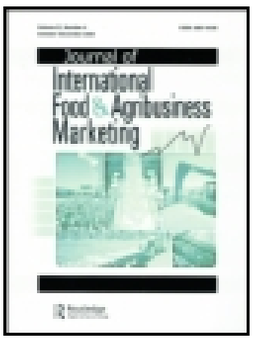

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Consumer Preferences for Fresh Tomatoes in Benin using a Conjoint Analysis

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ABSTRACT

Constraints related to the technical and socioeconomic aspects of adopting tomato varieties are well documented. However, preferences relating to the demand for this fruit are rarely studied. In fact, demand for the different varieties of tomatoes might be related to consumers' preferences for the extrinsic (color, size) and intrinsic (taste, nutritive value, water content) characteristics specific to each variety. It is therefore indispensable to determine the characteristics of tomatoes preferred by consumers. We examine consumers' preferences for tomato attributes among a sample of 600 consumers in four representative markets in the main cities in southern Benin. The study also identifies potential segments of consumers and the market shares of each profile for each segment. The study identifies four potential tomato market segments, two of which have a strong preference for local tomatoes, namely, those that can be conserved for long periods and those with a firm consistency.

KEYWORDS

Attributes; Benin; conjoint analysis; ordinary least squares method; preference; tomato

Introduction

Agriculture remains a sector with many production, export, and processing opportunities. One of the major components of plant production is vegetable production. In fact, vegetable crops play an important role in nutrition because of their extremely rich nutrient contribution, which helps to prevent diseases caused by micronutrient deficiencies (Dossou et al., 2007). Moreover, vegetable farming is one of the major agricultural activities performed by vulnerable groups of urban and peri-urban populations (Tokannou & Quenum, 2007). Despite their potentialities and strategic role, including the reduction of food insecurity and poverty, the development of the vegetable farming sector still remains a myth in many West African countries (AgroBénin, 2013). Such is the case for the tomato, which is one of the most cultivated vegetable products (AgroBénin, 2013).

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The tomato fruit is a staple condiment and is often used in the preparation of different dishes such as (of Benin, Nigeria, and Togo) "Moyo" and/or "juice", where the fruit is cut into pieces and cooked raw; and "simple sauce", where the fruit is ground and cooked with other condiments. It is also moderately used in the preparation of other dishes such as spaghetti, couscous, red paste, and ragout. Nutritionally, the tomato helps to correct micronutrient deficiencies due to its high mineral and vitamin content (Dossou et al., 2007). Regarding health, the tomato fruit contains high concentrations of lycopene, a very strong antioxidant, and thereby plays an important role in preventing prostate cancer in men. The tomato is often cultivated in house gardens, in developed agricultural schemes as a pure crop or in association with other crops during off-season and/or the rainy season.

In Benin, 80% of tomato production, which is estimated to be approximately 150,000 tons per year, takes place in the southern part of the country, where off-season production is well developed (Afangbédji, 2007; AgroBénin, 2013). However, the import of fresh tomatoes continues to increase due to not only a production deficit but also changes in consumer tastes and preferences. Therefore, one of the key challenges for the country is increasing tomato production to meet both quantity and quality demands.

Historically, research on horticultural products such as the tomato has largely focused on improved varietal development and releases, production and cultural practices, and reducing post-harvest losses. Several varieties of tomato have been developed and/or have been imported for cultivation in Benin. However, very few of these varieties are found in markets. For example, in the market of the southern zone of the country, only the Tounvi, Akikon, Thorgal, and Mongal varieties are frequently found, although the number of varieties introduced in the production systems is high. This difference between the number of varieties introduced in the production systems and the number frequently observed in the markets seems to be partially justified not only by technical and socioeconomic constraints but also by constraints in meeting the demand of quality fruits (Afangbédji, 2007; AgroBénin, 2013). The latter now seems to be crucial; as Brumfield, Adelaja, and Lininger (1993) argued, "Consumer preferences and tastes are key factors affecting consumer purchase decisions regarding horticultural products" (Brumfield et al., 1993, p. 433). Constraints related to technical and socioeconomic aspects of tomato varietal adoption have also been well documented. However, very little information exists on tomato demand-driving factors. In fact, the demand for different tomato varieties could be related to consumers' preferences of extrinsic (color, size) and intrinsic (taste, nutritive value, water content) characteristics specific to each variety. Low technology adoption could be partly due to their poor extrinsic and/or intrinsic characteristics (Ndjeunga & Nelson, 2005). Using knowledge about consumer demand for tomato characteristics can help

producers improve their product quality and hence their marketability. For this reason, knowing consumers' preferred tomato characteristics is indispensable not only for varietal improvement programs but also for the improvement of tomato commercialization, and hence for maintaining present and future business profitability. Consequently, this study analyzes tomato consumers' preferences in Benin using conjoint analysis to measure consumers' multi-attribute utility functions. The agricultural sector of Benin, like many other developing countries, occupies ~48% of the active population and contributes to over 36% of gross domestic product (MAEP, 2010). Many tomato cultivars are grown, but information on fresh tomato quality preferences along the tomato supply chains remains sparse. The objective of this paper is to provide more insight on how tomato value chain actors, including governments and development partners, can increase local tomato production and consumption.

The rest of this article is organized as follows. In the next section, the materials and methods used in the study are outlined. This section is divided into different subsections. In addition to the description of the study area, the theoretical framework underlying the study is presented. The application of each specific step in conjoint studies is then described. Next, this paper highlights a section on empirical results and discussions. The last section covers on the conclusion.

