Toward Understanding Household Preference for Millet Varieties in the West African Semi-Arid Tropics

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Abstract

In this study, we evaluate the preference of consumers in Niger for different *tuwo* or *couscous* characteristics using conjoint analysis. Data were collected through a structured survey administered at 4 sites. Preferences are estimated for three products (*couscous*, fermented *tuwo* and nonfermented *tuwo*) made from 5 pearl millet cutivars. We provide relative valuation for different traits by type of product. Results show that product taste, visual characteristics, and textural attributes are important. The different valuation of characteristics across products and ethnic groups, however, suggests that signals regarding preferences may be very noisy. Consequently, it might be difficult to design pearl millet improvement programs, or food processing programs that are broadly acceptable.
Key words: pearl millet genetics, characteristics, conjoint analysis, food processing.

1 Introduction

Pearl millet (*Pennisetum glaucum* L. Br.) is the primary food source for millions of people in the semi-arid tropics of West Africa. In Niger, pearl millet accounted for 77% of per capita consumption on average between 1994 and 1996 [19]. Pearl millet ranks first in terms of total cereal cultivated and production. It represented 72% of total cereal area and 80% of total cereal production in Niger for the period 1995-1997. Pearl millet is a subsistence crop, mainly consumed in the form of thick porridges (e.g., *tuwo*[1]); thin porridges (e.g., *fura, coco, bita*); cakes (e.g., *massa*) or steamed granulated products such as *couscous* [2][11].

Breeders have developed more than 17 improved pearl varieties in Niger[3][5]. But few of these varieties have been adopted by farmers. Poor adoption of improved varieties is partially explained by seed supply and demand constraints of the available varieties. Seed supply constraints in West Africa have been well researched. They include the low supply of breeder seed, poor seed demand estimation, poor distribution systems and low seed quality [18]. In contrast, demand constraints have been under-researched. Demand for varieties are a function of plant, grain and cooking traits preferred by farmers that are embodied in the varieties. The plant and grain traits preferred by farmers have been investigated for pearl millet and groundnut in Niger [14, 15]. While sorghum cooking traits have been well researched [9, 24, 25, 26, 27, 28, 29, 30, 31], knowledge of pearl millet cooking traits preferred by consumers is still limited. Farmers' rejection of varieties may be due their poor cooking traits [1]. Therefore, knowledge of traits preferred by consumers is valuable for crop improvement programs and provides market signals for food processors. The demand for improved pearl millet varieties is likely to increase if, among others, varieties are designed to include producers and consumers' preferred cooking traits. Improving the performance of varieties in terms of cooking quality traits will contribute to the productivity, efficiency and profitability of pearl millet production in Niger.

This study systematically evaluates the preferences that consumers placed on *tuwo* and *couscous* cooking quality characteristics. It uses conjoint analysis to measure

[1] *Tuwo* is a stiff porridge made from sorghum, pearl millet, maize, rice or finger millet flour. It is known in different countries by names such as *tuwo* in Niger, *tô* in Burkina Faso and Mali, *askfor* or *eko tutu* in Nigeria, *ugali* in Kenya, *atab* in Uganda, *aceda* in Sudan, *bogode jiva ting* in Botswana, *tuo jaafi* in Ghana, and *sakanti* in India [9, 12]. *Tuwo* is usually eaten with fingers and is accompanied by some types of sauce or stew made of many ingredients. The ingredients used vary between countries and their uses are dependent upon cost and availability. In Niger, the major ingredients used in the preparation of the sauce include tomato, okra, or baobab leaves, and meat [9].

[2] *Couscous* is a steamed granulated product made from sorghum, pearl millet, maize, fonio or wheat. For immediate use, the product is sprinkled with water and mixed thoroughly after adding baobab (*Adansonia digitata* L.) leaf powder, or okra powder. This flour aggregate mixture is again steamed for about 25 min to give the *couscous* product [12].

[3] A large number of other improved pearl millet varieties are awaiting release in Niger. They are listed as: ICMV89305, ICMV 92222, ICMV 94206, GB 8735, MTDO92, MTTY92, and CTO-V.

the value of *tuwo* and *couscous* cooking quality characteristics. Conjoint analysis is a survey-based valuation technique widely used in marketing research that relies on individuals' background and judgement of products to estimate the marginal contribution of each specific product traits to overall preference ratings. Consumer's relative preferences for attributes are estimated with an ordered probit model.

2 Empirical design and data collection

The development of a survey instrument involved a number of steps. First available literature was reviewed to develop a list of important *tuwo* and *couscous* characteristics for potential inclusion in the questionnaire. Texture, color, taste and keeping quality are often cited as *tuwo* quality characteristics important for sorghum consumers [9, 13, 26, 25, 29, 27, 28, 30, 31]. Few sensory studies have been documented on pearl millet quality. A study undertaken on *couscous* quality characteristics in 3 villages in Niger indicated that color, taste and texture were the most important quality traits [16].These characteristics, likely to be preferred by consumers, were used to conduct a focus group meeting with pearl millet consumers from two villages: Berikoira and Tagabati. The meetings were conducted to evaluate alternative question formats and contents, and to elicit general advice about traits desirable to consumers. The last stage was the development of the survey instrument.

