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# **Retail market prices of fonio reveal the demand for quality characteristics in Bamako, Mali**

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**Keywords** : fonio, cereal, quality, hedonic prices, PLS method, empirical investigation.

**JEL codes** : D120 - L150 - O330 - Q110 -

### **Abstract**

African consumers' expectations concerning the quality of food products are great. In spite of constrained budgets, we showed that market retail prices revealed quality preferences of the consumers and not just production costs. In very poor countries like Mali, food innovation is limited by the very low purchasing power of the population. However, technological food product or process innovations are possible and sometimes valuable. Demand driven innovation may lead to open new markets, opportunities for small and medium scale enterprises and to improve consumers' welfare. Based on this assumption, technical research was done to provide new food products. In this paper, we used both sensory tests and a hedonic price approach, to estimate the consumers' demand for different characteristics of fonio, a West African cereal, and showed that poor consumers have quality requirements and pay for them. We showed that the shadow price or hedonic price paid for quality characteristics is small but significant. A comparison between sensory tests and a market study showed a convergence between what people say they prefer and what they really pay for. Results were consistent and showed directions for technological improvement of the product and its production process. The partial least square method was used to estimate hedonic prices of the different modalities of fonio quality traits. This method was interesting since it solved the ordinary least square method's colinearity problems

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Mots clés : fonio, céréale, qualité, prix hédoniques, méthode PLS, enquête de terrain.

**Résumé** :

Les attentes des consommateurs africains concernant la qualité de l'alimentation sont importantes malgré des budgets très contraints. Nous montrons ici que les prix de marchés révèlent des préférences qualitatives et non seulement des coûts de production. Dans des pays très pauvres comme le Mali, l'innovation technologique est limitée par le très faible pouvoir d'achat de la population. Cependant les innovations technologiques sont possibles et parfois payantes. L'innovation en réponse à une demande peut permettre d'ouvrir de nouveaux marchés, de donner des opportunités aux petites et moyennes entreprises et d'améliorer le bien-être des consommateurs. Sur la base de cette hypothèse, la recherche technologique s'applique à fournir de nouveaux produits. Dans cet article, en utilisant à la fois des tests de dégustation et une analyse des prix hédoniques, nous estimons la demande des consommateurs pour différentes caractéristiques du fonio, une céréale d'Afrique de l'Ouest. Nous montrons que des consommateurs pauvres ont des exigences de qualité et paient de fait pour les satisfaire. Nous montrons que les prix hédoniques ou shadow prices payés pour les caractéristiques qualitatives sont faibles mais significatifs. La comparaison des tests sensoriels et de l'étude de marché montre une convergence entre ce que les gens disent et ce pour quoi ils paient réellement. Les résultats sont cohérents et montrent des directions pour l'amélioration technologique des produits et des procédés de transformation. La méthode des moindres carrés ordinaires a été utilisée pour l'estimation des prix hédoniques des différentes modalités des attributs de qualité du fonio. Cette méthode est intéressante car elle résout les problèmes de colinéarité.

## **Context and field of the study**

Food postharvest activities have increased tremendously in the last 30 years in sub-Saharan Africa to accompany the demographic transition toward urbanization. It is very difficult to assess the macro-economic impact on income generation since most of these activities are in the “informal” sector and concern many single working women (Broutin and Bricas, 2006). However, these latter authors also showed the enormous ongoing changes in food supply in African cities, the innovativeness of stakeholders, as well as the scattered nature of the evidences and study about these changes. Our study is part of a larger program dealing with the upgrading of food quality and competitiveness of fonio processing it gives an insight into the valuation of quality in both the traditional and new segments of this cereal market.

Postharvest research or development programs led either by public or private operators are based on changes concerning food products. Food innovation is a risky, difficult and long process, especially in very poor countries where the purchasing power is low. One should guess in advance the type of new products that will interest purchasers, processors and eaters<sup>1</sup>. Most eaters express preferences when testing or tasting a new product, and can explain rationally their preference for a product over another. However, it is difficult to predict if and how much they will pay for the new food or new attribute, hence if the proposed innovation will become a commercial success. In Mali, where our study was carried out, researches on infant food characteristics (e.g. Sanogo and Masters, 2002) showed that mothers were ready to pay for quality and quality certification.

Different methods are used in marketing studies or economics, based on consumers’ willingness to pay for new attributes or products. Even if these methods are quite sophisticated (e.g. conjoint

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<sup>1</sup> Consumption was a broad term that included three types of activities: purchasing of good, processing and preparing of meal, and finally eating. Concerning the word “consumer”, we preferred to be more specific, whenever possible, and used instead the terms of purchaser, processor and eater.

analyses or market experiments), they use declarations or an artificial context of purchase. In our work, we designed a protocol that reflected real purchases of various existing products in retail markets. We compared what people said they liked, with the product they actually bought and the price they paid for existing characteristics, using the classical hedonic approach (Rosen, 1972).

The study focused on fonio (*Digitaria exilis*), a cereal grown in West Africa, mainly in Guinea, Mali and Burkina Faso. This cereal is a “minor” product in terms of production (in Mali, for instance, it represents less than 1% of all cereals consumed, and total production in Africa is about 250,000 metric tons), but it is well appreciated by most consumers who know about it, and is consumed occasionally for family or religious events (Konkobo-Yameogo *et al*, 2004). These latter authors also show that its consumption is constrained both by high prices and long and difficult processing.

The fonio tiny grain (less than 1 mm) makes dehusking and milling, traditionally done by women using a pestle and mortar, highly laborious. After threshing, the paddy fonio grain is still surrounded by husks. Like rice, processing paddy fonio into milled fonio requires two steps. Firstly husks are removed (dehusking), from paddy grains to get whole grains. Secondly bran (pericarp and germ) is removed (milling) from whole grains. Dehusking and milling fonio grains require four to five successive poundings alternated with as many winnowings. Productivity is very low: it takes nearly one hour to mill just one or two kilograms of paddy fonio. Moreover, before cooking or precooking milled fonio, all bran, dust and sand must be eliminated by several times washing, which increases processing time and effort. Thus, mechanizing all processing steps seems to be essential both to reduce the laboriousness of women’s work and to improve the quality and availability of marketed fonio products (Cruz, 2004). Several research projects aimed at fostering the revival of the fonio commodity sector by improving processing techniques and developing new equipments to mechanize postharvest main operations. Once the fonio is milled and cleaned, the cooking process

is also a long technical task. It requires three successive steam cooking. Since the mid 1990s, several small scale enterprises have developed a new product: the precooked fonio. After milling and cleaning, they do the first cooking, dry the product, then seal it into plastic bags containing one kilogram. Konkobo-Yameogo *et al.*, (2004) showed the increasing interest of urban consumers for fonio and the rapid emergence of small scale enterprises proposing precooked fonio.

