8	9.5	0.216	11.3	9.3	0.222	26.5	11.9	0.026
	Flavor	4.4	8.8	0.619	20.5	9.2	0.026	27.7	11.9	0.020
	Micronutrient (MN)	-10.9	8.9	0.220	24.7	9.3	0.008	20.8	11.9	0.082
	MN from natural sources	0.5	8.9	0.956	-7.4	9.3	0.428	-4.0	13.2	0.760
	Constant	273.9	18.5	0.000	270.0	18.2	0.000	275.5	21.8	0.000
Model	σ_u	170.5			169.4			199		
	σ_e	61.8			64.9			83.3		
	ρ	0.9			0.9			0.85		
	Number of observations	470			494			462		
	Number of groups	100			101			98		
	R^2: within	0.01			0.12			0.13		
	R^2 between	0.01			0			0.01		
	R^2 overall	0			0.01			0.02		

"

The bids of Group 2, who went straight to the auction with information, were

" 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

" compared to the non-significant coefficient of Group 1 without information). The

" premium for flavored with mango and carrots was also high and significant (28 FCFA,

" compared to 20 FCFA for Group 1 with information). The premium for micronutrients

" was not as high (21 FCFA, and only marginally significant) but now lower than the

" premium in Group 1 with information (25 FCFA).

"

" **WTP – regression, long model**

" To analyze the effect of demographic and socio-economic characteristics of

" the participants on their WTP for the new products, these factors were included in the

" long model of Equation 4 (Table 6). 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 in the previous model, the WTP analysis

" shows large and significant premiums for flavor and micronutrients, but not for natural

" sources 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.

"

" Few of the socio-economic variables were significant, however. In Group 1,

" without information, the effect of gender was large, but only marginally significant

" (p=0.09) (Table 6, first model). Otherwise, the effects of the consumers' socio-

"

Table 6. Analysis of consumers' willingness to pay (WTP) for improved pearl millet

flours (in FCFA/250 g), using the long regression model (Equation 5)

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
Øæ&q̇ ¦•Á									
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
T[å^¦Á									
Number of obs	360			376			367		
Number of groups	77			77			78		
R^2 within	0.0087			1			0.171		
R^2 between	0.0584			4.9			0.1341		
R^2 overall	0.0618			5			0.1397		
σ_u	181.83			169.88			204.00		
σ_e	59.58			65.84			83.80		
ρ	0.90			0.87			0.86		
Wald χ^2 i(8)	7.01			52.16			70		
Prob > χ^2	0.6361			0			0		

economic 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 6, 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 6.5 FCFA. Including the cross-effect for education in the model, however, reduces the main effect for instant flour to the extent that it becomes insignificant. This might indicate that only people with education value instant flour.

DISCUSSION

The affective tests indicate that consumers did not differentiate between the different products in scoring for their sensory characteristics. As a result, participants who did not receive information on the products' content did not offer to pay premiums for 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 of this particular city resulted in a

"

" large proportion of poor and uneducated participants. As the results indicated that

" WTP increases with income and WTP for instant flour increases with education,

" future studies concerning this type of cereal product in developing regions 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 develop sustainable businesses (based on customers who can afford the

" products) and improving the nutrition of low-income groups can be in conflict.

" Alternatively, future research could focus on informing consumers who are less likely

" to buy the new products about their nutritional benefits, making the production and

" processing of these products more efficient and cost-effective to make them more

" affordable for the poor.

" Second, the results from the participants of Group 1 (who were asked to bid

" twice, the first time without information and the second time with information) after

" they were given information, were not as clear cut 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 could play 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 probably demanding too

" much concentration and effort.

" Third, another problem with the participants with little or no formal education

" was that many had difficulties reading or comprehending the information provided on

"

"

"   the label. The information had to be translated and explained in the local language

"   (Wolof). The enumerators were not initially prepared for this and some ad hoc

"   training had to be organized. In the future, this information needs to be

"   unambiguously written, translated and practiced, so all participants receive exactly

"   the same information.

"   Fourth, comparing the experience of this study with previous studies indicates

"   that the BDM mechanism, an individual procedure, is also convenient to estimate

"   WTP in central location settings in urban areas. The 5-point hedonic scale, in

"   contrast to the 9-point scale, was easy to use with consumers with little or no

"   education as its five classes are easily expressed in local languages.

"   Unlike previous studies, the WTP for the new products was decomposed into

"   premiums for the different traits, such as instant and fortified with different

"   ingredients. These premiums can now be compared to the cost of adding those traits

"   to cereals in the production process to assess its economic efficiency. Since the

"   results show that consumers in a low-income developing country 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 micronutrients, 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 such products needs to be established among consumers, with

"   higher income and education, either through a repetition of this experiment in more

"   upscale markets, or a pilot marketing project.

"

"

"   Finally, this work highlights the difficulty inherent in many development-type

"   projects trying to help create sustainable businesses while at the same time reaching

"   the very poor with improved nutrition. As sustainability is essential, this goal needs to

"   be pursued first, and profitable markets need to be identified, likely first among

"   consumers with higher incomes and education levels. Once these markets have

"   been explored and businesses are established, appropriate affordable products for

"   the poor can be developed.