The characteristics included in the survey instrument were those ranked high in the focus group meetings. In general, a *couscous* of light color (white cream or yellow), with a nice aroma and taste, and with a good overall texture is likely to be most preferred. Texture is a composite of cohesiveness, stickiness, and chewiness. A *couscous* that does not feel hard to the touch, is not sticky, and is not hard to chew would have good texture. A *tuwo* with light color, good taste, good texture, and good overnight keeping quality is likely to be preferred by consumers. Taste has been found to be strongly influenced by color and texture [13]. The desirable textural attributes are hardness, cohesiveness, and adhesiveness. Because *tuwo* is eaten with fingers it should be firm enough to scoop a piece that holds together and does not crumble under finger pressure. Consumers want *tuwo* to not stick to the fingers, teeth, or palate[9]. *Tuwo* left over from a meal is often stored overnight, and consumed the following day. Thus, a good *tuwo* should remain stiff during overnight storage.

The survey included 7 *couscous* characteristics and 11 *tuwo* characteristics. *Couscous* products were evaluated on the basis of: color (disliked, liked); aroma (disliked, liked); cohesiveness (soft, just right, hard); stickiness (not sticky, just right, too sticky); taste (disliked, liked); chewiness (disliked, liked); and texture (disliked, liked). *Tuwo* products were evaluated on the basis of: color (disliked, liked); appearance-interior (disliked, liked); aroma (disliked, liked); cohesiveness (soft, just right, hard); stickiness (not sticky, just right, too sticky); consistency (disliked, liked); taste (disliked, liked); the way the *tuwo* dissolves in the mouth (slow, just right, fast); chewiness (disliked,

liked); texture (disliked, liked); and *tuwo* overnight keeping quality (not consistent, just right, too consistent). Respondents evaluated *couscous* and *tuwo* made from five different varieties, giving the varieties scores on a five-point preference scale (0 being the least preferred and 4 being the most preferred).

Tuwo and *couscous* products were processed from 5 pearl millet varieties: 4 improved varieties, and a local cultivar, included as a check. These cultivars were recommended by pearl millet breeders and food technologists and varied in pericarp color and endosperm texture. The improved cultivars were grown in the Dosso department in Niger during the 1998 crop season. The traditional technology was used to process all products. In each site and for each variety, a local woman was hired to decorticate the grain, mill the decorticated grain into a fine flour and process the flour into *tuwo* or *couscous*. The processing technology, from decortication of grains to milling into flour, was identical with slight variations for fermented *tuwo*. Pearl millet grain (1.5 kg) was placed in the mortar, sprinkled with some water and pounded with pestle until the pericarp was removed. This process took on average 13 minutes. The decorticated grain was then winnowed and washed to remove bran, averaging about 5 minutes. The washed grain was softened by soaking in a small amount of water and pounded in the mortar until a flour was obtained. The flour was sifted through a sieve with 2-mm mesh openings to separate the coarse particle from the fine flour. This process took about 13 minutes.

In order to process nonfermented *tuwo*, about 3.5 liters of water was boiled in a metal pot over the fire. At the same time, the flour was sifted through a sieve with 1-mm mesh openings to separate finer particles from those above 1-mm. A small quantity of flour of larger particles was mixed with cold water in a calabash until homogenous and then added to the boiling water. The boiling gravy was stired until thickened. Then gradually, the finer flour was added followed by whipping. The addition of gravy continued until all the finer flour was used. The process ended when the *tuwo* was homogenous and very thick. Then the *tuwo* was removed from the fire, uncovered, spooned into serving bowls and allowed to cool. *Tuwo* was left for an hour at room temperature before being evaluated by the taste panel. The complete process, including water boiling took an average of 50 minutes. These timings are consistent with research results reported for *tuwo* processing in Niger or Mali [9, 25]. This processing technology is identical to that of fermented *tuwo*, except for the fact that grains have to be decorticated, winnowed, and soaked in water for overnight fermentation. The next day, the grains are washed, dried and milled.

Couscous processing differs from *tuwo* processing after a finer flour (less than 1-mm mesh opening) has been obtained. The flour is then soaked in a calabash with cool water and agglomerated into small particles with fingers. The agglomerated particles are steamed in a perforated and covered pot placed over another pot containing boiling water. The joint between pots is carefully sealed to ensure an efficient steaming process. After a few minutes of steaming, the agglomerated flour particles form a loose chunk,

which is retrieved, broken into pieces, and further steamed. In some cases, this process could be repeated to ensure better disaggregation of particles. Then, the product is removed from the pot and is ready for use. The time span between water boiling and *couscous* took, on average, 44 minutes. This processing technology is consistent with that described by Murty, *et al.* [12]

The panelists used in this experiment were a mixture of literate and illiterate adults, averaging 44 years of age. A total of 114 panelists were selected on the basis of ethnicity, gender and urbanization. About half the consumers were adult female. Two-thirds of panel came from the *zarma* ethnic group and about one-third from the *haoussa* ethnic group. About one third of the panelists were literate. More than 80% and 50% of the panelists ate *tuwo* or *couscous* at least once a day respectively. Table 1 presents a summary of the characteristics of the survey sample gender, age, household size, ethnic group, level of education, and daily consumption frequency of *tuwo* or *couscous*.