In Bamako, consumers do not buy paddy for food consumption, but they can choose from different traditional products and several brands of precooked new products. Traditional products are commonly divided into three main categories by buyers and sellers:

- ✓ *decorticated* or *premilled*<sup>2</sup> fonio, which is actually a mixture of paddy, dehusked and milled grains in various proportions, more or less mixed with sand, dust and bran. A few stakeholders of the market chain, such as restaurant keepers or traders, are able to subdivide the category into subgroups according to the region or country of origin, or to the milling quality (they give quality grades to different lots). However, traders and final buyers do not always agree on these subdivisions.
- ✓ *milled and not washed*<sup>3</sup>, which contains milled grains with dust, bran, and sand,
- ✓ *milled and washed*<sup>4</sup>, which means milled clean grain.

Traditional and new products differ mainly according to their place in a technological process (from less to more processed), but they are also sold in different places and to different people: traditional products are sold in markets, while precooked products are sold in small supermarkets or in small scale enterprises.

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<sup>2</sup> “*Décortiqué*”

<sup>3</sup> “*Blanchi non lavé*”

<sup>4</sup> “*Blanchi lavé*”

## **Data collection**

The field part of the study was organized into two main activities. Using individual interviews, focus group techniques, and sensory tests, the first one aimed at determining the habits and preferences of several types of consumers and stakeholders at different stages: purchasing, processing including cooking, and eating. The second one aimed at collecting market data on fonio purchases at different places of Bamako, selected for their representativeness of the city selling places. This market survey was implemented during September and October 2006. All 174 purchases of traditional products and 65 purchases of new products were surveyed respectively in markets and supermarkets. The data collected concerned the price actually paid and the characteristics of (i) the supplier (type of market, supermarket), (ii) the product (type, size, colour...) estimated by the buyer, (iii) the buyer (age, education level, sex...), and (iv) the destination of the product (given, eaten at home, processed, prepared in a meal...).

Six focus groups were organized to check the list of quality traits collected through individual interviews and to synthesize general data on local population behaviour. In order to avoid the emergence of leaders during the discussion, each focus group was composed of six persons recruited during individual interviews from a same group of stakeholders. Thus, there was successively a focus group of “big” processors, “small” processors, restaurants (cheap and expensive) cooks, traditional fonio consumers, and precooked fonio consumers. After a general discussion on “what is for you a good fonio when you buy it, when you process it and when you consume it” following a list of questions, the six persons were asked to talk about 10 different types of fonio bought from retailers during individual interviews and to justify their preferences: first-quality fonio from Guinea, second-quality fonio from Guinea, third-quality fonio from Guinea, fonio from Koutiala, Mali, fonio from San, Mali, roasted fonio from Guinea, milled and washed fonio from Mali, milled and washed fonio from Guinea, new (i.e. harvested the year of the survey) fonio from Mali, and old fonio from Mali.



Sensorial tests were conducted in order to have a better perception of the quality and consumer sensory preferences. Rank tests and triangular tests were performed. Rank tests were performed with three groups of 20 persons, 60 persons in total, who were asked to range five types of cooked fonio from the one they preferred to the one they least liked and to explain their choices. Four different fonios (from Guinea, San, Bougouni, Dogon plateau) were first bought at the market, one of them (fonio from Guinea) was also parboiled in IER (soaked, steamed and dried). The five types of fonio were then milled with GMBF<sup>5</sup> fonio dehuller, washed and each one was cooked under optimal conditions (various cooking times and water quantities) before being served in the same plate, in same quantities and at the same time to each person of the group.

Triangular tests were performed with the six persons of five of the six focus groups, 30 persons in total, in order to determine if they could differentiate between two types of cooked fonio that ranked very close in the previous test. Three samples were presented to each person: two came from the same cooked fonio and the third one from the other. The question was: what sample is different from the other two? There were six possibilities with the samples coded as follows: AAB, ABA, BAA, BBA, BAB, ABB. To know if there was a significant difference between the two fonios, the number of correct answers were counted and compared to the value in the table of binomial law for a probability of 1/3.

### **Model and method of analysis**

Based on Rosen (1974) and Lancaster (1966), a product (a good) can be considered as a “*package of characteristics*” or a “*bundle of attributes*”. According to Rosen, in a competitive market, market prices reveal the preferences of the consumers for a specific combination of the characteristics. In addition to the quality characteristics of the product, we supposed that prices also depended on the partners of the transaction, since information might be distributed in a

heterogeneous way. This was the reason why we included characteristics of the seller and the buyer in the hedonic model. The model can be written as follows:

$$p(z) = p(z_1, z_2, \dots, z_n)$$

where  $p$  is the unit price of the good and  $z_i$  is the quantity of characteristics  $i$  incorporated in good  $z$ .

Regressing a quantitative variable over a large number of qualitative variables generates problems of colinearity because qualitative exogenous variables are less discriminant (modalities of each characteristic are in small numbers: for instance there were only four different colours) and the exogenous variables are often closely related (cleanliness with colour for instance). The OLS [Ordinary Least Square] estimate drops the variables which are the most collinear in the dataset. Complete estimation cannot be achieved. The PLS [Partial Least Square] method, due to Wold (1984), allows to exceed the colinearity problem at the time of estimating the coefficients of variables. It combines several techniques:

1. Projection of the variables on an axis (component). This axis is a linear combination of the exogenous variables (principal component analysis principle). One repeats the process on the residuals of the regression.
2. Linear estimate between the first two principal components which are orthogonal.

Because the estimate was realized between orthogonal components, we could not obtain the  $t$ -Student coefficient to control then level of significance of the variables: we used the Jackknife criteria and the VIP [Variable Importance in the Projection] table (Tenenhaus, 1998).