Materials and methods

Study population, area, and sampling procedure

This study was performed in Benin, West Africa. Benin is a country of approximately 10.32 million people (World Bank, 2010). Tomato is one of the staple condiments of its population. The sampling unit for this study is the consumer of tomato fruits, defined as any individual who buys tomato fruits to meet personal needs or those of his/her family. A combination of sampling approaches was adopted. We followed a stratified sampling approach to select the study markets (Ingenbleek, Tessema, & van Trijp, 2013). First, we limited our sampling to the regions where tomato production is an important economic activity. The study markets were selected in southern Benin as ~80% of tomato production takes place in that part of the country (Afangbédji, 2007; AgroBénin, 2013). Second, we restricted our sampling frame to the two main cities as the two major consumption localities in the region, namely Cotonou and Porto-Novo. Finally, the interviewed consumers were selected in two respective representative markets in each city of the study that were highly frequented by the different populations. The choice of these different markets was made with the assistance of resource persons from these zones (e.g., heads of residential areas, women's

associations) and monitoring agents. The Dantokpa and Saint Michel markets were selected in Cotonou and the Ouando and Ahouangbo markets were used in Porto-Novo. Consumers at each market were recruited using a non-probabilistic convenience sampling approach. A total of 600 tomato consumers were involved in the study (200 in Porto-Novo and 400 in Cotonou).

Preference analysis theoretical framework

The decisions regarding fresh tomato consumption result from a six-stage process: need recognition; search for information; evaluation of alternatives; purchase; consumption; and post-purchase evaluation (Valli & Traill, 2005). Consumer preferences play an important role in evaluating alternatives. Preferences determine the specific fresh tomato that a consumer would choose in a given situation. Marketing literature has proposed several models to explain factors affecting consumer preference for food. The 'lens' model and the multi-attribute attitude approach are the two most widely referenced in the literature (Engel & Blackwell, 1982). The former assumes that consumers form preferences for products based on their perceptions on their characteristics. In turn, preferences determine the specific products that a consumer would consider choosing in a given situation. The conceptual basis of the latter is in social psychology (Fishbein, 1967), psychometrics (Torgerson, 1958), and the new economic theory of consumer choice formulated by Lancaster (1966). This approach views products as bundles of characteristics. In addition, the approach assumes that these characteristics generate utility for consumers, which explain their preferences for products. This implies that overall utility derived from a product is decomposed into separate utilities, and each pertains for a characteristic (Louviere, 1994). The approach is used to evaluate alternative products based on different characteristic or cues, which are traded against each other before deciding whether to buy a product and which one to choose (Engel & Blackwell, 1982). Lancaster's new consumer economic theory of demand for characteristics provides the theoretical basis of the model of consumer preferences used in this study. Indeed, Lancaster argues that consumers derive utility from the characteristics after the transformation of the products into completed meals using labor, time, and perhaps other inputs. Lancaster assumed that $\boldsymbol{g}(\boldsymbol{x})$ is linear. In addition, he postulates that the technology that transforms product x into attributes is the same for all consumers. Finally, this study targeted the products that yield common characteristics. This hypothesis corresponds to the separability assumption, usually made in empirical consumer demand analysis (Rao, 2007; Ratchford, 1975).

Following Lancaster's theory, consumers are hypothesized to maximize utility of attributes, subject to the transformation function, and budget constraints. The consumer maximizing behavior can be formally written as:

$$\text{Maximize} \quad U = U(z) \tag{1}$$

$$\text{Subject to} \quad z = g(x) \tag{2}$$

$$\text{and} \quad px < M. \tag{3}$$

Restating the consumer's problem yields the indirect utility function:

$$V = V(p,\ z,\ M), \tag{4}$$

such that

$$px < M, \tag{5}$$

where
U is the utility of the consumers; $\boldsymbol{z} = \boldsymbol{g}(\boldsymbol{x})$ is the transformation function; x is the products vector; P is the price vector; $\boldsymbol{z}$ is the attributes vector; and M is the consumer's income. V represents the maximum utility achievable for a consumer given product attributes, prices and income.

Ratings-based conjoint model specification

This study applied the conjoint analyses method to modeling consumer preferences for fresh tomatoes. Conjoint analysis is a decompositional model widely used in applied marketing research to estimate the structure of a consumer's preferences (i.e., estimates of part-worths, importance weights of attribute levels, and ideal points). The model decomposes the consumers' ratings, rankings, or choice of alternative products to estimate the part-worth attached to each of the main product attributes (Green & Srinivasan, 1990; Ruiz de Maya & Munuera, 1993). The reasons for using the conjoint analysis in this study are four-fold, as the approach can (1) guide the researchers in the breeding of the varieties of fresh tomatoes that consumers preferred eating; (2) determine market segments of fresh tomatoes; (3) estimate market shares for competitive products (Dangedji, 2014; Guyon, 2010); and (4) design promotion strategies (Green & Krieger, 1991).

The choice of a conjoint analysis model depends on the function of each attribute. The study used a cumulative part-worth approach that provides the greatest flexibility in allowing different shapes for the preference function of each of the attributes. In addition, it is the simplest and most frequently used model in marketing research (Steenkamp, 1987). The cumulative model assumes that the overall utility provided by an alternative fresh tomato is the sum of the values of the separate parts of the attributes. Although the part-worth model seems to be the most attractive in terms of being compatible with any arbitrary shape for the preference

model, this benefit comes at the cost of having to estimate additional parameters (thereby lowering their reliability) and the need to approximate intermediate values by linear interpolation (Green & Srinivasan, 1978).