During the first two days of the survey, enumerators collected information on the respondents socio-economic profile. During the third day, panelists familiarized themselves with the terminology used and the rating scales. Tests were carried out at ambient temperature in three separate rooms with one enumerator and a food technologist per room. Panelists were asked to avoid communication during the test. In each of four successive days, the panel evaluated five nonfermented *tuwo* samples made from the 5 pearl millet varieties. The next day, panelists were asked to evaluate the overnight keeping quality of the *tuwo*. The same day, respondents were also evaluated five *couscous* products made from the same 5 pearl millet varieties. During the last two days, the panelists were asked to evaluate five fermented *tuwo* products and the next day, its keeping quality.

The local check for all products was the pearl millet variety used in the village. In each case, the local cultivar *Hainikire* was used. Each of the panel members evaluated the product using the cards presented in table 12 for *tuwo* and in table 13 for *couscous*. The questionnaire covered all relevant attributes of *tuwo* and *couscous*. Due to time constraints faced by consumers in urban Niamey, the fermented *tuwo* test could not be implemented. Thus, results reported for fermented *tuwo* cover three sites: Berikoira; Karabedji; and Chikal. Contrary to expectations, panelists in urban Niger, the Gaweye site, did not differ significantly from respondents in the rural area. Therefore, no attempt was made to compare valuation of product traits on the basis of rural/urban differences.

3 Theoretical framework

The survey data was analyzed with a behavioral model of consumption that explains variety choice by preferences for product characteristics, as in the Lancasterian theory of consumer choice [7]. This characteristic based choice model was used to evaluate preference for *tuwo* and *couscous* characteristics. In this model, the characteristics of

the goods generate utility for consumers [20]. The specification of intrinsic properties of goods as arguments of the utility function, and the possibility of confining analysis to goods which yield common characteristics is important in empirical demand analysis [32].

Let U represent utility for an individual. Utility is hypothesized to be a function of various factors, including the characteristics of the products, s, the individuals' socio-economic background, Z, and an interaction term between the individuals' background and the products' characteristics, μ. The decisionmaker will choose the product which provides the highest utility [6]. That is the decisionmaker will choose product j over j' if and only if $U_j > U_{j'}$. The utility function can be formally written as:

$$U_j = f\left(S_{1j}, S_{2j}, \ldots, S_{gj}; Z_1, Z_2, \ldots, Z_i; \mu_1, \mu_2, \ldots, \mu_{gji} | \Theta_g\right) + e \tag{1}$$

where $j = 1, 2, \ldots, m$; $g = 1, 2, \ldots, k$; $i = 1, 2, \ldots, n$. j represents the product from a given variety ;g the preference traits for the product, and i each consumer socio-economic characteristics. The variables s and Z are the main effect variables representing the products' attributes and the individuals' profile respectively. The term $\mu_{gji} = S_{gj} \times Z_i$, is the interaction variable between the products' characteristics and individuals' profiles. Since only a portion of the arguments in the above equation are observed, the equation is stochastic and variable e is a spherical disturbance term. The parameter estimates are represented by the vector Θ_g.

Market researchers have used different approaches, compositional and decompositional, to estimate the vector Θ_g. The decompositional approach uses measures of preference (e.g., rating or ranking) for multivariate alternatives or products to estimate the values attached to underlying characteristics. The partial derivative of the j_{th} product (e.g., *tuwo*) with respect to the products'characteristics (e.g., color), gives the value of the partworth that the consumer assigns to the g_{th} characteristic level of the j_{th} product [21]. Since the utility of a product to an individual is a function of both the product's characteristics and the individuals' profile, the partworth is a joint effect of the two variables [22]. For example, the change of utility of a *tuwo* to a consumer is determined by the variation of the *tuwo* characteristics and background of the consumer. More formally,

$$\frac{\partial U(s^*)}{\partial S_g} = \frac{\partial f(\cdot)}{\partial S_g} + \frac{\partial f(\cdot)}{\partial \mu_g} \times \frac{\partial \mu_g}{\partial S_g} \tag{2}$$

where the first side of the equation is the partworth of the g_{th} level of the characteristic of a product to a given individual. It is composed of two parts. The first, the marginal value of the g_{th} attribute level, measures the changes in the utility when only product attributes levels are allowed to vary and will be referred to as V_g. The second part is a product of two partials. The first term measures the variation in the utility associated with the changes of the interaction term. It is also referred as the weight factor (b_g). The second term of the combination, Z_i, represents an individual's socio-economic