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5 GMBF = "Guinée Mali Burkina France"

## **Results of interviews: declared preferences by consumers when buying, processing or eating**

### **fonio**

When all the eaters (including all different stakeholders of the fonio market chain) were asked “*what’s for you a good fonio when eating it*”, gustative but also visual and olfactive criteria stood out, with a particular emphasis on gustative criteria. The question concerned the most common recipe (foyo), whereby fonio is steamed. Interviewed persons preferred fonio when it was well cooked, with a soft consistency (30 people out of 30), swollen, not sticky and with no sand (30/30); grains must be individual (27/30), smooth (28/30), not rough (25/30); colour must be light (20/30), with a minimum of paddy, herbs and other impurities (26/30). A sugary (23/30) and wild (10/30) smell were well appreciated, while dusty and old smell must be avoid (9/30).

The unanimously quoted quality attributes for home processing were the levels of milling and of cleanliness. These attributes were determined by the duration of the processing, and were quoted both by professionals (street restaurant keepers, processors) and ordinary consumers. Professionals were able to talk longer about the characteristics of the grain itself: they said that some grains were breakable while others did not break when milled. When soaked in water for cleaning, some grains became smooth and lost starch, while others remained whole. They said the good grains were mature, which was an image since all grains were mature when harvested. However, it reflected a real difference in the grain technological properties.

When buying fonio, all buyers said they preferred white, well decorticated and clean fonio. They usually thought that fonio imported from Guinea was cleaner, better decorticated, whiter, and more mature than fonio coming from Mali (its dryer regions especially).

## **Results of the sensory tests**

Among the 60 persons who participated in the rank test, two were set aside because of their incoherent answers. Considering the 58 persons left, cooked fonios were ranked in a decreasing order of preference as follows: Bougouni, Guinea, Dogon, San and in the last position fonio from Guinea parboiled in IER. According to Friedman test and using a rank sum analysis, we found that the panel appreciated differently the five samples and there was no significant difference of preference between fonio from Bougouni and from Guinea. These two fonios appeared very close in ranking. The percentage table showed that when fonio from Bougouni came first, fonio from Guinea came second at 79.3% and, conversely, when fonio from Guinea came first, fonio from Bougouni came second at 71.4%.

At the question “*For what reasons do you prefer this fonio*”, the most frequently named criteria were first colour (50%), then taste (25.9%), consistency (15.5%); grain size, smell and cleanness ranked far behind.

**Table 1: Sensory test: number of citations per criterium and as first criteria**

| Criteria    | Number of criteria citations | 1 <sup>st</sup> criteria |      |
|-------------|------------------------------|--------------------------|------|
|             |                              | Frequency                | %    |
| Colour      | 52                           | 29                       | 50.0 |
| Taste       | 52                           | 15                       | 25.9 |
| Consistency | 43                           | 9                        | 15.5 |
| Size        | 15                           | 3                        | 5.2  |
| Smell       | 25                           | 1                        | 1.7  |
| Cleanliness | 8                            | 1                        | 1.7  |

All samples were clean, well milled and well steamed.

## **Discussion**

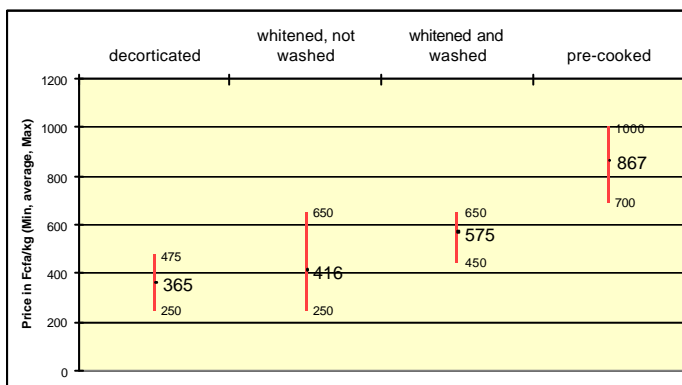
For everybody and at each stage (purchasing, processing, eating), cleanliness and milling degree were essential quality requirements. A light colour was also quoted by everybody. These were vertical quality attributes and differences in prices ought to have been found for the different levels of these attributes. On the opposite, results were not clear for the other attributes. Texture of the grain (called *maturity*) was mainly quoted by professionals. Regarding the size, big grains were considered by some as a sign of good quality while others preferred small grains and others yet

were indifferent to it. The origin was an indicator of cleanliness and good milling, but was not always associated with good taste. We did not have any quantitative data on another common recipe in Bamako, *djouka*, a brown-coloured salted meal, based on fonio and roasted groundnut. It was very often said by interviewees that brownish or immature grains were used to make *djouka*.

### **Results of the retail price analysis**

The market prices were essentially determined by the technical status of the products. The average price of the 239 purchased fonios reached 538 CFAF/kg<sup>6</sup>; 85% of the variations in retail prices were explained by the type of fonio. An analysis of variance (ANOVA) showed that the average price of each of the four main types of fonio significantly differed from each other (level of significance 1%).

**Figure 1: Retail prices of several types of fonio products in Bamako- Mali, October 2006**



From the least to the most processed fonio, the price was multiplied by a factor of two to four (from 250 to 1000 CFAF/kg). The difference between average prices gave the average market value of milling (50

CFAF/kg), washing (160 CFAF/kg), and precooking plus packaging (290 CFAF/kg). At this stage, it was not possible to determine the part involved by processing costs, market segmentation or monopole, and consumers' preferences in price differences. For various reasons, one could suppose that traditional products were in competition (everyone knew the product, each seller had at least two or three different types of fonio), while very few suppliers had the precooked product, which was mostly sold in supermarkets, where no traditional products could be found. Thus, in the case of traditional fonios, we could suppose that prices really reflected both supply and demand, and therefore consumers' preferences, and willingness to pay for the different attributes. This was not as

clear for the precooked product. When we analyzed each type separately, we showed what really counted apart from the level of processing. Descriptive statistics of average and standard deviation of price per different modality of each characteristic were presented in Table 3 (*decorticated*), 4 (*milled*) and 5 (*precooked*).