Drawing on the theoretical framework and following Jain et al. (1979), the part-worth model of a tomato profile $(X_{1j}, X_{2j}, \cdots, X_{nj})$ consisting of n attributes with each attribute defined at m_i levels is formulated as:

$$V = V_1(X_{1j}) + V_2(X_{2j}) + \cdots + V_n(X_{nj}) \tag{6}$$

where V is the overall indirect utility a consumer derived from the eating of a fresh tomato profile; $V_i(\bullet)$ is the part-worth function specific to the ith attribute; and X_{ij} is the jth level $(j, j = 1, 2, \ldots, m_i)$ for a fresh tomato profile on the ith attribute. A constant term is included in any one of the $V_i(\bullet)$ functions. The specification of the $V_i(\bullet)$ function for any attribute will depend on its type (categorical and quantitative).

The indirect utility function V is not observable; however, it is assumed to underlie the observed vector of importance ratings or rankings Y of the fresh tomato profiles. As the vector Y is expressed as an ordinal ranking, the following regression model is specified to assess the effect of selected attributes on the relative importance ratings of fresh tomatoes profiles for Benin consumers:

$$Y = \alpha_0 + \sum_{i=1}^{n} \sum_{j}^{m_i} \alpha_{ij} X_{ij} + \varepsilon \tag{7}$$

where Y is the rating on the rth fresh tomato profile; α_{ij} is the part-worth contribution associated with the jth level of the ith attribute; α_0 is a constant that represents the average preference level for each product; and ε is the random error of the model assumed to be normally distributed with zero mean and variance of σ^2.

Implementation of the conjoint analysis

Choosing the attributes and their levels

Choosing the attributes is the first step in the implementation of a conjoint analysis. An attribute is a key characteristic of the product that participates in the evaluation of the quality of the product it characterizes (Halbrendt et al., 1991). In this study, the attributes of tomato consumers' preferences are identified by exploiting the literature on tomato commercialization and marketing (Afangbédji, 2007; AgroBénin, 2013; Fagbohoun & Kiki, 1999), followed by an exploratory survey. The exploratory study was carried out in four representative markets in the main cities in southern Benin (the markets Dantokpa and Saint Michel in Cotonou and Ouando and Ahouangbo in Porto-Novo) (Afangbédji, 2007; AgroBénin, 2013; Fagbohoun & Kiki, 1999). The data from the exploratory survey was collected from 50 tomato

Table 1. Attributes retained and their levels.

Attributes	Levels
Color	Dark red
	Orange-red
Taste	Acidic
	Non-acidic
Price	900
	1200
Consistency	Firm
	Medium
	Soft
Duration of conservation	Long
	Average
	Short
Origin of the varieties	Local
	Imported

consumers randomly identified and interviewed. The major attributes of tomatoes in which consumers are interested are the origin of the varieties, water content, color, the utilization of chemical products for production, shape, the consistency of tomatoes, taste, weight, size, duration of conservation, presence of foreign bodies in the fruits and, finally, price. Because of their high number, the attributes gathered were then submitted to the main component analysis to be reduced (Aldenderfer & Blashfield, 1984). The analysis results identified six potential attributes to which consumers refer during the different tomato purchases (cf. Table A1 for the results of the main component analysis in the Appendix): color, duration of conservation, conservation, taste, origin of the varieties, and price. Attributes and their levels are presented in Table 1.

Establishment of the experimental design and its implementation

Once the attributes are selected and their levels defined, the different hypothetic tomato profiles were generated (Gil & Sánchez, 1997). This study has adopted the partial profile approach. In fact, based on the important factors of preference and their modalities, 144 complete profiles of tomato can be created, i.e., 2*2*2*3*3*2. However, evaluating 144 profiles of tomatoes would be impossible for consumers and would lead to non-objective judgments. To avoid this kind of situation, the number of profiles to be submitted to the evaluation of the consumers was reduced by applying an orthogonal fractional factorial design using SPSS software (SPSS, Chicago, IL) that preserved the validity of the experimentation. Sixteen (16) profiles were obtained. After defining the 16 hypothetical tomato profiles, the questionnaire for the survey was developed. One example is included in Figure 1. In the survey, respondents were asked to grade each hypothetical profile on a 10-point Likert scale (from 1 = not appreciated at all to

Tomato profile	1
Color	Orange-red
Taste	Non-acidic
Price	600
Consistency	Soft
Duration of conservation	Long
Origin of the varieties	Local
Your rating	
I would like to buy	

Figure 1. Example of (one-of-sixteen) d hypothetical tomato profiles.

10 = very appreciated). Table A2 in the Appendix presents the 16 hypothetical profiles retained.

Conjoint model estimation

The part-worth conjoint preference model was estimated as follows (7). As all six attributes included in the model are categorical, only $(m_i - 1)$ dummy variables are necessary for each attribute i to estimate the preference model specified in (7). The estimates of the variables that were not used in the model are calculated as the negative of the sum of the estimated coefficients of the level of attribute that were used for estimation (Tano et al., 2003). Accordingly, the part-worth preference conjoint model at the individual consumer level is expressed as follows:

$$\begin{aligned}\text{Rating} = {} & \beta_0 + \beta_1 \textit{Dred} + \beta_2\ \textit{Mecons} + \ \beta_3\ \textit{Scons} + \beta_4\ \textit{Natas} + \beta_5\ \textit{Locorg} + \beta_6\ \textit{Lgcons} \\ & + \beta_7\ \textit{Mecons} + \beta_8\ \textit{Shopp} + \beta_9\ \textit{Shopp} \times \textit{Locorg} + \beta_{10}\ \textit{Dred} \times \textit{Locorg} \\ & + \beta_{11}\ \textit{Mecons} \times \textit{Locorg} + \varepsilon\end{aligned} \tag{8}$$