background. In general the partworth's of a product's attribute to an individual can be represented easily by:

$$\frac{\partial U(s^*)}{\partial S_g} = V_g + Z_i \times b_g \tag{3}$$

The weight factor, b, is hypothesized to take any value from negative infinity to positive infinity and captures the variability in preferences for a product due to the interaction between a person's background and product attributes. This is a direct measure of segmentability of the market. People with the same b coefficient have similar preferences, and hence can be grouped into one segment. Partially differentiating equation (1) with respect to individuals' profiles, gives variations in the utility which are accounted for by the changes in the individuals' socio-economic variables. In many cases, one is not interested at all in the main effects due to personal attributes, since the main effects may only reflect response biases [3].

The relative importance of products for respondents can be computed using estimates from equation (1) For example, how important is one *tuwo* attribute relative to all other *tuwo* characteristics ? The formula for the relative importance is:

$$\psi_a = \frac{[max(\nu^*_{ga}) - min(\nu^*_{ga})]}{\sum \omega_a} \tag{4}$$

where ν^*_{ga} is the marginal value of the g_{th} level of the a_{th} attribute; ψ_a represents the relative importance for the a_{th} attribute, $\sum \omega_a$ is the sum of all ranges; $\left[max(\nu^*_{ga}) - min(\nu^*_{ga})\right]$, across all attributes. ψ_a for a consumer can be normalized to ascertain its relative importance with regard to the other attributes and across consumers [33]

4 Estimation technique and the econometric model

OLS estimation is frequently employed in conjoint analysis, despite its limitations analyzing data with categorical dependent variables [4][8]. The linear probability model is a procedure for discrete dependent variables, but it has a number of shortcomings. The error term is heteroscedastic, so it produces inefficient estimates ([10],p. 663). Because of these difficulties, an ordered probit model will be specified and estimated. The specified model consists of U as an unobservable dependent variable, R_γ (where $\gamma = 0, 1, 2, 3, \ldots, w$) as the choice alternative or observable dependent variable, ν and μ as the block of independent variables, and γ as the threshold variable. It can be formulated as:

$$U = \alpha + S\nu + \mu b + e \tag{5}$$

where $e \sim N(0,1)$ and
$R=0$ if U $\leq$ 0.

[4]Maddala refers to the preference measured on a scale of 1,2,...,5 with 1 being intensely disliked and with 5 being intensely liked as an ordered categorical variable [2]

R=*1* if U $\leq \gamma_1$
R=*2* if $\gamma_1 \leq U \leq \gamma_2$
$\vdots$ R=w if $\gamma_{w-2} \leq U$

where U is a $j \times 1$ vector of unobservable utility, of, say, a *tuwo* from a pearl millet cultivar, and R_γ is a vector of preference ratings. The γ's are threshold variables or cut-off points which provide the ratings of alternatives, S is a matrix of non stochastic effect-coded variables of N attribute levels for the M products; ν is a matrix of marginal values of the gth characteristic level for the jth product; and μ is another matrix of non stochastic interaction variables of M products and N individuals' characteristics. The interaction terms are effect coded (-1,0,1) ; b is the weight of the interaction term between the gth product's attribute and the ith consumer's characteristics; α is a column vector of constants or the intercept of the equation; and e is the stochastic error term.

The threshold concept is central to economic theory of consumer behavior [8]. The theory asserts that a buyer responds (buys or rates alternatives) when utility exceeds a threshold or critical level of satisfaction. For example, variations in the independent variable would cause a switch into a consumer preference ratings when utility reaches some levels. The cut-off points vary with individuals. Individuals with similar tastes and background have similar cut-off points.

5 Results and discussions

5.1 Rating and attribute levels

The average ratings for the various sensory attributes and overall average rating for nonfermented *tuwo*, fermented *tuwo*, and *couscous* are presented in tables 2, 3 and 4 respectively. The results indicate that the panelists were able to discriminate between two samples of the same product for each of the attributes and their overall acceptability. For nonfermented *tuwo*, there was a large range in liking of color (0.47 to 0.97), aroma (0.54 to 0.92) and overall acceptance of the product (2.36 to 3.78), but smaller differences in stickiness (table 2). Cultivars #1 and #2 had the best overall ratings, while cultivar #3 had the lowest score. Similar patterns were found for for fermented *tuwo* and *couscous* in tables 3 and 4 respectively. Oneway ANOVA was used to measure discrimination between two samples. The F-ratio and Least Significant Difference statistics (LSD) were generated from ANOVA and used to assess differences between two samples. For nonfermented *tuwo*, for example, color, cohesiveness, aroma and appearance had the highest F-ratio indicating that these attributes showed the most discernible. On the other hand, stickiness and taste traits had the lowest F-ratio indicating that either these traits are relatively similar or that panelists had difficulty

in discerning among two *tuwo* samples for those two traits (table 2). These results are consistent with findings on sorghum *tuwo* quality evaluation in Niger from which appearance and color showed the most discrimination [9]. Similar patterns are recorded for other products. However, for fermented *tuwo*, taste was more discernible than cohesiveness (table 3). *Couscous* consumers were able to discriminate well samples on the basis of color, aroma, cohesiveness and chewiness (table 4).

