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Descriptive Sensory Analysis, Consumer Liking and Preference Mapping for Solar Dried Mango cv *Dodo*

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Abstract
Descriptive sensory characteristics, consumer liking and preference mapping of solar dried mango cv *Dodo* were investigated in this study. Three solar drying methods solar cabinet direct dryer (CDD), cabinet mixed-mode dryer (CMD) and Tunnel dryer (TD) were used to dry mango samples while fresh sample was used as control. Descriptive sensory analysis was performed by 15 trained panelists who used 6 descriptors to quantitatively describe the sensory characteristics of mango samples while 78 consumers were used to assess the degree of liking of products' sensory attributes using nine-point hedonic scale. External preference mapping was performed by relating sensory data with hedonic responses. Randomized complete block research design with panelists and samples as main principal factors was used. The results showed significant differences ($p<0.05$) in mean intensity scores of whiteness, hardness and sweetness attributes with dried samples having higher values than their fresh counterparts. Fresh sample had significantly ($p<0.05$) higher colour intensity score than dried samples. The consumer study showed that, with exception of taste attribute, consumers showed significant ($p<0.05$) differences in colour, texture, mouth feel and overall acceptability with fresh samples having higher values than dried counterparts. Moreover, the preference mapping results showed colour and acidity (flavour) attributes to be the main driver for positive consumer preference for fresh samples. Among the drying methods, tunnel dryer showed a relatively close relationship with these attributes than cabinet dryers. In conclusion, solar drying has significant effect on sensory attributes of dried mango especially colour and flavour which is also dependent on the drying method employed. Therefore, selection of appropriate drying method which will retain these attributes is of greater importance for consumer acceptability and marketability.
Keywords: Mango, Sensory, Descriptive, Consumer, Preference Mapping

1. Introduction

Fruit and vegetables are of greater nutritional importance since they make a significant contribution in supplying wealth of essential vitamins, minerals, antioxidants, fibre and carbohydrate that improve the quality of the diet (Barrett, 2008). However, despite their nutritional and health benefits, many fruits and vegetables, mango inclusive are highly seasonal and perishable resulting into huge postharvest losses (Idah and Aderibigbe, 2007). According to Karim and Hawlader (2005), the post-harvest loss in fruits and vegetables is estimated to be 30-40 % in developing countries. Some of the major contributing factors are poverty, inadequate postharvest handlings, lack of appropriate processing technology and storage facilities, poor infrastructure as well as poor marketing systems (Perumal, 2007).

Drying of fruits and vegetables is one of the oldest procedures for food preservation known to man (Sobukola *et al.*, 2006). It is a process that involves removal of biologically active water to a safe level that reduces deteriorative chemical reactions, provides microbiological stability and extends the shelf life of dried products (Perumal, 2007). Furthermore, it substantially reduces weight and volume; minimize packaging, storage and transportation costs (Sagar and Suresh, 2010). Sun drying is a well-known method for drying agricultural commodities immediately after harvest, especially in developing countries. However, sun drying is plagued with in-built problems, since the product during drying is unprotected from rain, storm, windborne dirt, dust and infestation by insects, rodents, and other animals (Folaranmi, 2008). Consequently the quality of dried products may adversely be affected, failing to meet the required local and international standards (Ivanova and Andonov, 2001). Moreover, mechanical drying such as freeze, drum and cylone drying, which could otherwise be used is costly and hazardous to environment; hence more importance is given nowadays to use solar energy as an alternative in drying agricultural produces (Eltief *et al.,* 2007). However, it has been noted that, drying at higher temperatures may cause damage to sensory attributes such as colour, texture and flavor of the dehydrated products (Praveenkumar *et al.,* 2006). Despite adequate literature review, information on the sensory quality of solar dried mango in Tanzania is limited.