where Rating is the preference rating $(0, 1, 2, \ldots, 10)$ given to each hypothetical profile of tomato variety; Dred is a dummy variable that takes the value 1 if the tomato fruit has a dark color and 0 otherwise; Mecons is a dummy variable that takes the value 1 if the tomato fruit has a medium consistency and 0 otherwise; Scons is a dummy variable that takes the value 1 if the tomato fruit has a soft consistency and 0 otherwise; Natas is a dummy variable that takes the value 1 if the tomato fruit has a non-acidic taste and 0 otherwise; Locorg is a dummy variable that takes the value 1 if the tomato fruit is produced locally and 0 otherwise; Lgcons is a dummy variable that takes the value 1 if the tomato variety has a long length of conservation and 0 otherwise; Mecons is a dummy variable that takes the value 1 if the tomato variety has a medium length of conservation and 0 otherwise; Shopp is a dummy variable that takes the value 1 if the tomato price is for the shortage period and 0 otherwise; Shopp * Locorg is the interaction term between the variables Shopp and Locorg; Dred * Locorg is the interaction term between the variables Dred and Locorg; and Mecons * Locorg is the interaction term between the variables Mecons and Locorg.

To avoid perfect multi-collinearity, the following variables are not included: Ored (a dummy variable that takes the value 1 if the tomato fruit has an orange color and 0 otherwise); Ficons (a dummy variable that takes the value 1 if the tomato fruit has a firm consistency and 0 otherwise); Atast (a dummy variable that takes the value 1 if the tomato fruit has an acidic taste and 0 otherwise); Imporg (a dummy variable that takes the value 1 if the tomato fruit is imported and 0 otherwise); Shocons (a dummy variable that takes the value 1 if the tomato variety has a short length of conservation and 0 otherwise); and Abpp (a dummy variable that takes the value 1 if the tomato price is for the abundance period and 0 otherwise). These variables represent the reference level for each attribute, and their coefficients are calculated from the estimated parameters β; ε is the error term.

The dependent variable Rating is measured using a 10-point Likert scale and assumed approximately interval scale properties. The ordinary least squares (OLS) regression is therefore an appropriate method for estimating the model in (8) (Gil & Sánchez, 1997; Halbrendt et al., 1991). However, the results from the Breusch–Pagan (Novales, 1993) test indicated the rejection of the null hypothesis that errors were homoskedastic (65.8 while the critical value at the 5% level of significance is 3.84). Thus, the model in (8) was estimated by weighted least squares (WLS).

Following the estimation of the conjoint model, the importance of each attribute was computed (Gil & Sánchez, 1997; Halbrendt et al., 1991). The relative importance of each attribute (i) is calculated in a two-step process. First, for each attribute, the highest and lowest part-worth for the attribute are determined. Then, the attribute part-worth range, consisting of the difference between the highest and lowest part-worth, is calculated. Next, the sum of the ranges over all attributes is computed. The relative importance of an attribute (i) to consumers is defined as follows:

$$\text{Relative importance } (i) = \frac{100 \times \text{ range } (i)}{\sum \text{range } (i)} \tag{9}$$

An important result of the conjoint analysis is also the possibility to identify market segments, which allows differentiated marketing strategies (Gil & Sánchez, 1997). The identification of consumer segments with homogenous preferences expresses the heterogeneity of consumers' preferences. This study was inspired by the Calinski–Harabasz index to identify the number of potential tomato consumer segments based on expressed preferences (Gil & Sánchez, 1997; Kamakura & Gary, 1989). It is a method of the centroid K applied to the true vectors of a principal component analysis (PCA) of the correlation matrix between the different potential segments. This index, similar to the F statistics of Fisher in the univariate analysis, depends on the ratio of intergroup and intragroup variance

(Calinski & Harabasz, 1974):

$$\mathrm{VRC}(k) = \text{Pseudo } F = \mathrm{CH}(k) = \frac{B(k)/(k-1)}{W(k)/(n-k)} = \frac{\mathrm{BGSS}/(k-1)}{\mathrm{WGSS}/(n-k)} \tag{10}$$

where n is the number of observations; k is the number of groups; $B(k) = \mathrm{BGSS}$ is the sum of the intergroup squares; and $W(k) = \mathrm{WGSS}$ is the sum of squares of the intragroup.

We then applied discriminant analysis to identify the characteristics that determine the most different segments of potential consumers obtained from the PCA.

Another interesting analysis that can be derived from conjoint techniques is the possibility of simulating the market shares of different hypothetical tomato profiles. The selection was made taking into account the profiles that could be realistic, but also are more found on the Beninese markets and covering the price range considered in the study (Aguilar, Cai, Mohebalian, & Thompson, 2015; Gil & Sánchez, 1997). However, four alternatives profiles of varieties including two local (Tounvi, Aklinkon), and two others introduced by the research (Mongal, Thorgal) were selected (Fagbohoun & Kiki, 1999; Komlan, Singbo, & Mensah, 2005). These varieties have been introduced more precisely to improve the production of tomatoes (to facilitate their resistance to climate change, diseases, pests, and boost yield), and for processing canned tomatoes (Fagbohoun & Kiki, 1999; RUAF, 2010). The characteristics of the varieties (Mongal, Akikon, Thorgal, Tounvi) are presented in Table 2 by the Program of Agricultural Productivity in West Africa (PPAAO), the tests carried out by SIST (2016) and Komlan et al. (2005).