**Prices of *decorticated* fonio depended mainly on recipe, grain origin, milling degree, and grain colour.**

During the period of the survey, the prices of decorticated fonio ranged from 250 to 475 CFAF/kg. We supposed that variations in prices were linked to (i) the different characteristics of the products themselves (in the so-called *decorticated* group) including the purchase location, and (ii) the consumers' expertise or ability to recognize the different characteristics. The R<sup>2</sup> of the PLS regression was 0.4, which was good for such a regression and indicated a relatively good fit of the model. The model parameters are presented in Table 2. When the VIP value is above 0.8, the parameter of the variable is considered as being statistically different from zero. The result of the regression can be written as follows:

$$\begin{aligned}
 P_{\text{fonio}} = & 360,696 \\
 & + 2,463(\text{Medina market}) - 2,059(\text{Lafiabougou market}) - 1,572(\text{Magnambougou market}) \quad \text{place of purchase} \\
 & - 5,021(\text{badly milled}) + 5,021(\text{well or very well milled}) \quad \text{milled degree} \\
 & - 0,285(\text{very dirty}) - 0,736(\text{dirty}) + 0,898(\text{clean}) \quad \text{cleanliness} \\
 & + 4,505(\text{white}) + 12,462(\text{cream white}) - 1,157(\text{grey}) - 4,812(\text{red, brown, not white}) \quad \text{colour} \\
 & + 1,679(\text{big}) + 1,002(\text{small}) - 5,077(\text{do not know}) \quad \text{grain size} \\
 & + 4,572(\text{Guinea}) - 5,685(\text{Mali}) + 0,996(\text{do not know}) \quad \text{origin} \\
 & - 5,858(\text{Djouka}) + 4,889(\text{other salted meal}) + 7,262(\text{do not know}) \quad \text{recipe} \\
 & - 2,691(\text{for sale or gift}) - 0,558(\text{week-end meal}) + 3,038(\text{special event meal}) \\
 & + 0,996(\text{regular meal}) + 7,135(\text{illness}) \quad \text{occasion} \\
 & + 0,102(\text{household consumption}) - 2,576(\text{processing for sale in a small restaurant}) \\
 & + 4,377(\text{processing for a gift}) - 0,183(\text{gift: no home process}) \\
 & + 7,135(\text{processing for sale in a precooked type}) \quad \text{destination} \\
 & + 2,675(\text{mother or other woman in the family}) - 3,254(\text{employee}) \\
 & + 2,1(\text{father or other man in the family}) - 2,732(\text{child, young of the family}) \quad \text{status of the buyer} \\
 & - 3,054(\text{under 20 years old}) + 3,751(\text{between 21 and 35}) - 3,316(\text{between 36 and 50}) \quad \text{age of the buyer} \\
 & - 0,183(\text{man}) + 0,945(\text{woman}) \quad \text{sex of the buyer} \\
 & + 0,928(\text{employee}) - 2,391(\text{independent worker}) - 2,446(\text{others}) + 4,71(\text{housewife}) \quad \text{activity of the buyer} \\
 & + 0,866(\text{region of production of fonio}) - 1,146(\text{region with no production of fonio}) \quad \text{region of origin of the buyer} \\
 & - 1,042(\text{primary school}) - 1,513(\text{secondary school}) + 2,264(\text{highschool and beyond}) \\
 & + 0,872(\text{other}) \quad \text{education level of the buyer}
 \end{aligned}$$

Note that each exogenous variable is binary, and takes the value 0 or 1.

$P_{\text{fonio}}$ , the endogenous variable is quantitative; it is the unit price of fonio in CFAF/kg.

<sup>6</sup> 656 CFAF = 1 Euro

The most significant (first rank of VIP) characteristic of the model was the fonio recipe; all modalities were different from zero and the parameters took the expected sign: to make *djouka* consumers bought cheaper fonio than they would for *foyo*. Grain origin, grain colour and milling degree were also very significant with the following expected parameters: positive for Guinea and negative for Mali, positive for white colour and negative for brown colour, and positive for well milled and negative for poorly milled. A comparison of means, with ANOVA using the Fisher test for each characteristic, confirmed these results. The four characteristics that had a significant effect on the average price were the recipe, grain origin, colour and milling degree.

Other significant modalities were more difficult to analyze. Destination such as “processing for sale in a small restaurant” was significant and negative while “processing for a gift” was positive. These results could be explained by the fact that women who cooked for street restaurants were used to buy fonio in large quantities at very low cost. On the opposite, someone who bought fonio in order to cook it and give it away did so not in such large quantities and possibly at irregular intervals. Characteristics of the buyer were less significant but more difficult to analyze at this stage.

It was surprising that the cleanliness level was not significant. During interviews it was always quoted as important, but the model showed that the level of cleanliness, as perceived by the buyer, had no impact on the price of *decorticated* fonio. It could be argued it was a bias of the survey based on interviewees’ perceptions, and not on physical measures. People might not have understood the question or might have been over-optimistic regarding the product they just bought. On the other hand, other technological characteristics, collected with the same methodology, appeared to be significant, and coherent with empirical knowledge. At this stage, it seemed that while buyers were able to assess milling degree, grain colour, size and origin by themselves or with indications from sellers, they were not able to assess the level of cleanliness during the purchase, which they would discover at home when processing the product. Each specific type was usually

associated with a certain idea of level of cleanliness for most buyers. Cleanliness was actually not a real issue in the *decorticated* fonio “group” for the majority of individual buyers, who bought fonio very rarely (from once a week to once a month), in very small quantities (80% of the purchases of decorticated or milled fonio weighed less than four kilograms). Caution was necessary to differentiate between retail and wholesale markets as some were very close to each other: in wholesale markets professionals, such as restaurant keepers and small scale entrepreneurs bought their decorticated fonio and had greater expectations concerning quality. They bought larger quantities (from around 300 to 500 kg per month), on a regular basis, and paid different prices for different levels of cleanliness of decorticated fonio (our interviews). The same regression done at the wholesale market about larger quantities would certainly have shown different results concerning the cleanliness level.

**Prices of *milled* fonio depended more on environment characteristics linked to supply and buyers than on grain characteristics (except for colour)**

The analysis of variance was conducted for each characteristic and showed that the average price varied depending on the purchase location, colour, size, destination, status of the buyer, sex of the buyer, and activities of the buyer (at 1% significance level), occasion, education level (at 5% level). The PLS regression and VIP criteria gave more detailed results (Table 4).