The sensory quality is what consumers perceive directly and is the ultimate measure of product quality (Drake

2007). Therefore, analysis of sensory quality serve as a guide for understanding deviation from specifications and for application of appropriate corrective measures during processing and storage of food products. The analysis is made possible through employment of basic techniques such as descriptive sensory analysis, consumer test and preference mapping. Descriptive analysis is a sensory methodology that provides quantitative descriptions of all the sensory attributes of a food or product products, based on perceptions of a group of qualified assessors while consumer test is a methods used to assess whether the consumers like the product, prefer it over another product or find the product acceptable based on its sensory characteristics (Lawless and Heyman, 2010). Preference mapping is a perceptual map that describes which attributes contributed to consumer liking by using the relationship distances of consumers' hedonic judgments and/or a matrix of descriptive sensory data (Tenenhaus *et al*. 2005) In short, it helps in understanding the descriptive sensory attributes that influence consumer preferences (Murray and Delahunty, 2000). Two main types of preference mapping are normally applied in sensory science; internal preference mapping and external preference mapping. In internal preference mapping, the process begins with performing PCA or other multivariate analyses on the consumer data while in external preference mapping, the process begins with performing the PCA on descriptive sensory data and the results of the PCA are related to the consumer data.
Therefore, this study was carried out to evaluate the sensory profiles, consumer liking and external preference mapping of solar dried mango samples from different drying methods in order to establish their sensory quality.

2. Materials and methods

2.1. Materials

Mango (*Mangifera indica* cv. *Dodo*), were procured at physiological maturity and ripeness from selected farmers in Morogoro Region, Tanzania and dried using three different solar drying methods. The samples were collected from farmers in order to ensure freshness of the produce and for proper post-harvest handling prior to preparation and drying. A total of 320 mangoes were sampled for the study. The indicated amount had been predetermined to give one kilogram of dried product in each dryer

2.2. Methods

2.2.1. Research design

Complete randomized block design (CRBD) was used in the study and the principal factors were drying methods (Fresh-control, (FR), cabinet direct dryer (CDD), cabinet mixed mode dryer (CMD) and Tunnel dryer (TD)) and panelists. The effects of these factors on sensory attributes during drying were determined. The mathematical expression is

$$yij = \mu + \tau_i + \beta_j + ij\ \varepsilon$$

Where

μ = the overall mean
$i\ \tau$ = the ith treatment effect (Samples)
$j\ \beta$ = the jth block effect (Assessors)
$ij\ \varepsilon$ = the random effect

2.2.2. Drying procedures

Solar drying of fresh mango was done by procedure explained by King'ori *et al.* (1999). Fresh mature ripe mango samples were washed, peeled and sliced to 5 mm thick and each sample divided into 3 portions that were subjected in equal loading density of 2.91 kg/m^2 to either cabinet direct dryer (CDD) with temperature ranging from 30-55ºC for about 3 days, cabinet mixed mode dryer (CMD) with temperature ranging from 25-49ºC for about 3 days and tunnel dryer (TD) with temperature ranging from 30-73ºC, for about 2 days. These temperatures were not preset but obtained during drying process and samples were offloaded from dryers after predetermined moisture levels were obtained after the stated duration. The dried products were packed in polyethylene bags and stored at -4º C prior to sensory analysis.

2.2.3. Quantitative descriptive analysis (QDA)

A descriptive sensory profiling was conducted at the Department of Food Science and Technology by trained sensory panel of 15 assessors, comprising of 8 males and 7 females with age ranging from 23 to 28 years according to method described in Lawless and Heyman (2010). The assessors were selected and trained according to ISO Standard (1993). In a pre-testing session the assessors were trained in developing sensory descriptors and the definition of the sensory attributes. The assessors developed a test vocabulary describing differences between samples and they agreed upon to 6 descriptors for whiteness, colour, aroma, sweetness, hardness and acidity attributes (Table 1). An unstructured line scale was used for rating the intensity of an attribute. The left side of the scale corresponded to the lowest intensity of each attribute (value 1) and the right side corresponded to the highest intensity (value 9). Descriptive analyses of 4 fresh and dried samples were carried out in two sessions and each assessor was evaluating 2 samples per session. The samples coded with 3-digit random numbers were served to each panellist in a randomized order and instructed to rate the whiteness,

colour, aroma, hardness and sweetness attributes. Water was served alongside samples for rinsing mouth before evaluating other samples during the test. The average response were used in the univariate and multivariate analyses

2.2.4. Consumer test

The test was carried out in the Department of Food Science Laboratory by 78 untrained consumers aged 18 and above years arrived in groups of 10 using a 9 point hedonic scale (where 1 = dislike extremely and 9 = like extremely) as described by Lawless and Heyman (2010). The samples were sliced into pieces of uniform thickness (2 cm), coded with 3-digit random number using statistical random tables and served to the panellists at around 10.15 a.m. with distilled water in a randomized order. The judges were instructed to rate the colour, aroma, taste, and texture, mouth feel and overall acceptability attributes indicating their degree of liking or disliking by putting a number as provided in the hedonic scale according to their preference. Testing completed in one session and each consumer evaluated all 12 samples with a 10-minute break after four samples were tasted. Sample evaluation was conducted under the same conditions as for the sensory descriptive test.