Potential market shares were estimated based on the expected effects of marginal increases of tomato prices as performed by Aguilar and Cai (2010), Mohebalian, Cernusca, and Aguilar (2012), and discussed by Greene (2003). In fact, the price of the selected varieties has been adjusted in increments of 100 FCFA from 900 to 1200 FCFA/Kg. On the basis of the different potential consumers segments obtained, the market shares estimated exclusively for the selected tomato profiles is based on the average of the probabilities that a given profile would be chosen (Gil & Sánchez, 1997; Ohannessian, 2008). The choice probabilities were generated using the Bradley–Terry–Luce method by dividing the partial utility of a given

Table 2. Hypothetical tomatoes profiles for simulation market share in different consumer segments.

Profile	Variety	Color	Taste	Price during scarcity	Consistency	Duration conservation	Origin
2	Mongal	Dark red	Acidic	1200	Firm	Long	Imported
5	Akikon	Dark red	Non-acidic	900	Firm	Short	Local
8	Thorgal	Orange-red	Acidic	900	Firm	Long	Imported
11	Tounvi	Dark red	Non-acidic	900	Medium	Long	Local

hypothetical tomato profile (p_i) by the sum of the partial utilities of all profiles:

$$Pi = \frac{\Sigma \text{Probabilities choice of profil } i \text{ of segment } s \text{ consummers}}{\text{Number of consummers in segment } s} \quad (11)$$

Results and discussion

Estimation of the conjoint model (COM) parameters

The estimation results of Equation 2 show that the model performs quite well. The model is globally significant at the threshold of 1%, implying that the coefficients of the explanatory variables introduced in the model are not simultaneously equal to zero. The R^2 is relatively high at 60%, which indicates that ∼60% of the interviewed consumers' preference variations are explained by the explanatory variables used in the model. This testifies to a good adjustment of the estimated model to the data, and therefore a good explanatory power of the estimations.

The estimated coefficients of the variables specifying the dark red color, the acidity, the local origin, the long, and average conservation duration of tomato were significant at the threshold of 1%. Consumers would, therefore, prefer a tomato with a dark red color, local origin, and non-acidic taste, which can be conserved for a more or less long period. Soft tomatoes with medium flesh firmness are less appreciated by consumers (negative and significant coefficients at the threshold of 1%). In contrast, those with a firm consistency are more desired. This result is in accordance with those of Oltman et al. (2014).

The "price in period of scarcity" variable was significant at the threshold of 1% but had a negative sign. This result suggests that consumers are more sensitive to price changes of locally produced tomatoes during the off-season than tomatoes other than those locally produced during that period and hence may perceive imported tomatoes to be of higher quality than those that are locally produced during the off-season. Specifically, an increase in the price of tomato that generally comes in periods of scarcity limits consumer preference, which suggests that consumers perceive tomatoes as a product that can be easily substituted when they become too expensive. This result is similar to the study of Brumfield et al. (1993), based in New Jersey. Share and Stewart-Knox (2012) and Dekhili et al. (2011) also reached the same conclusion, namely that price is an important factor affecting a consumer's food preferences.

The "local origin" variable was positively significant at a threshold of 1%. This suggests not only that the origin of tomatoes is an important factor for consumers but also that consumers prefer local-origin tomatoes more than imported ones. This result is similar to the empirical results of

Brumfield et al. (1993), who have shown that consumers from New Jersey prefer to consume tomatoes produced locally, as they are considered to be of better quality. This result implies that it is not only the characteristics of tomatoes *per se* that determine their preferences by consumers, as their origin is also important.

The coefficients of the variables "long duration of conservation" and "medium duration of conservation" were positive and significant, indicating that the interviewed consumers would prefer more the profiles of hypothetical tomatoes with the attributes "long duration of conservation" or "medium duration of conservation" than those having the attribute "short duration of conservation". These results demonstrate the importance that consumers give to the capacity of variety of tomatoes produced to be conserved over medium to long periods.

The coefficients of the variables dark red and non-acidic taste were positive and significant at the threshold of 1%, respectively. These results may suggest that tomatoes with dark red color (contrary to those presenting an orange color) and those without any acidic taste, i.e., having a (very) low-acidic content, are more preferred by consumers. These results are similar to a study by Dossou et al. (2007) in Benin in which consumers revealed their willingness to accept tomatoes because of their bright red color, consistency, and taste. Similar results were observed by Rocha et al. (2013) and Causse et al. (2010) among a majority of Brazilian and European consumers (French, Dutch, and Italians).

The coefficient of the interaction between the variables "local origin" and the "medium duration of conservation" was negative and significant at the threshold of 5%. As the effects of the individual variables "local origin" and "medium duration of conservation" on consumers' preferences were positive and significant, the negative and significant effect of their interaction may suggest that at an equal duration of conservation (here medium duration of conservation), imported tomatoes would be more preferred than locally produced ones. This means that the effect of local origin of tomatoes on consumers' preferences is less important when the duration of conservation is short and vice versa. This implies that if locally produced tomatoes have long conservation duration as an attribute, it will be preferred by consumers. The other interaction variables taken into account in the estimated model, price * local origin and dark red * local origin, were not significant. Although the interaction variable of price * local origin is not significant, its negative sign may suggest that, although preferred, locally produced tomatoes could in the long run have preference difficulties because of their high prices. The positive sign (even if not significant) of the interaction variable of dark red * local origin may suggest that, to be accepted by consumers, locally produced tomatoes should be dark red in color (Table 3).

Table 3. Estimation of the parameters of the weighted least squares model and calculation of the parameters for levels of attributes not introduced in the model.