Oneway ANOVA was used to assess differences in traits' ratings based on socio-economic variables such as gender, ethnic group, level of education, age groups, household size, daily consumption frequency of *tuwo* or *couscous*. The results indicated that consumers' ratings of all traits did not differ by gender, level of education, age, household size, daily consumption frequency of *tuwo* or *couscous*. However, consumers' rating of traits (except for color) significantly differed by ethnic group. Therefore further analysis did include ethnic group only as socio-economic variable.

5.2 Ordered probit models results

Separate models were estimated for *couscous*, fermented *tuwo* and nonfermented *tuwo* using ordered probit. All explanatory variables are noncontinuous and entered as effect-coded variables (for example taking the values of (-1,1) rather than a series of 0-1 dummy variables). The use of effect coding instead of dummy leads to marginal effect coefficients equal to partworths [7]. Results of the ordered probit models, major statistical properties and specification test results are reported in table 5. According to Maddala, the threshold coefficients or γ_i's should exhibit the following relationship positive $\gamma_1 \leq \gamma_2 \leq \ldots \leq \gamma_{w-2}$, and must be positive. Failure to exhibit any of these conditions would imply specification error of the model. All threshold coefficients were positive and statistically significant at the 95% confidence interval (table 5) implying that there is no specification error.

A second test was done to look at the overall significance of the independent variables (levels of product attributes and consumer profile) in explaining the variation in the dependent variable ratings. A log-likelihood test using $\chi^2_{551,5\%}$ with a critical value of 10.12 indicated rejection of the null hypothesis of the test, $\nu = b = 0$ at the 95% confidence level for nonfermented *tuwo* for example. Similar results are recorded for fermented *tuwo* and *couscous* (table 5). This means that the product attributes and consumer profile variables are relevant in explaining variation in consumer preferences. Lastly, estimated coefficients listed in table 5 were tested using a t-test. The critical value of the two-tailed t-test, $t_{551,0.975}$; was 1.645. For nonfermented *tuwo*, color, cohesiveness, taste, consistency coefficients were found to be statistically significant at the 90% confidence interval. Stickiness, taste, chewiness, consistency and mouthfeel coefficients were significant at the 90% confidence level for fermented *tuwo*. All *couscous* attributes were significant at least at the 10% level except for aroma and stickiness. The nonsignificance of a coefficient does not mean that the attribute or the level of

the attribute is not important to consumers. Rather, it implies that consumers are indifferent to the proposed range of variation in the level of attributes.

5.3 Partworth estimates

The strength of conjoint analysis technique is to decompose the revealed preference, i.e. ratings, of all individuals into marginal values or partworth estimates [5]. Table 5 contains the main effect coefficients of product attributes which represent marginal values or partworths that a "typical" consumer, irrespective of background, places on attributes of *couscous*, fermented *tuwo* or nonfermented *tuwo*. To illustrate, the color of a nonfermented *tuwo* product has a marginal value of 0.328 to an average consumer. Similarly, the taste of a fermented *tuwo* has a marginal value of 0.335 to an average consumer. Negative partworths mean that consumers' preference would decrease when attribute levels are increased. For example, for a typical fermented *tuwo* consumer, stickiness has a negative marginal value (-0.283). Since utility or preference in an ordinal measure, the relative importance of those coefficients is more important than absolute magnitude. Table 6 contains the estimated coefficients of interaction terms between ethnic group and product characteristics. They represent the incremental value of preferences for products attributed to ethnic group. For example, a typical *haoussa* would value more the consistency of fermented *couscous*; the cohesiveness of nonfermented *couscous* and the stickiness of *couscous* compared to the average *zarma* consumer.

5.4 Attribute value and relative importance of product attributes

Partworth values are commonly utilized in conjoint analysis. A large partworth value associated with an attribute level indicates high preferences for that particular level. These results are consistent with prior sorghum sensory studies. The criteria for a good sorghum *tuwo* found in Mali were the taste, color, texture, and keeping quality [25]. In Burkina Faso and Mali, a good *tuwo* is one with a firm paste that holds together and does not crumble under finger pressure. Firmness and nonstickiness must remain constant when *tuwo* is stored overnight before consumption. Yellow or white *tuwo* is preferred but pink, red or gray *tuwo* may be rejected [26]. Similarly, in East and Southern Africa, light colored *ugali* with desirable texture and keeping quality are the most important traits [29]. Light colored, white-cream,or yellowish colored with good keeping quality are preferred by *tuwo* consumers in Nigeria. In Niger, stickiness of the *tuwo* in the mouth and cohesiveness were the most important traits. Taste and aroma

[5]The use of effect coding (-1,1) instead of dummy (0,1) leads to marginal effect coefficients equal to partworths

were also proven to be important. Color, taste and texture were found to be the most important traits preferred by *couscous* consumers in Niger [16].