2.2.5. Statistical data analysis

The data were analysed by using R statistical package (R Development Core Team, Version 3.0.0, Vienna, Austria) for one-way and two way analysis of variances to determine the significant differences and interaction between the factors means at ($p<0.05$). Means were separated by Turkey's Honest Significant Difference at $p<0.05$. Principal component analysis (PCA) and partial least squares regression (PLSR) were performed using the Unscrambler statistical package (Camo, version 8.0, Oslo, Norway). The main sources of systematic variation in the average sensory descriptive results were determined by using Principal Component Analysis (PCA) while the relationship between descriptive data and hedonic liking from the consumers were determined by PLSR. The variables were standardized and full cross-validation was applied. Correlation loading plots were applied with circles indicating 50 and 100% explained variance, respectively. In the correlation loadings plots products were included as dummy variables to improve the visual interpretation as described by Martens and Martens (2001)

3. Results and discussion

3.1. Quantitative Descriptive analysis (QDA)

3.1.1. Assessors' effect

Figure 1 shows the F plot for assessors' effect on each attribute. The result shows no significant variations in all attributes between assessors. This implies that assessor had similar agreement in judging these attributes.

3.3.2. Product effect

Mean intensity ratings of descriptive attributes of samples are shown in Figure 2. The results showed significant ($p<0.05$) differences in intensity scores between fresh and dried samples and between dried samples under different drying methods. Dried samples had significantly higher mean intensity scores in whiteness, hardness and sweetness than their fresh counterparts which had only higher colour scores. The variation among drying methods was significant ($p<0.05$) in hardness with tunnel dried samples having higher intensity score than cabinet dried samples.

3.2. Consumer studies

Demographic and consumption characteristics of consumers are shown in Table 2. The results show that, out of 78 consumers participated in the study, 61.5% were males and 38.5% were females. Most of these consumers, 77% were between 15-30 years while only 3% were between 46-60 years old suggesting youth dominance in the study. As for consumption frequency, the results showed majority of the consumers, 92.3% are seldom consumed the products. This suggests that consumers in this study consumed dried mango infrequently.

The mean hedonic scores of consumers for fresh and dried mango samples are presented in Table 3. With exception of taste attribute, consumers showed significant ($p<0.05$) differences in all other attributes evaluated. Fresh samples scored higher values than dried counterparts in colour, mouth feel and overall acceptability. Furthermore, drying methods differed significantly ($p<0.05$) in texture attribute only, with tunnel dryer having scored lowest value.

3.4. Preference mapping

3.4.1. Principal component of descriptive sensory data

Figure 3 shows bi-plot with the two first significant principal components from principal component analysis (PCA) on average sensory attributes. The results show principal component (PC) 1 accounted for 81.7% of the systematic variation in the data while principal component (PC) 2 accounted for 17.9%. Fresh and dried samples were well separated. Dried samples correlated positively with descriptive attributes whiteness, sweetness, hardness and aroma and they correlated negatively with acidity and colour attributes. Fresh correlated positively with attribute acidity and colour. The results indicate, the variation between samples was explained by attributes

aroma, hardness, sweetness and whiteness on one side and attributes colour and acidity on the other side along PC 1, while PC 2 was mainly described by variation in whiteness and the remaining attributes.

3.4.2. Relationship between descriptive data and hedonic liking by PLSR

Figure 4 shows the results from a partial least square regression (PLSR) using descriptive data as X-variables and liking rated by the consumers as *Y*-variables. The finding shows that, the explained variance was relatively high; the two first significant components described 61% of the variation in *Y*. The figure shows that almost all the consumers fall to the right of the vertical Y-axis, outside the 50% explained circle which means that, the acceptance values of these persons go in the direction of fresh sample associated with colour and acidity. It indicates that, in mango consumer showed a strong preference for fresh samples than dried ones. The x-axis showed similar high preference for fresh and tunnel dried samples due to their high association with colour and acidity and none preferred direct and mixed dried samples due to their whiteness (loss in colour saturation).