Variables	Estimated coefficients	Variables	Calculations of the parameters
Dark red	1.54*** (0.13)	Orange-red	−1.54***
Medium consistency	−0.51*** (0.11)	Firm consistency	0.83***
Soft consistency	−0.32*** (0.14)	–	–
Non-acidic taste	1.59*** (0.13)	Acidic taste	−1.59***
Local origin	2.33*** (0.79)	Imported origin	−2.33***
Long duration of conservation	2.57*** (0.09)	Short duration of conservation	−5.01***
Medium duration of conservation	2.44*** (0.14)	–	–
Price in scarcity period	−0.001*** (0.0002)	–	–
Interaction price and local origin	−0.001 (0.001)	Interaction price and imported origin	0.001
Interaction dark red and local origin	0.01 (0.20)	Interaction dark red and imported origin	−0.01
Interaction medium duration of conservation and local origin	−0.51** (0.20)	Interaction between orange red and local origin	−0.01
Constant	2.45*** (0.18)	Interaction between medium duration and imported origin	0.51**
F-Statistics	1834.59***	–	–
R^2 adjusted Adj-Squared	0.60	–	–
Observations	9600	–	–

Note. Significant threshold: 1%*** and 5%**; (…): Standard deviation.

Determining the value of the importance of attributes

Estimations of the relative importance of each attribute involved in the consumer's preference are presented in Figure 2. The origin of the variety and taste represent the two most important attributes for tomato consumers, accounting for ∼27% and 23%, respectively, of the total preference. These attributes were followed by the color of the tomato, ∼22% of the total preference. The consistency of the varieties and their price were relatively less important in the preference of consumers (∼8% and 1% of the total preference, respectively).

Segmentation of the potential markets

The estimation results of the Calinski–Harabasz coefficient and of discriminatory analysis are presented in Tables 4 and 5, respectively. The maximum value for the Calinski–Harabasz coefficient was obtained for the four segments solution (Table 4). The discriminatory analysis according to the different attributes and the sociodemographic characteristics (Table 5) reveals that the first segment was made of tomato consumers (6.9%), the majority of whom were women living in urban area, with an average age of 34 years. The average daily expenditures were estimated to be FCFA 796 (i.e., 1.21 Euros at an exchange rate of 1 Euro = 656 FCFA). Tomato consistency was the major criterion of choice for individuals in this segment.

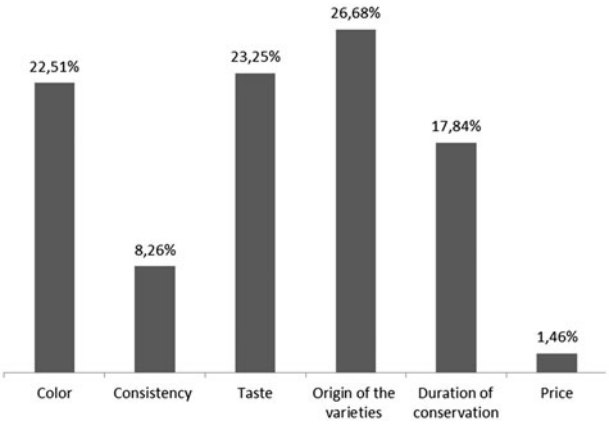

Figure 2. Estimating the relative importance of the attributes.

Table 4. Calinski–Harabasz coefficient or pseudo-F.

Number of classes	Calinski–Harabasz coefficient or pseudo-F
2	26.04
3	18.47
4	26.82
5	20.91

Table 5. Consumers' preferences according to market segmentation.

Variables	Segment 1: Young urban women spend less on tomatoes (6.9%)	Segment 2: Young urban women spend on tomatoes (59.1%)	Segment 3: Elderly urban women spend less on tomatoes (19.0%)	Segment 4: Young urban women spend less on tomatoes (15.0%)	Statistical test
Consistency	1.51	0.33	1.14	0.69	11136.13***
Taste	0.55	2.20	0.30	1.20	7436.79***
Duration of conservation	1.45	4.22	0.31	2.12	6784.48***
Age	34.30	34.18	35.32	34.26	4.87***
Expenditures on tomato	796.38	836.20	789.12	790.62	3.21***
Place of residence					
Urban (%)	86.7	81.5	87.8	83.3	44.864***
Suburb (%)	13.3	18.5	12.2	16.7	44.86***
Sex					
Female (%)	83.7	82.3	80.6	85.0	11.21**
Male (%)	16.3	17.7	19.4	15.0	11.21**
Level of education					
None (%)	32.2	32.7	34.4	38.2	16.61***
Primary (%)	24.7	21.0	25.4	20.4	20.07***
Secondary (%)	31.6	31.8	29.1	30.1	5.16
Higher (%)	11.5	14.5	11.1	11.3	22.04***
Size of the household	2.98	3.72	3.72	3.134	11.97**
Number of individuals (%)	6.9	59.1	19.0	15.0	–

Note. Significance thresholds: 1%*** and 5%**.

The second largest segment (59.1%) was women living in urban areas, like consumers of the three other segments (1, 3, and 4). Consumers in this segment belonged to a household composed of four people on average and spent approximately FCFA 836 per week on tomatoes (i.e., 1.28 Euros at an

exchange rate of 1 Euro = 656 FCFA). The most important tomato attribute for consumers of this segment was the conservation duration of tomato. The third segment was composed of consumers (19%) who spent on average FCFA 789 per week on tomatoes (i.e., 1.20 Euros at an exchange rate of 1 Euro = 656 FCFA). The majority of this segment was made of illiterate individuals (34.4%), and only 29.1% had a secondary education level. The most important attribute for these consumers was tomato consistency.

Consumers of the last segment belonged to households composed on average of 3 persons and spent on average more than CFA 790 per week on tomatoes (i.e., 1.20 Euros at a fixed exchange rate of 1 Euro = 656 FCFA). The major attribute that consumers of this segment valued was the duration of conservation. This segment was made up of more illiterate individuals (38.2%) than the other segments (1, 2, and 3); only 20% had a primary education level.