Findings from this study indicate that taste, chewiness, color, cohesiveness are the most important attributes preferred by couscous consumers. In effect, light, white creamed or yellowish colors were found to be the most preferred color. These colors are similar to *couscous* made of wheat found in the market. Dark colors were found to be the least preferred. For nonfermented *tuwo* consumers, color, cohesiveness, taste and consistency were the most important traits. Finally, stickiness, taste, chewiness, consistency and mouthfeel were found to be the most important fermented *tuwo* traits. Color was not found to be an important trait for fermented *tuwo*. In effect, fermentation may improve *tuwo* color if grains are soaked in an acid environment. The ph level plays an important role in determining color. Acid *tuwo* color is always lighter than alkali *tuwo* color [25]. In this study, fermentation of grains may have improved the color of the *tuwo*. Thus, consumers may have unable to discern the color of the fermented *tuwo*. Keeping quality was found to be an important trait in many studies. However, in this study, significant and positive association were found between the ranking before and after overnight suggesting that for the varieties tested, keeping quality was consistent across varieties. In effect, varieties which were poorly rated the previous day were also poorly rated after overnight. In effect, every time a *tuwo* has poor texture, it also has poor keeping quality. No exception was found to that rule [25].

In order of increasing importance, taste, color, texture and keeping quality were the most important traits [25]. Similarly, stickiness and cohesiness which are textural traits, taste and aroma were also found to be the most important traits by order of importance in Niger [9]. The relative importance of product traits differ in this study. In effect, for nonfermented *tuwo* consumers; taste, color, consistency and cohesiveness are the important traits by order of importance. The discrepancies from prior evaluation studies may be explained by the unaccountability of multiple correlation that exist between traits. Most of these studies used simple correlation or single regression models to derive the relative importance of traits to consumers.

Table 7 shows the relative importance of traits for the three products to consumers. It is computed by taking the difference between the highest and the lowest partworth value of an attribute over the sum of the ranges for all attributes. Relative importance allows an attribute-to-attribute comparison. It indicates which attributes producers value more. For *couscous*, the taste and chewiness are the most important attributes followed by color and cohesiveness. For nonfermented *tuwo*, taste, color, consistency and cohesiveness are decreasing important. Finally, for fermented *tuwo*; taste, chewiness, stickiness and mouthfeel are decreasingly important (table 7).

6 Summary and conclusion

In order to develop varieties that are acceptable to producers and food processors, breeders must select for desirable traits and food processors should match products to consumer needs. The primary objective of this study was to evaluate c0onsumer preference for *tuwo* and *couscous* traits that are highly valued by consumers using 5 pearl millet varieties. Ultimately it might have been interesting to trace the system by looking at the whole range of plant, grain and cooking traits of different cultivars.

Conjoint analysis was utilized to estimate the value of product attributes. Two types of coefficients were estimated from the probit routine. The first type of coefficients which was obtained by deriving the consumer ratings with respect to product attributes; was referred to as average partworth value of attribute level. It represented average preferences of a typical consumer surveyed for the product attributes. The second type of coefficient derived from consumer ratings with respect to the interaction variables (a combination of level of attributes and consumer profiles) represented incremental partworths associated with consumer profile.

All direct effects had plausible signs and significance tests agreed with prior expectations. In case where attributes were the same, consumers rated their importance substantially differently for fermented *tuwo*, nonfermented *tuwo* and *couscous*. In general, attributes affecting the utility of the three products to consumers differed implying that signals regarding preferences between different products may be noisy. This would seem to lend support for contract breeding for specific purposes and contract farming for specific varieties used by food processors.

Commercialization of *couscous* made from pearl millet varieties would require food processors to place high values on taste, chewiness, color and softeness at touch. Failure to include those traits in a *couscous* product will constrain the demand for *couscous* products. Similarly the demand for cultivars for making fermented *tuwo* or nonfermeted *tuwo* is likely to increase if cultivars are suitable for making *tuwo* that is tasty, light colored, consistent, with some some amount of cohesiveness and good keeping quality.

Relationship between consumer ratings and laboratory measurement of pearl millet quality parameters should be emphasized. Physico-chemical characterization and their relationship with consumer ratings of traits have been undertaken for sorghum [9, 13]. In contrast, very little research has been done on pearl millet. These linkages are essential to build a bridge between pearl millet breeders and consumers via food scientists.

Finally, this study has been limited only to preference for two products (*tuwo* and *couscous*) that are widely consumed in Niger. This kind of analysis provides signals to breeders and food processors via food scientists as to what characteristics to look for when breeding for specific purposes or for processing commercializable products.