Compared to *decorticated* fonio, the milling degree had no effect any longer on the price since the type was more homogeneous. The recipe had the correct sign (minus for *djouka* and plus for other salted meal) but was not significant any longer since very few people bought this kind of fonio to process it and sell it in large quantities to street restaurants. The origin was not significant any longer. The level of cleanliness gave incoherent results. The colour remained the only common significant characteristic.



Characteristics of buyers were here more significant: men, civil servants, higher educated persons paid a higher price compared to women, housewives, or less educated persons. In addition, the location was significant: prices in Magnambougou market and at the Niger riversides were higher than in Medina Koura and Korofina markets. This seemed logical and linked to the customers since Magnambougou was located in a wealthier area, and Niger riversides' purchasers were usually richer than people going to other markets.

**Prices of precooked fonio depended mainly on supply characteristics (brand and purchase location).**

For precooked fonio, only purchase location and brand had a significant effect on the unit price average (ANOVA test). All other variables (quality, buyer characteristics, etc.) had a minor effect on price (see Table 5). The product was standardized and variations in technological quality were low. Supply systems and brands were not competing with one another. Each purchase location and each processor had its price policy. The product being new the consumers were not accustomed to it yet and had no means to make price comparisons. In the case of precooked fonios, prices resulted from a supply policy and not from the meeting between suppliers and purchasers.

**Discussion and conclusion**

We showed that the fonio price was mainly determined by the grain milling degree. The four existing types of fonio, known by individual buyers at the retail markets, explained almost 90% of price variation. The market was thus well segmented for that product. In addition, the hedonic price estimation with the PLS method showed that for each type of fonio different attributes had a significant value.

For the decorticated fonio, the main determinants of price variation around the average were the final recipe, grain colour, grain origin, and grain milling degree. Specific characteristics of buyers (related to their idiosyncratic competence or sociocultural specificities) and supply (market places) played a minor role. The geographic origin of the grain guaranteed somewhat the level of cleanliness. Although buyers would rather purchase clean fonio (no dust, no sand), there were not many ways to check this at time of purchase, and they used the origin as a means to estimate *ex ante* the level of cleanliness. Decorticated fonio is heterogeneous in terms of technological characteristics compared to milled fonio, and price variations are mainly linked with technological characteristics. The main determinants of the price variation of milled fonio were the purchase location, grain colour, and size of the grain, occasion, destination, and the sex, type of employment and level of education of the buyer. Final recipe, milling degree and grain origin had no influence on the price. The main determinants of the price variation of the precooked product were the place of purchase and brands. Intrinsic characteristics of the product had little influence on price variation. Results of the hedonic models on the market prices were consistent with results from interviews and sensory tests, and revealed consumers' preferences. It highlighted the fact that the fonio market was efficient for traditional products (decorticated and milled).

This study contributed to the programming of technological and agronomic research since it gave quantified results concerning buyers' preferences. It showed that cleanliness, milling degree and colour were vertical attributes for almost all buyers. For decorticated fonio, (the least processed and cheapest product), the geographical origin was a valuable attribute since it gave indication on other characteristics (cleanliness in particular). For more processed and more standardized products, the origin had no influence on the price. The grain size did not impact on the price, except for precooked fonio.

This study did not tackle the question of access to the products, which remained expensive compared to other cereals (two to three times more expensive in terms of unit price). However, other analyses, based on the same surveys, not presented here, showed that consumers' profiles, as well as final uses differed from one type to another. Decorticated and milled fonios were bought mainly by women (90% of the buyers), who did all the final processing (pounding, cleaning) themselves, and who often cooked it to generate income (25% of the buyers of decorticated fonio processed it for sale in small restaurants). Milled and washed fonio as well as precooked fonio were more often bought by men (30% of precooked buyers), who belonged to a higher income class (civil servants), and who gave it to their spouses. This fonio was usually eaten at home or given. It was never used to generate income. Other ongoing researches are assessing the impact of the development of these new products on income generation and distribution. The hypothesis is that it creates new activities for small scale processors and their employees; it generates new incomes since it reaches new consumers, who are reluctant to clean and pound the milled or decorticated products. The risks are that the supply will not meet the growing demand and the price will increase. If this happens, the actual decorticated and milled products may reach higher prices that would deprive poor women of their income generating activity.

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**Table 1: Parameters of the PLS regression for *decorticated fonio*.**