Simulation market shares

Figure 3 shows the simulation results of the market shares of the four tomato profiles (Mongal, Akikon, Thorgal, and Tounvi) according to an increase in prices, at the levels of the four identified segments. For all consumers, the results indicate that an increase in price led to an increase in Tounvi's market share and a slight decrease in market share of the other three varieties (Morgal, Akikon, and Thorgal). Regardless of the price level, the Tounvi variety had the largest market share (at a price of 900 and 1200 FCFA/Kg, its respective market share was 32.28% and 35.6%). This result shows that consumers are very sensitive to the Tounvi variety. This result joins those of Afangbedji (2007) and Agrobénin (2013).

Taking into account intrasegment variations, the local Tounvi and Thorgal imported varieties were the most preferred varieties by consumers of segment 1 (young urban women who spend less on the tomatoes) regardless of the level of price fluctuation. However, unlike the Thorgal variety, the market share of the Tounvi variety tends to decrease as the price increases. In the segment of young urban women who do spend on tomatoes (segment 2), the Morgal imported variety was the most preferred by more than 37% of consumers compared with other varieties, when the price was low (900 FCFA). An increase in the price from 900 to 1000 FCFA/Kg results in a decrease in the Morgal's market share and an increase in that of the other varieties, especially for the Akikon variety (from 24.08% to 29.05%). Therefore, an increase in the price of Morgal would imply a substitution of this variety with the other varieties, specifically Akikon. As regards the market segment 3 (composed of elderly urban women who spend little on tomatoes) and market segment 4 (young urban women who

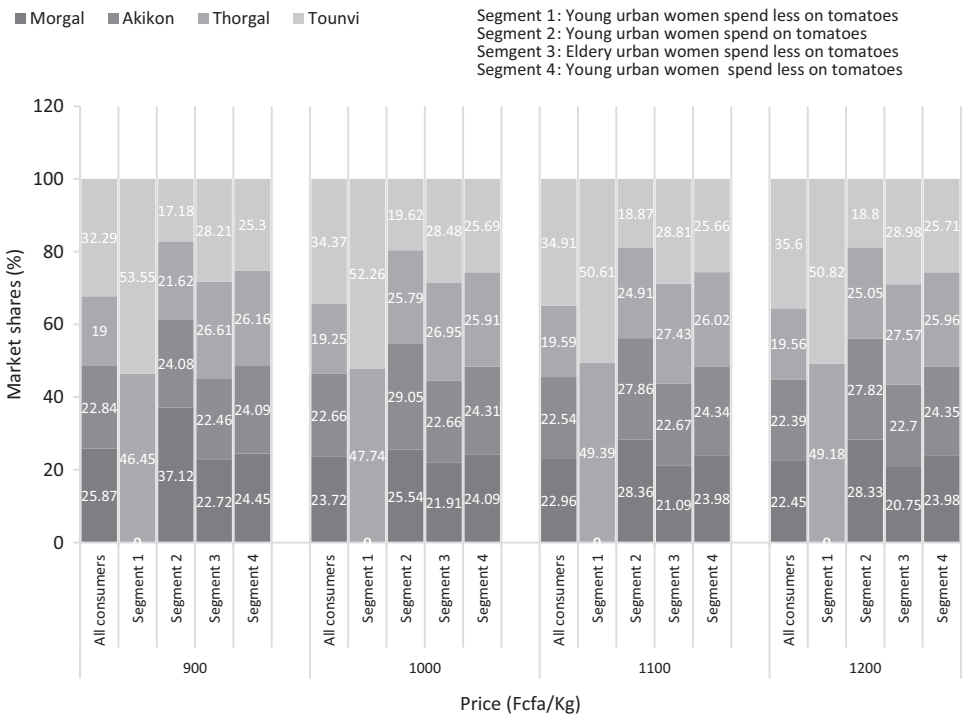

Figure 3. Estimated market share of local (Tounvi, Akikon) and imported (Morgal, Thorgal) varieties with increment of price.

spend less on tomatoes), the Tounvi and Thorgal varieties were the most preferred, respectively, regardless the level of price variations. A rise in the price led to a slight increase in the market share of these two varieties and therefore a decrease in that of Akikon and Morgal.

Considering intersegment variations, the Tounvi variety was the most preferred by consumers of the segments 1 and 4 regardless of the level of price variations. Consumers in the market segment 2 had a strong attachment to the Morgal variety. Any price changes would particularly affect purchasing behaviors of consumers in the segments 1; 2; and 4, and would have an undeniable effect on the preferences of consumers in the segments 1 and 4 who would switch to the imported Thorgal variety. In contrast, consumers in the market segment 2 would tend to intuitively switch their preference toward the imported Morgal variety.

Conclusion

The objective of this study was to analyze the most desired tomato characteristics by Benin consumers and the heterogeneity of preferences by using a conjoint analysis method. The results show that six major attributes are preferred by consumers during their decision to choose a tomato: color,

duration of conservation, conservation, taste, origin of varieties, and price. The importance given to each of these attributes varies according to the consumers, thus indicating the heterogeneity of the expressed preferences. The identification of the market segments based on the expressed preferences and the socioeconomic and demographic characteristics of the consumers led to four segments. Two of the market segments have a great preference for local tomatoes, those that can be conserved over a long period, and tomatoes with a firm consistency. Only one segment of consumers prioritizes price in their preference.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix

Table A1. Principal component analysis (PCA).