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Table 1. Characteristics of consumers surveyed in Niger

	Survey site				
	Berikoira	Karabedji	Gaweye	Chikal	Total
Sample size	30	30	25	29	114
1. *Distribution of respondents by gender*					
Men	15	15	13	15	58
Women	15	15	12	14	56
2. *Age distribution in years*					
Average (years)	45	41	45	46	44
$\leq$ 30 years	3	4	2	3	12
$>$ 30 years	27	26	23	26	102
3. *Average household size*	13	9	6	11	10
Less than 4 members per household	0	1	6	1	8
Between 4 and 8 members	8	15	16	12	51
More than 8 members	22	14	3	16	55
4. *Ethnic groups*					
Zarma	30	30	18	0	78
Haoussa	0	0	1	29	30
Others (Gourma, Gaboro, Peulh, Dendi)	0	0	6	0	6
5. *Level of education*					
Illetrate	21	25	13	24	83
Literate[1]	9	5	12	5	31
6. *Daily consumption frequency for:*					
Tuwo					
Less than 1 *tuwo* per day	0	0	5	15	20
More than 1 *tuwo* per day	30	30	20	14	94
Couscous					
Less than 1 *couscous* per day	14	12	12	21	59
More than 1 *couscous* per day	16	18	13	8	55

Source: ICRISAT/INTSORMIL survey, 1999.

[1] includes all panelists with koranic, primary or secondary education.

Table 2. Comparison of the means of 5 pearl millet cultivars for nonfermented tuwo sensory attributes rating

Attributes	Cultivar#1	Cultivar#2	Cultivar#3	Cultivar#4	Cultivar#5	Average	F-ratio	$LSD_{0.05}$
Color	0.95	0.90	0.47	0.65	0.56	0.71	28.8	0.11
Appearance(interior)	0.92	0.84	0.60	0.75	0.62	0.75	12.2	0.11
Aroma	0.92	0.81	0.54	0.75	0.69	0.74	13.2	0.11
Cohesiveness	0.90	0.87	1.50	1.27	0.97	1.11	16.8	0.18
Firmness	0.89	0.75	0.64	0.77	0.63	0.74	7.2	0.11
Stickiness	0.94	1.10	1.04	0.89	1.18	1.03	2.54	0.20
Taste	0.85	0.83	0.68	0.81	0.70	0.78	4.0	0.11
Chewiness	0.89	0.84	0.70	0.81	0.70	0.79	5.2	0.10
Mouthfeel	1.07	1.03	0.63	0.89	0.91	0.91	4.8	0.22
Texture	0.90	0.84	0.75	0.82	0.69	0.80	4.8	0.10
Average score	3.78	3.54	2.36	2.95	2.37	3.0	29.3	0.34

Source: ICRISAT-INTSORMIL Survey, 1999.

Color: (0=Dislike,1=Liked)
Appearance (interior): (0=Dislike,1=Liked)
Aroma : (0=Dislike,1=Liked)
Cohesiveness :(0=Soft, 1=Average, 2=Hard)
Firmness: (0=Dislike,1=Liked)
Stickiness: (0=Not sticky, 1=Average, 2=Sticky)
Taste : (0=Dislike,1=Liked)
Chewiness: (0=Dislike,1=Liked)
Mouthfeel : (0=Dislike,1=Liked)
Texture : (0=Dislike,1=Liked)

Cultivar #1: Hainikiré
Cultivar #2: MTDO92
Cultivar #3: ZATIB
Cultivar #4: Souna III
Cultivar #5: CTO-V.

Table 3. Comparison of the means of 5 pearl millet cultivars for fermented tuwo sensory attributes ratings

Attribute	Cultivar#1	Cultivar#2	Cultivar#3	Cultivar#4	Cultivar#5	Average	F-ratio	$LSD_{0.05}$
Color	0.96	0.90	0.33	0.71	0.62	0.70	34.7	0.12
Appearance(interior)	0.99	0.91	0.52	0.45	0.42	0.78	20.4	0.11
Aroma	0.97	0.91	0.47	0.72	0.78	0.78	22.2	0.11
Cohesiveness	1.11	1.19	0.97	1.29	1.21	1.16	2.6	0.21
Firmness	0.97	0.83	0.58	0.70	0.72	0.76	11.2	0.12
Stickiness	0.89	1.09	1.30	0.88	1.04	1.04	4.3	0.23
Taste	0.94	0.90	0.54	0.78	0.78	0.79	14.7	0.12
Chewiness	0.93	0.85	0.53	0.79	0.73	0.79	12.9	0.12
Mouthfeel	0.94	1.00	0.70	0.92	0.88	0.89	1.65	0.25
Texture	0.91	0.90	0.54	0.76	0.74	0.77	12.52	0.12
Average score	4.13	3.94	1.90	2.56	2.52	3.0	69.4	0.33

Source: ICRISAT-INTSORMIL Survey, 1999

Color :(0=Dislike,1=Liked)
Appearance (interior) :(0=Dislike,1=Liked)
Aroma :(0=Dislike,1=Liked)
Cohesiveness :(0=Soft, 1=Average, 2=Hard)
Firmness :(0=Dislike,1=Liked)
Stickiness :(0=Not sticky, 1=Average, 2=Sticky)
Taste :(0=Dislike,1=Liked)
Chewiness : (0=Dislike,1=Liked)
Mouthfeel : (0=Dislike,1=Liked)
Texture : (0=Dislike,1=Liked)

Cultivar #1: Hainikiré
Cultivar #2: MTDO92
Cultivar #3: ZATIB
Cultivar #4: Souna III
Cultivar #5: CTO-V.