|                            |   | parameters    | VIP*>0.8   | VIP rank  |
|----------------------------|---|---------------|------------|-----------|
|                            | Constant                                    | 360,696       |            |           |
| Purchase location          | Medina market                               | 2,463         | 1          | 16        |
|                            | Lafiabougou market                          | -2,059        |            |           |
|                            | Magnambougou market                         | -1,572        |            |           |
| <b>Milling degree</b>      | <b>Poorly milled</b>                        | <b>-5,021</b> | <b>1,9</b> | <b>4</b>  |
|                            | <b>Well or very well milled</b>             | <b>5,021</b>  | <b>1,9</b> | <b>3</b>  |
| Cleanliness degree         | Very dirty                                  | -0,285        |            |           |
|                            | Dirty                                       | -0,736        |            |           |
|                            | Clean                                       | 0,898         |            |           |
| <b>Grain colour</b>        | <b>White</b>                                | <b>4,505</b>  | <b>1,6</b> | <b>9</b>  |
|                            | <b>Cream white</b>                          | <b>12,462</b> | <b>1,8</b> | <b>7</b>  |
|                            | Grey  | -1,157        |            |           |
|                            | <b>Red, brown, not white</b>                | <b>-4,812</b> | <b>1,9</b> | <b>6</b>  |
| Grain size                 | Big   | 1,679         |            |           |
|                            | Small                                       | 1,002         |            |           |
|                            | Do not know                                 | -5,077        | 1,3        | 12        |
| <b>Grain origin</b>        | <b>Guinea</b>                               | <b>4,572</b>  | <b>1,7</b> | <b>8</b>  |
|                            | <b>Mali</b>                                 | <b>-5,685</b> | <b>2,1</b> | <b>2</b>  |
|                            | Do not know                                 | 0,996         |            |           |
| <b>Recipe</b>              | <b>Djouka</b>                               | <b>-5,858</b> | <b>2,3</b> | <b>1</b>  |
|                            | <b>Other salted main meal</b>               | <b>4,889</b>  | <b>1,9</b> | <b>5</b>  |
|                            | Do not know                                 | 7,262         | 1          | 14        |
| <b>Occasion</b>            | For sale or gift                            | -2,691        | 1,1        | 13        |
|                            | Week-end meal                               | -0,558        |            |           |
|                            | Special event (familial/religious) meal     | 3,038         | 0,8        | 22        |
|                            | Regular meal                                | 0,996         |            |           |
|                            | Illness                                     | 7,135         |            |           |
| <b>Destination</b>         | Household consumption                       | 0,102         |            |           |
|                            | Processing for sale in her small restaurant | -2,576        | 0,9        | 21        |
|                            | Processing for a gift                       | 4,377         | 1          | 17        |
|                            | Gift (no home process)                      | -0,183        |            |           |
|                            | Processing for sale as precooked type       | 7,135         |            |           |
| Buyer status in the family | Mother or other woman                       | 2,675         | 1          | 15        |
|                            | Employee                                    | -3,254        |            |           |
|                            | Father or other man                         | 2,100         |            |           |
|                            | Child, youngster                            | -2,732        | 0,9        | 18        |
| Buyer age                  | Less than 20 years                          | -3,054        | 0,9        | 20        |
|                            | Between 21 and 35 years                     | 3,751         | 1,3        | 11        |
|                            | Between 36 and 50 years                     | -3,316        |            |           |
| Buyer sex                  | Man   | -0,183        |            |           |
|                            | Woman                                       | 0,945         |            |           |
| Buyer job                  | Employee                                    | 0,928         |            |           |
|                            | Self-employed worker                        | -2,391        | 0,9        | 19        |
|                            | Other                                       | -2,446        |            |           |
|                            | <b>Housewife</b>                            | <b>4,710</b>  | <b>1,5</b> | <b>10</b> |
| Buyer origin               | Region of fonio production                  | 0,866         |            |           |
|                            | Region with no fonio production             | -1,146        |            |           |
| Buyer education level      | Primary school                              | -1,042        |            |           |
|                            | Secondary school                            | -1,513        |            |           |
|                            | High school                                 | 2,264         |            |           |
|                            | Other                                       | 0,872         |            |           |

**Table 2: Descriptive statistics of prices for *decorticated fonio***

| Characteristics            | Modalities of each characteristic           | Frequency |           | Unit Price CFAF/kg |                    |
|----------------------------|---|-----------|-----------|--------------------|--------------------|
|                            |   | N         | N% column | Average            | Standard Deviation |
| Purchase location          | Medina market                               | 28        | 48,3%     | 371                | 38                 |
|                            | Lafiabougou market                          | 8         | 13,8%     | 356                | 18                 |
|                            | Magnambougou market                         | 22        | 37,9%     | 360                | 31                 |
| Milling degree             | Poorly milled                               | 23        | 39,7%     | 350                | 26                 |
|                            | well milled                                 | 33        | 56,9%     | 373                | 35                 |
|                            | Very well milled                            | 2         | 3,4%      | 400                | 0                  |
| Cleanliness degree         | very dirty                                  | 9         | 15,5%     | 364                | 28                 |
|                            | Dirty                                       | 25        | 43,1%     | 363                | 33                 |
|                            | Clean                                       | 24        | 41,4%     | 368                | 36                 |
| Grain colour               | White                                       | 18        | 31,0%     | 381                | 29                 |
|                            | Cream white                                 | 2         | 3,4%      | 425                | 71                 |
|                            | Grey  | 14        | 24,1%     | 361                | 27                 |
|                            | red, brown, not white                       | 24        | 41,4%     | 351                | 28                 |
| Grain size                 | Big   | 14        | 24,1%     | 371                | 27                 |
|                            | Small                                       | 37        | 63,8%     | 367                | 32                 |
|                            | do not know                                 | 7         | 12,1%     | 343                | 45                 |
| Grain origin               | Guinea                                      | 20        | 34,5%     | 380                | 38                 |
|                            | Mali  | 19        | 32,8%     | 346                | 13                 |
|                            | do not know                                 | 19        | 32,8%     | 368                | 35                 |
| Recipe                     | Djouka                                      | 28        | 48,3%     | 350                | 26                 |
|                            | Other salted main meal                      | 28        | 48,3%     | 378                | 34                 |
|                            | do not know                                 | 2         | 3,4%      | 400                | 0                  |
| Occasion                   | For sale or gift                            | 26        | 44,8%     | 358                | 22                 |
|                            | Week-end meal                               | 4         | 6,9%      | 363                | 32                 |
|                            | Familial or religious event                 | 8         | 13,8%     | 378                | 31                 |
|                            | Regular meal                                | 19        | 32,8%     | 368                | 46                 |
|                            | Other                                       | 1         | 1,7%      | 400                | .                  |
| Destination                | Familial consumption                        | 31        | 53,4%     | 365                | 32                 |
|                            | Processing for sale in her small restaurant | 14        | 24,1%     | 355                | 20                 |
|                            | Processing for a gift                       | 5         | 8,6%      | 385                | 34                 |
|                            | Gift (no home process)                      | 7         | 12,1%     | 364                | 56                 |
|                            | Processing for sale as precooked type       | 1         | 1,7%      | 400                | .                  |
| Buyer status in the family | Mother or other woman                       | 36        | 62,1%     | 370                | 39                 |
|                            | Employee                                    | 4         | 6,9%      | 350                | 0                  |
|                            | Father or other man                         | 3         | 5,2%      | 375                | 25                 |
|                            | Child, youngster                            | 15        | 25,9%     | 355                | 19                 |
| Buyer age                  | Less than 20 years                          | 10        | 17,5%     | 353                | 18                 |
|                            | Between 21 and 35 years                     | 42        | 73,7%     | 370                | 32                 |
|                            | Between 36 and 50 years                     | 5         | 8,8%      | 350                | 61                 |
| Buyer sex                  | Man   | 7         | 12,5%     | 364                | 24                 |
|                            | Woman                                       | 49        | 87,5%     | 366                | 35                 |
| Buyer job                  | Employee                                    | 12        | 21,1%     | 369                | 28                 |
|                            | self-employed worker                        | 28        | 49,1%     | 359                | 31                 |
|                            | Other                                       | 6         | 10,5%     | 354                | 25                 |
|                            | Housewife                                   | 11        | 19,3%     | 384                | 44                 |
| Buyer origin               | Region of fonio production                  | 29        | 51,8%     | 367                | 41                 |
|                            | Region with no fonio production             | 27        | 48,2%     | 362                | 23                 |
| Buyer education level      | Primary or religious school                 | 23        | 40,4%     | 362                | 34                 |
|                            | Secondary school                            | 6         | 10,5%     | 358                | 34                 |
|                            | High school and beyond                      | 7         | 12,3%     | 375                | 32                 |
|                            | Other                                       | 21        | 36,8%     | 368                | 35                 |
| Total                      |   | 58        | 100,0%    | 365                | 33                 |