Attributes	Component 1	Component 2	Component 3
Origin of varieties	0.934	0.190	–0.112
Water content	0.892	0.218	–0.147
Color	0.869	0.271	–0.154
Shape	0.823	–0.001	–0.213
Utilization of chemical products	0.749	0.181	0.445
Consistency	0.748	–0.148	–0.146
Taste	0.575	0.244	0.030
Weight	0.095	0.875	0.208
Duration of conservation	0.172	0.814	–0.006
Size	0.010	0.807	0.135
Foreign bodies	0.275	0.750	–0.330
Price	0.242	0.083	0.857
Total variance (%)	44.731	20.292	8.914

Table A2. Design of the conjoint experiment.

								Average of preference notes			
								Cotonou		Porto-Novo	
Profiles	Color	Taste	Price during abundance	Price during scarcity	Consistency	Duration conservation	Origin	Urban	Suburb	Urban	Suburb
1	Dark red	Non-acidic	600	1200	Soft	Long	Local	3.04	3.76	6.05	5.18
2	Dark red	Non-acidic	600	1200	Firm	Long	Imported	3.47	4.94	5.92	2.78
3	Dark red	Non-acidic	600	1200	Medium	Long	Imported	2.76	3.74	2.44	1.81
4	Dark red	Non-acidic	600	1200	Soft	medium	Local	1.47	2.63	1.41	2.37
5	Dark red	Non-acidic	400	900	Firm	short	Local	4.85	5.41	5.19	5.18
6	Dark red	Non-acidic	600	1200	Medium	long	Local	1.94	2.83	1.51	1.87
7	Dark red	Non-acidic	400	900	Medium	Medium	Local	5.07	4.75	4.62	3.53
8	Dark red	Non-acidic	400	900	Firm	Long	Imported	2.19	2.38	3.40	1.12
9	Dark red	Non-acidic	600	1200	Firm	Short	Local	2.04	2.33	2.29	1.37
10	Dark red	Non-acidic	400	900	Firm	Medium	Imported	1.98	2.31	2.08	1.56
11	Dark red	Non-acidic	400	900	Firm	Long	Local	9.36	8.15	9.47	9.09
12	Dark red	Non-acidic	600	1200	Firm	Medium	Imported	3.14	4.90	2.80	1.5
13	Dark red	Non-acidic	400	900	Medium	Short	Imported	1.82	2.15	1.14	1.40
14	Dark red	Non-acidic	400	900	Soft	Long	Imported	1.41	2.14	1.24	1.12
15	Dark red	Non-acidic	600	1200	Soft	Short	Imported	1.66	2.77	1.69	1.12
16	Dark red	Non-acidic	600	1200	Firm	Medium	Local	2.19	2.52	2.72	1.37

Table A3. Classification of condiments used to replace tomato fruit in case of scarcity.

	Cotonou		Porto-Novo	
Condiments	Average rank	Ranking	Average rank	Ranking
Onion	1.47	1	1.51	1
Tinned tomato	2.76	2	2.50	2
Palm nuts	2.77	3	2.50	2
Big dried pepper	3.21	4	3.58	4
Aubergine	4.78	5	4.91	5
Kendall concordance test	0.57***		0.67***	

Note. Significance thresholds: 1%***.

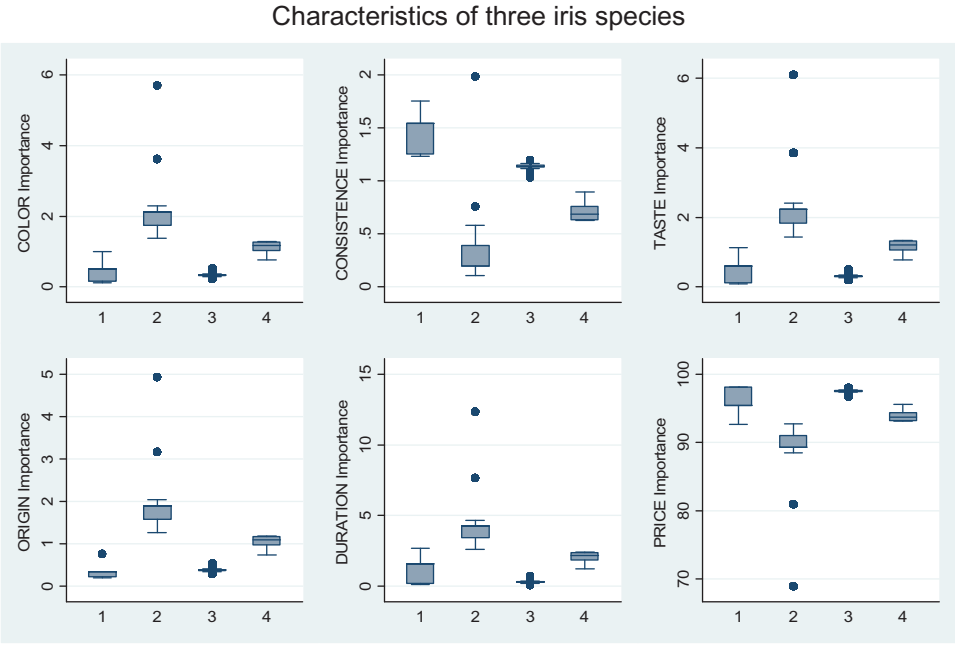

Figure A1. Graph translating the preference of individuals according to the segment.

Table A4. Classification of individuals in each group according to their preference.

Type of segment	1	2	3	4
Number well classified	661	5671	1710	1372
Number badly classified	116	70	0	0
Total	777	5741	1710	1372
Proportion of good classification (%)	85.1	98.8	100	100
Global classification rate	98.1%			