Table 4. Comparison of the means of 5 pearl millet cultivars for couscous sensory attributes ratings

Attribute	Cultivar#1	Cultivar#2	Cultivar#3	Cultivar#4	Cultivar#5	Average	F-ratio	$LSD_{0.05}$
Color	0.96	0.97	0.54	0.59	0.81	0.77	32.8	0.10
Aroma	0.89	0.89	0.57	0.63	0.79	0.76	15.2	0.11
Cohesiveness	0.84	0.43	0.98	1.23	1.18	0.94	22.9	0.18
Stickiness	0.53	1.11	0.82	0.79	0.66	0.78	10.4	0.19
Taste	0.89	0.95	0.61	0.66	0.82	0.78	15.8	0.10
Chewiness	0.89	0.96	0.64	0.62	0.79	0.78	16.3	0.10
Texture	0.86	0.92	0.69	0.72	0.77	0.79	6.6	0.10
Average score	3.75	3.75	2.25	2.45	2.79	3.0	36.3	0.33

Source: ICRISAT-INTSORMIL Survey, 1999.

Color: (0=Dislike,1=Liked)
Aroma : (0=Dislike,1=Liked)
Cohesiveness (hard at touch): (0=Soft, 1=Average, 2=Hard)
Stickiness : (0=Not sticky, 1=Average, 2=Sticky)
Taste (0=Dislike,1=Liked)
Chewiness : (0=Dislike,1=Liked)
Texture : (0=Dislike,1=Liked)

Cultivar #1: Hainikiré
Cultivar #2: MTDO92
Cultivar #3: ZATIB
Cultivar #4: Souna III
Cultivar #5: CTO-V.

Table 5: Main effects estimates: effects of product attributes on ratings and major statistical properties of the ordered probit models.

	Product		
Variables	Fermented *Tuwo*	Nonfermented *tuwo*	*Couscous*
Constant	0.250	0.239	0.691
Color	0.053	0.328^{**}	0.259^{***}
Aroma	-0.007	-0.152	0.092
Cohesiveness (hard at touch)	0.109	0.171^{*}	-0.156^{***}
Stickiness	-0.283^{**}	-0.008	-0.090
Taste	0.335^{*}	0.535^{**}	0.311^{***}
Chewiness	0.313^{**}	-0.042	0.310^{***}
Appearance-interior	0.096	0.258	
Consistency	0.275^{*}	0.252^{**}	
Mouthfeel	0.169^{*}	0.119	
Coefficient of the threshold variables			
γ_1	0.754^{***}	0.823^{***}	0.790^{***}
γ_2	1.391^{***}	1.505^{***}	1.432^{***}
γ_3	2.098^{***}	2.213^{***}	2.124^{***}
Log-likelihood	-631.926	-749.380	-760.941
Restricted Log.Likelihood(slopes=0)	-716.200	-869.097	-869.097
Chi-squared(18-18-12)	168.548	239.433	216.311
Significance level	0.000	0.000	0.000
Degree of freedom	426	551	551

Note: * denotes significance at the 10% level, **, at the 5% level, and ***, at the 1% level.

Table 6: Selected interaction effects of ethnic and product attributes on ratings.

Variable	Fermented *tuwo*	Nonfermented *tuwo*	*Couscous*
Color	-0.237	0.128	-0.231
Aroma	-0.137	-0.249	0.048
Cohesiveness (hard at touch)	0.068	0.212*	-0.015
Stickiness	-0.058	0.022	0.331*
Taste	0.018	0.120	-0.242
Chewiness	0.125	-0.166	0.123
Appearance	-0.041	0.05	
Consistency	0.274*	0.155	
Mouthfeel	0.133	0.060	

Note: * denotes significance at the 10% level, **, at the 5% level, and ***, at the 1% level.

Table 7. Relative importance of product attributes (%)

Product attributes	fermented *tuwo*	Nonfermented *tuwo*	*couscous*
Color	0	26	25
Aroma	0	0	0
Cohesiveness (hard at touch)	0	13	15
Stickiness	21	0	0
Taste	24	42	30
Chewiness	23	0	30
Appearance-interior	0	0	
Consistency	20	20	
Mouthfeel	12	0	
Total	100	100	100