The findings have shown that, solar drying has significant effect on sensory attributes of mango mainly colour and flavour attributes. Colour change during drying may be attributed to a number of chemical and biochemical reactions and the rates of such reactions depend strongly on the drying methods and the processing parameters (Bonazzi and Dumoulin, 2011; Al-Juamily *et al*., 2007). Discoloration due to browning and pigment degradation is one of colour-related problem that is always encountered during drying and long-term storage of dried fruits and vegetables (Maskan, 2001). Phenolic compounds often contained in fruit and vegetable products are oxidized and polymerized to form brown pigments, melanin (Perera, 2005). It has been reported that, the change in the brightness of dried samples can be taken as a measurement of browning (Tijskens *et al*., 2001). Krokida, Maroulis, and Saravacos (2001) found that the conventional air drying to cause extensive browning with a significant drop of the brightness and an increase in the redness and yellowness of dried potato.

The increase in sweetness in dried fruit samples could be attributed to moisture removal accompanied with increasing the concentration of flavour compounds in the remaining mass. For instance, sugars in fruits are concentrated and dried products becomes sweeter that their fresh counterpart (UNIDO, 2001). Texture is one of the quality parameters and its change in dried samples indicates a quality change. Gabas *et al. (*2007) associated changes occurring during drying to collapse of structure due to heat application with resulting firmer texture and increased chewiness. Various studies in tomato (Doymaz, 2007), mango (Mercer and Myhara, 2008), pineapple (Karim, *et al.,* 2008 and banana (Cano-Chauca *et al.,* 2002) have reported changes in textural properties during drying.

The varied consumers' preferences provided insight into the sensory attributes that are important to individual consumer acceptability of samples. Preference mapping results showed colour and acidity (flavour) as the most important drivers for positive consumer liking of fresh samples under the study. This goes in line with the report by Methakhup *et al*. (2005) that colour and appearance are the initial quality attributes that attract person to a food product and thus considered as an index of the inherent good quality of foods associated with the acceptability of food. Therefore, drying methods that retains most sensory attributes especially colour and flavours of dried samples are of greater consideration for consumer acceptability and marketability. Preference mapping results has shown close relationship between tunnel dryer and both attributes while only flavour has been associated with cabinet dryers.

4. Conclusion

Solar drying has effect on the mango with colour and flavour being the most affected sensory attributes. The attributes have been observed to be the drivers for positive consumer preference for fresh and dried products respectively. Among the drying methods, tunnel dryer has shown to perform better in retaining these attributes compared to cabinet dryers. Therefore, a better choice of methods and operations that will retain sensory attributes mainly colour and flavor should be considered before drying process commence for high consumer acceptability and marketability

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Table 1: Definitions of sensory attributes used in descriptive sensory analysis

Attribute		Definition
Colour	Colour hue	Yellow/red to red/blue
	Whiteness	Degree of white/black in the colour
	Colour intensity	Clear, strong colour
Aroma	Fruity	Aromatics associated with fresh fruit
Taste	Sweetness	The taste associated with sucrose solution
	Acidity	The taste associated with citric or malic acid
Texture	Hardness	The force to compress a sample via first compression (The force required to bite through the sample)

Table 2 Demographic and consumption characteristics of consumers

Characteristic		N	(%)
Sex			
	Male	48	(61.5)
	Female	30	(38.5)
Age group			
	15-30	61	(77.0)
	31-45	15	(19.2)
	46-60	3	(3.8)
Consumption Frequency	1-2 times/week	4	(5.1)
	3 or more/ week	2	(2.6)
	Seldom	72	(92.3)