**Table 3: Milled fonio: descriptive statistics and parameters of the model**

| Characteristics            | Modalities = variables of the model      | Descriptive statistics (price in CFAF/kg) |               |              | Results of the model     |          |
|----------------------------|--|---|---------------|--------------|--------------------------|----------|
|                            |  | N   | Average       | SD           | Parameter                | VIP rank |
| <b>Total</b>               |  | <b>99</b>                                 | <b>416,21</b> | <b>52,98</b> | <b>constant = 431,61</b> |          |
| Purchase location          | Medina Koura market                      | 18  | 392           | 35           | -7,08                    | 15       |
|                            | Korofina market                          | 44  | 394           | 16           | -9,30                    | 6        |
|                            | Lafiabougou market                       | 11  | 400           | 0            | -4,31                    |          |
|                            | Magnambougou market                      | 21  | 450           | 32           | 10,19                    | 8        |
|                            | <b>Niger Riversides</b>                  | <b>5</b>                                  | <b>590</b>    | <b>55</b>    | <b>43,21</b>             | <b>1</b> |
| Milling degree             | Poorly milled                            | 2   | 400           | 0            | -3,91                    |          |
|                            | Well milled                              | 22  | 417           | 28           | 0,11                     |          |
|                            | Very well milled                         | 75  | 417           | 59           | 0,31                     |          |
| Grain colour               | <b>White</b>                             | <b>79</b>                                 | <b>403</b>    | <b>30</b>    | <b>-15,54</b>            | <b>3</b> |
|                            | <b>Cream white</b>                       | <b>11</b>                                 | <b>505</b>    | <b>77</b>    | <b>23,46</b>             | <b>2</b> |
|                            | Grey                                     | 5   | 445           | 97           | 7,16                     |          |
|                            | Red/brown/not white                      | 4   | 400           | 0            | -3,99                    |          |
| Grain size                 | Big                                      | 23  | 425           | 37           | 2,77                     |          |
|                            | Small                                    | 38  | 431           | 76           | 5,64                     | 14       |
|                            | Do not know                              | 38  | 396           | 14           | -7,72                    | 9        |
| Grain origin               | Guinea                                   | 67  | 422           | 54           | 4,02                     |          |
|                            | Mali                                     | 4   | 419           | 38           | 0,62                     |          |
|                            | Do not know                              | 28  | 403           | 51           | -4,45                    |          |
| Recipe                     | Djouka                                   | 30  | 403           | 24           | -4,47                    |          |
|                            | Other salted meal                        | 69  | 422           | 61           | 4,47                     |          |
| Occasion                   | For sale or gift                         | 21  | 401           | 24           | -4,64                    |          |
|                            | Week-end meal                            | 18  | 414           | 32           | -0,67                    |          |
|                            | Familial or religious event              | 13  | 390           | 50           | -7,02                    | 18       |
|                            | Ordinary meal                            | 45  | 433           | 66           | 7,07                     | 11       |
|                            | Other                                    | 2   | 400           | 0            | -3,91                    |          |
| Destination                | <b>Familial consumption</b>              | <b>40</b>                                 | <b>443</b>    | <b>69</b>    | <b>10,56</b>             | <b>5</b> |
|                            | Processing for sale in small restaurants | 26  | 404           | 15           | -3,77                    |          |
|                            | Processing as gift                       | 11  | 389           | 54           | -7,32                    |          |
|                            | Gift (no home process)                   | 22  | 395           | 15           | -6,30                    | 17       |
| Buyer status in the family | Mother or other woman                    | 74  | 413           | 49           | -3,09                    |          |
|                            | Employee                                 | 7   | 411           | 28           | -1,40                    |          |
|                            | <b>Father</b>                            | <b>3</b>                                  | <b>550</b>    | <b>132</b>   | <b>32,57</b>             | <b>4</b> |
|                            | Other household member                   | 15  | 408           | 22           | -2,19                    |          |
| Age                        | Less than 20 years                       | 16  | 405           | 19           | -3,24                    |          |
|                            | Between 21 and 35 years                  | 73  | 418           | 57           | 1,19                     |          |
|                            | Between 36 and 50 years                  | 8   | 431           | 70           | 3,86                     |          |
| Buyer sex                  | Man                                      | 8   | 466           | 103          | 12,69                    | 12       |
|                            | Woman                                    | 88  | 412           | 45           | -9,58                    | 13       |
| Buyer job                  | Employee                                 | 10  | 408           | 24           | -2,29                    |          |
|                            | Self-employed worker                     | 24  | 424           | 46           | 2,48                     |          |
|                            | Student                                  | 10  | 400           | 0            | -4,26                    |          |
|                            | <b>Civil servant</b>                     | <b>9</b>                                  | <b>478</b>    | <b>93</b>    | <b>15,99</b>             | <b>7</b> |
|                            | Unemployed                               | 3   | 400           | 0            | -3,95                    |          |
|                            | Retired                                  | 4   | 450           | 100          | 8,31                     |          |
| Buyer origin               | Housewife                                | 37  | 401           | 44           | -5,60                    | 16       |
|                            | Region of fonio production               | 57  | 414           | 46           | -1,46                    |          |
|                            | Region with no fonio production          | 40  | 421           | 63           | 1,80                     |          |
| Buyer education level      | Primary or religious school              | 43  | 411           | 30           | -2,35                    |          |
|                            | Secondary school                         | 10  | 463           | 94           | 12,15                    | 10       |
|                            | High school and beyond                   | 12  | 423           | 60           | 1,80                     |          |
|                            | Other                                    | 32  | 408           | 55           | -2,93                    |          |