"

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References

30' Vc{nqt'LTP.'Dcttkqp'UE'cpf 'Tqqpg{'NY.'Rgctn'o kngv/pgy 'f gxgnqr o gpvu'kp'cpekgpv'hqqf i tckp0'*Cereal Foods World* **55**‹38/3; '*4232+0'

40' Ukpi j 'U.'I co pcvj 'U'cpf 'Y cnglkpi 'N.'Pwtkvkqpcn'cur gevu'qh'hqqf 'gzvtwukqp‹'c'tgxkgy 0'*International Journal of Food Science & Technology* **42**‹38/;4; '*4229+0'

50' [gw'M.'Ngg'['cpf 'Ngg'U[.'Eqpuwo gt'Ceegr vcpeg'qh'cp'Gzvtwf gf 'Uq{/Dcugf 'J ki j /Rtqvgkp'Dtgcmhcuv'Egtgcn0'*Journal of Food Science* **73**‹U42/U47'*422: +0'

60' HCQUVCV.'*FAOSTAT Production Data Base. URL: http://faostat.fao.org/site/339/default.aspx, accessed on December 1, 2016.*

70' F g'I tqqvg'J 'cpf 'Mko gplw'UE.'Eqpuwo gt'r tghgtgpegu'hqt'o ckg'r tqf wevu'kp'wtdcp'Mgp{c0'*Food and Nutrition Bulletin* **33**‹; ; /332'*4234+0'

80' Vqo nkpu'M.'Pf wi wtw'I .'Uco dw'M.'Lqujwc'P.'Pi gpf gmq'V.'Ty k| c'G.'Cm qwt'T.'Tco cf j cp'D.'Mcr cpf g'C'cpf 'Y uvdt{'C.'Ugpuqt{'gxcnwcvkqp'cpf 'eqpuwo gt'ceegr vcdknkv{'qh'r cng/hnguj gf 'cpf 'qtcpi g/hnguj gf 'uy ggv'qcvq'd{ 'uej qqn'ej knf tgp'cpf 'o qvj gtu'y kj 'r tguej qqn'ej knf tgp0'*Journal of the Science of Food and Agriculture* **87**‹4658/4668'*4229+0'

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: 0' O ggpcmuj k'LX.'Dcpgtlk'C.'O cp{qpi 'X.'Vqo nkpu'M.'M kwcn'P 'cpf 'J co wny cnc'R 'Wukpi 'c'f kuetgvg'ej qkeg'gzr gtko gpv'vq'gnkekv'y j f go cpf 'hqt'c'pwtkvkqwu'hqqf ‹Y knnkpi pguu/vq/r c{ 'hqt'qtcpi g'o ck| g'kp'twtcn'\ co dkc0'*Journal of Health Economics* **31**‹84/93'*4234+0'

; 0'   Ej qy f j wt{'U.'O ggpcmij k'LX.'Vqo rkpu'M'cpf 'Qy qtk'.E.'Ctg'eqpuwo gtu'y kmkpi "vq'r c{'o qtg'hqt" dkqhqtvkhkgf "hqqf uÄ'Gxkf gpeg'htqo "c'hkgrf "gzr gtko gpv'kp'Wi cpf cÖ*American Journal of Agricultural Economics* 93< 5/; 9'*4233+0'

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330'   F g'I tqqvg'J .'Vqo rkpu'M.'J cnggi qcj 'L.'Cy qqrÖ'O cpf 'Hko r qpi 'DP.'*Assessing rural consumers' WTP for orange, biofortified maize in Ghana with experimental auctions and a simulated radio message. Paper presented at the Conference of the African Agricultural Economics Association., Cape Town, 19th - 23rd Sept. 2010.''*4232+0'

340'   Dcpgtik'C.'Ej qy f j wt{'U.'F g'I tqqvg'J .'O ggpcmij k'LX.'J cnggi qcj 'L'cpf 'Gy qqrÖ'O .'Wukpi " Grkekcvkqp'O ech cpko u'vq'Guvko cvg'vj g'F go cpf 'hqt'P wtkkqwu'O ck{ g<'Gxkf gpeg'htqo "Gzr gtko gpvu'kp" Twtcn'I j cpcÖ*Canadian Journal of Agricultural Economics* '*Hqtvj eqo kpi +0'

350'   I wpcrcvcpc'P U.'Dquj c'V.'Dgmc{pgj 'F .'Hgmcf wV'cpf 'F g'I tqqvg'J .'Y qo gpÖu'cpf 'ej krftgpÖu" ceegr vcpeg'qh'dkqhqtvkhkgf "s wcrkv{'r tqvgkp'o ck{ g'hqt"eqo rrgo gpvct{ "hegf kpi "kp'rwtcn'Gyj kqrkc0*Journal of the Science of Food and Agriculture* 96<565; /5667'*4238+0'