Table 3: Mean hedonic scores for the fresh and dried mango samples

Drying methods	**Attributes**					
	Colour	**Taste**	**Aroma**	**Texture**	**Mouth feel**	**Overall accept**
FR	8.0 ± 0.7^{a}	7.8 ± 0.9^{a}	7.1 ± 1.3^{a}	7.3 ± 1.1^{a}	7.5 ± 1.3^{a}	7.5 ± 0.8^{a}
CDD	7.0 ± 1.0^{b}	7.4 ± 1.1^{a}	7.4 ± 1.5^{a}	7.1 ± 1.7^{a}	6.7 ± 0.9^{b}	6.8 ± 1.0^{b}
CMD	6.8 ± 0.9^{b}	7.3 ± 1.0^{a}	6.2 ± 1.6^{b}	7.0 ± 1.1^{a}	6.7 ± 0.9^{b}	6.7 ± 0.8^{b}
TD	7.3 ± 1.3^{b}	7.5 ± 0.7^{a}	6.7 ± 1.4^{ab}	6.1 ± 0.8^{b}	6.3 ± 1.5^{b}	6.9 ± 1.6^{b}

Different letters along the column indicate values are significantly different ($p<0.05$)

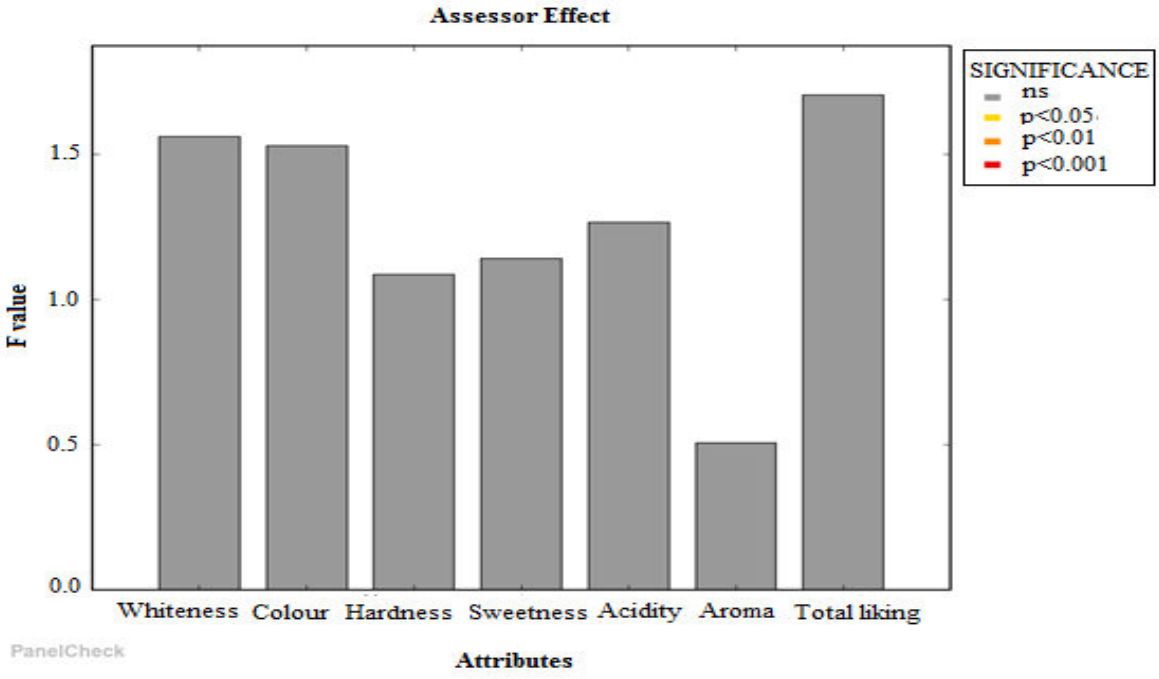

Figure 1. F-value plot for each attribute for assessors' effect

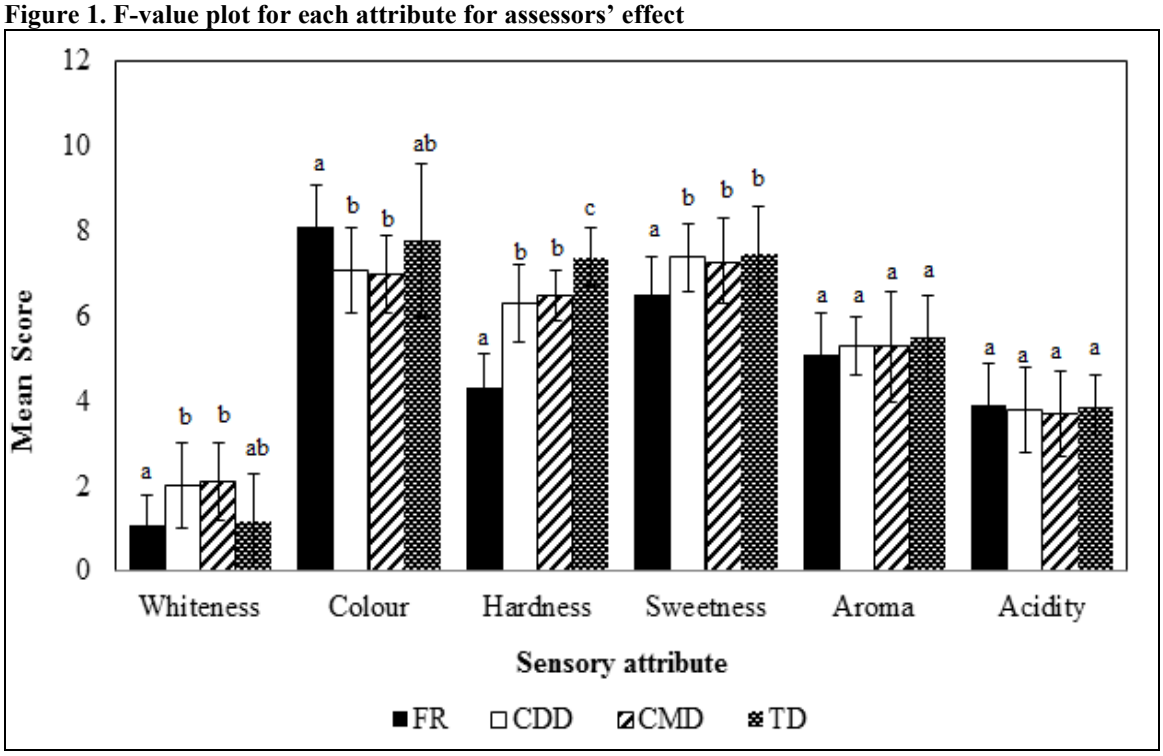

Figure 2. Mean intensity scores of descriptive attributes of fresh and dried mango samples. Bar indicates mean±SD and those with different letters are significantly different at p<0.05