**Table 4: Precooked fonio: descriptive statistics and parameters of the model**

| Characteristics       | modalities = variables of the model | descriptive statistics (price in CFAF/kg) |              |           | Results of the model |          |
|-----------------------|-------------------------------------|---|--------------|-----------|----------------------|----------|
|                       |                                     | N   | Average      | SD        | Parameter            | VIP rank |
| <b>Total</b>          |                                     | <b>65</b>                                 | <b>867</b>   | <b>88</b> | constant = 874,483   |          |
| Purchase location     | At the processing unit              | 12  | 858          | 76        | 4,553                |          |
|                       | <b>Speciality store</b>             | <b>26</b>                                 | <b>792</b>   | <b>27</b> | <b>-55,107</b>       | <b>1</b> |
|                       | <b>Supermarket 1</b>                | <b>2</b>                                  | <b>1 000</b> | <b>0</b>  | <b>85,484</b>        | <b>6</b> |
|                       | supermarket 2 (Badalabougou)        | 11  | 879          | 29        | 1,784                |          |
|                       | <b>Supermarket 3 (Hippodrome)</b>   | <b>11</b>                                 | <b>995</b>   | <b>15</b> | <b>51,369</b>        | <b>2</b> |
|                       | <b>Supermarket 4 (Hippodrome)</b>   | <b>2</b>                                  | <b>1 000</b> | <b>0</b>  | <b>92,527</b>        | <b>7</b> |
|                       | Supermarket 5 (Hippodrome)          | 1   | 830          |           | -15,932              |          |
| Brand                 | Brand-1                             | 6   | 800          | 0         | -34,238 9            |          |
|                       | Brand-2                             | 1   | 1 000        |           | 83,788 18            |          |
|                       | Brand-3                             | 2   | 900          | 71        | -8,960               |          |
|                       | Brand-4                             | 1   | 850          |           | 7,923                |          |
|                       | Brand-5                             | 16  | 850          | 89        | -4,370               |          |
|                       | <b>Brand-6</b>                      | <b>15</b>                                 | <b>790</b>   | <b>39</b> | <b>-40,739</b>       | <b>4</b> |
|                       | Brand-7                             | 1   | 825          |           | -24,197              |          |
|                       | <b>Brand-8</b>                      | <b>18</b>                                 | <b>953</b>   | <b>54</b> | <b>43,287</b>        | <b>3</b> |
|                       | Brand-9                             | 2   | 830          | 0         | -19,947              |          |
|                       | Brand-10                            | 3   | 933          | 58        | 47,318               |          |
| Grain colour          | Blanc                               | 18  | 865          | 87        | 1,145                |          |
|                       | Cream white                         | 27  | 875          | 91        | 3,189                |          |
|                       | Brown, red, grey, not white         | 20  | 858          | 87        | -4,711               |          |
| Grain size            | <b>Big</b>                          | <b>7</b>                                  | <b>936</b>   | <b>94</b> | <b>15,704</b>        | <b>5</b> |
|                       | Small                               | 24  | 856          | 86        | -8,291               |          |
|                       | Do not know                         | 30  | 858          | 84        | 2,614                |          |
|                       | several different sizes             | 4   | 874          | 95        | -3,943               |          |
| Grain origin          | Guinea                              | 2   | 975          | 35        | 8,972 13             |          |
|                       | Mali                                | 1   | 850          |           | -8,294               |          |
|                       | Do not know                         | 62  | 864          | 88        | -3,224               |          |
| Recipe                | Djouka                              | 7   | 914          | 107       | 12,117 19            |          |
|                       | Other salted meal                   | 53  | 866          | 87        | -5,881               |          |
|                       | Other                               | 5   | 810          | 22        | -3,930 20            |          |
| Occasion              | For sale or gift                    | 8   | 838          | 69        | 3,052                |          |
|                       | Week end                            | 25  | 876          | 72        | 6,013                |          |
|                       | Familial or religious meal          | 9   | 827          | 83        | -22,951              |          |
|                       | Ordinary meal                       | 23  | 883          | 107       | 4,309                |          |
| Destination           | Household consumption               | 55  | 875          | 88        | 8,208 12             |          |
|                       | Processing for sale                 | 1   | 800          |           | -10,608              |          |
|                       | Gift (no home process)              | 8   | 819          | 84        | -9,524 14            |          |
|                       | Other                               | 1   | 850          |           | 7,923                |          |
| Status of the buyer   | Mother                              | 39  | 849          | 80        | -12,885 11           |          |
|                       | Employee                            | 4   | 911          | 86        | -0,452               |          |
|                       | Father                              | 13  | 875          | 91        | 7,074                |          |
|                       | Other member of the family          | 9   | 911          | 105       | 16,653 15            |          |
| Buyer age             | less than 20 years                  | 2   | 900          | 141       | 10,385               |          |
|                       | Between 21 and 35                   | 15  | 889          | 100       | -1,504               |          |
|                       | Between 36 and 50                   | 31  | 862          | 81        | -1,770               |          |
|                       | More than 51                        | 17  | 853          | 87        | 2,065                |          |
| Buyer sex             | Man                                 | 19  | 862          | 88        | 1,309                |          |
|                       | Woman                               | 46  | 869          | 89        | -1,309               |          |
| Buyer job             | Employee                            | 13  | 858          | 74        | -2,057               |          |
|                       | Self employed worker                | 6   | 892          | 102       | -3,335               |          |
|                       | Student                             | 4   | 950          | 100       | 11,938 10            |          |
|                       | Civil servant                       | 31  | 862          | 87        | 7,145                |          |
|                       | Retired                             | 5   | 859          | 89        | -0,324               |          |
|                       | Housewife                           | 6   | 838          | 101       | -21,964              |          |
| Buyer origin          | Region of production of fonio       | 29  | 879          | 90        | 4,725                |          |
|                       | Region with no production           | 35  | 861          | 83        | 1,147                |          |
| Buyer education level | Primary school                      | 13  | 902          | 91        | 8,652 16             |          |
|                       | Secondary school                    | 23  | 843          | 78        | -6,917 17            |          |
|                       | High school and Beyond              | 29  | 870          | 91        | 0,798                |          |

<sup>1</sup> Note that VIP= Variable Importance in the Projection = 3.11 for rank = 1 ; VIP = 0.86 for rank = 20