360'   O gkti cctf 'O .'Ekxkrg'I X'cpf 'Ectt'DV.'*Sensory Evaluation Techniques 4th Edition*0'ETE 'Rtguu." Hqtkdfc.'WUC'*4229+0'

370'   Equvcpki tq'O .'Mtqm'U.'Vj kmo cp{ 'D 'cpf 'Dwppkpi 'O .'Kÿkv'nqxg'hqt 'nqecnÖqri cpke'qr hj cvg'hqt" eqpxgpvkqpcnÄ'Cu{o o gvtke'ghhgevu'qh'kphqrm cvkqp'cpf 'cvvg'qp'ncbgn'r tghgtgpegu'kp'cp'gzr gtko gpvn' cwevkqp0*Food Quality and Preference* 31<, 6/327'*4236+0'

380'   Uk{ 'DO .'Ecmkpu'ET.'Hgw{ 'F O .'Wo dgti gt'Y L'cpf 'Gumtkf i g'MO .'Eqpuwo gt'ugpuqt{ " ceegr vcpeg'cpf 'xcmwg'qh'f qo guke.'Ecpcf kcp.'cpf 'Cwutcrkcp'i tcuu/hgf 'dggh'uvgcm30*Journal of Animal Science* 83<4: 85/4: 8 '*4227+0'

390'   Wo dgti gt'Y L.'Hgw{ 'F O .'Ecmkpu'ET'cpf 'Mkmki gr/O cpp'M.'WUU'eqpuwo gt'r tghgtgpeg'cpf " y kmkpi pguu/vq/r c{'hqt'f qo guke'eqrn/hgf 'dggh'xgtuwu'kpvgrpcvkqpcn'i tcuu/hgf 'dggh'o cuwtgf 'vj tqwij 'cp" gzr gtko gpvn'cwevkqp0*Agribusiness* 18<6; 3/726'*4224+0'

3: 0'   Uvghcpk'I .'Tqo cpq'F 'cpf 'Ecvkeej k'C.'Eqpuwo gt'gzr ecvkqpu.'rkmkpi 'cpf 'y kmkpi pguu'vq'r c{" hqt'ur gekcn{ 'hqqf u<'F q'ugpuqt{ 'ej ctcevgtkuvku'vgm'yj g'y j qrg'uvqr{A'*Food Quality and Preference* 17<75/84'*4228+0'

3; 0'   Lqpgu'NX.'Rgr {co 'F T 'cpf 'Vj wvuvqpg'NN.'F gxgrqr o gpv'qh'c'Uecrg'hqt'O gcuwtkpi 'Uqrf kgtuÖ' Hqqf 'Rtghgtgpegu0*Journal of Food Science* 20<734/742'*3; 77+0'

420'   Xkemrg{'Y .'Eqpvgtur ecvkqp.'Cwevkqpu.'cpf 'Eqo r gvkvkxg'Ugcrgf 'Vgpf gtu0*The Journal of Finance* 16< /59'*3; 83+0'

430'   Y c{wc'HQ.'Uj kdkc'O I .'O cm q'O U.'Dckrg{ 'F 'cpf 'Eqr r qem'F N.'Y kmkpi pguu'vq'r c{'hqt" ko r rqxgf 'm km/ugpuqt{ 'ej ctcevgrkuvku'cpf 'cuuwtcpegu'kp'pqtyj grp'Mgp{cÄ'wukpi 'gzr gtko gpvcn'cwevkqpu0' *International Food and Agribusiness Management Review* 12<8; /: : '*422; +0'

440'   Dgmgmg'CF .'Dgwvkpi 'L'cpf 'Twdgp'T.'J qy 'f q'j gcmj 'kphqro cvkqp'cpf 'ugpuqt{ 'cwtkdwgu" kphnwgpeg'eqpuwo gt'ej qkeg'hqt'f ckt{ 'r tqf wevuÄ'Gxkf gpeg'htqo "c'hkgrf 'gzr gtko gpv'kp'Gyj kqr kc0' *International Journal of Quality & Reliability Management* 34<889/8: 5'*4239+0'

450'   F go qpv'O .'\ quuqw'Gt.'Twuucgrv'R 'P f qwt'O .'Xcp'O grg'R 'cpf 'Xgtdgrg'Y .'Eqpuwo gr'xcmcvkqp" qh'ko r tqxgf 'rkeg'r ctdqkrkpi 'vgej pqrqi kgu'kp'Dgpkp0*Food Quality and Preference* 23<85/92'*4234+0'

460'   F go qpv'O .'Twuucgrv'R 'P f qwt'O .'Xgtdgrg'Y .'Ugem'RC 'cpf 'Vqmgpu'G.'Gzr gtko gpvn'cwevkqpu." eqpgevkxg'kpf wevkqp'cpf 'ej qkeg'uj khv<'y kmkpi pguu/vq/r c{'hqt'rkeg's wcmkv{ 'kp'Ugpgi cn0*European Review

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