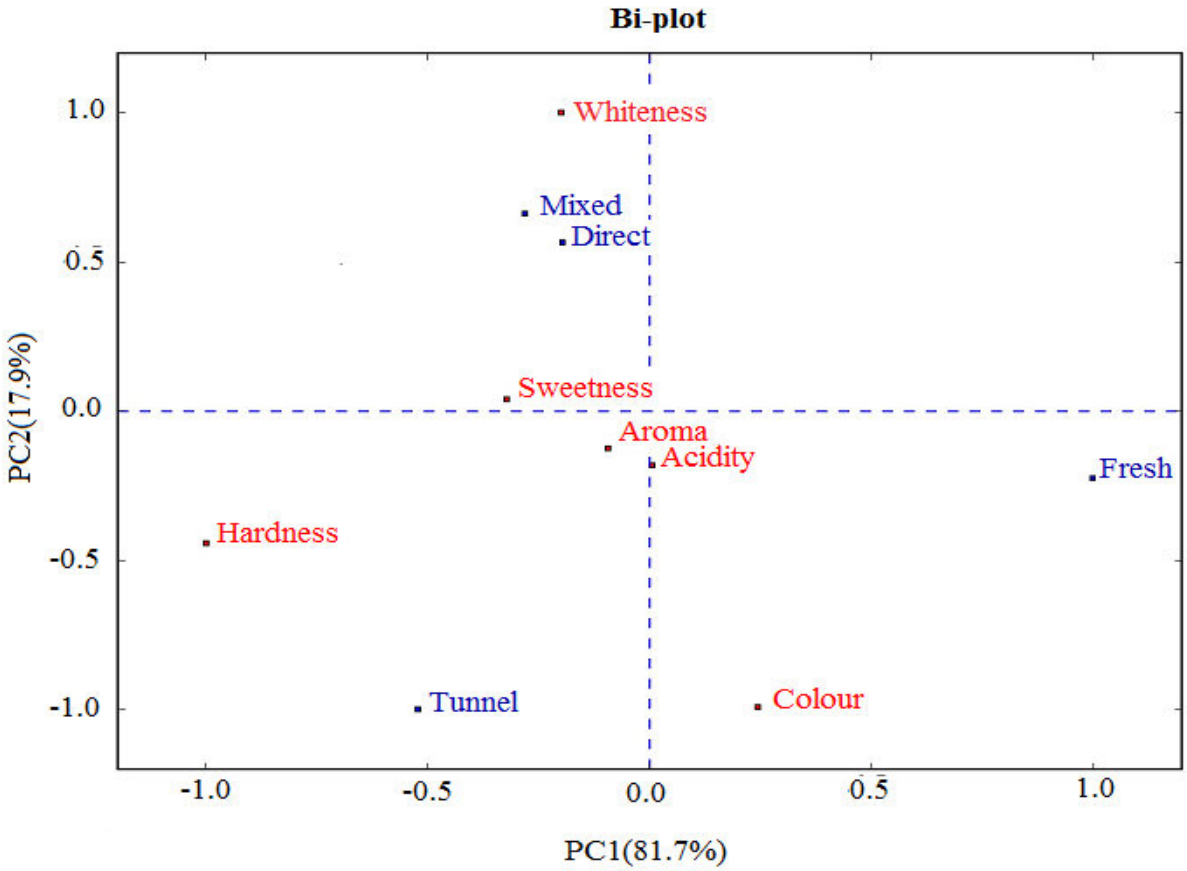

Figure 3 Bi-plot from PCA of descriptive sensory data for fresh and dried mango samples

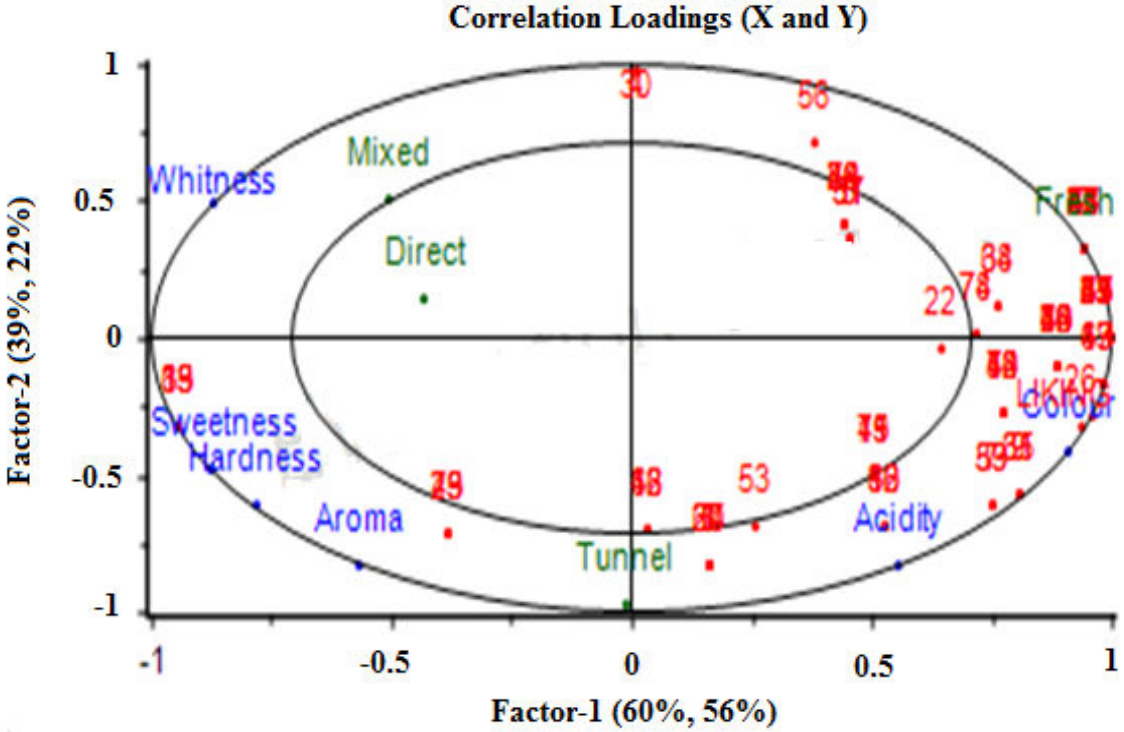

Figure 4. Correlation loadings from a partial least squares regression of fresh and dried mango samples with descriptive data as X variables and hedonic rating as Y variables