Farmer preferences for cooking characteristics of local rice and implication for food security in sub-Saharan Africa: A Community-based evaluation approach

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Abstract

Farmers are the first consumers of the rice they produce and then, their choice for any types of rice consumed is supposed to depend strongly on the product characteristics that give them the high level of satisfaction. Among these characteristics, those of cooked rice: aroma, easy of cooking, swelling capacity, stickiness, storage and taste are key determinants. This study identified the most preferred cooking characteristics of five types of local rice varieties by the communities of farmers in rice sector development hubs of 10 African countries namely Benin, Cameroun, Cote dôIvoire, Ghana, Gambia, Mali, Nigeria, Senegal, Sierra Leon and Togo.

These types of rice including both traditional and improved local rice were submitted to the appreciation of communities of rice farmers during the baseline surveys conducted for various projects from 2013 to 2014 in 459 communities. The data were collected using a multistage stratified random sampling and a community-based evaluation approach.

Results from Principal Component Analysis showed that rice farmers have generally a good appreciation of the cooking characteristics of rice. Specifically, the characteristics such as aroma, easy of cooking, long time storage after cooking and good taste were the most appreciated by these communities among the six characteristics. However, that middle assessment varies according to each country and types of rice. Given this middle farmersô appreciation, the communities of researchers and policy decision makers should continue efforts to improve specific attributes in rice mostly targeted in each selected country in order to preserve food security for the selected communities of farmers. In future, this action could be turned in incentive bringing rice farmers to produce more over their own need for the market.

Key words: *Traditional and improved local rice, cooking characteristics, food security, principal component analysis.*

1. Introduction

Rice has become critical for food security and political stability throughout Africa, especially in West Africa (AfricaRice, 2011). Between 2007 and 2010, rice consumption in Africa increased at a rate of 4.41% per year, despite the upsurge in rice price during the food crisis (AfricaRice, 2012). This strong demand for rice could be explained by the combined effects of urbanization, population growth, income, change in consumersô preferences in the urban and rural areas and other factors such as relative ease of storage and preparation of rice when compared to other foods (AfricaRice, 2011; USAID, 2009; Calpe, 2006). This pattern in rice consumption in Africa results from individual African country. For instance, the countries with the highest growth rates in rice consumption over the whole period of 2001-2010 were Benin (17.41%) followed by the Gambia (10.20%) and Liberia (8.77%) (AfricaRice, 2012). As a consequence, rice consumption outpaces rice production, leading to a relatively low self-sufficiency ratio estimated at 76% for Africa, 37% for Central Africa, 84% for East Africa, 133.6% for North Africa, 2.1% for Southern Africa and 64% for West Africa, indicating a level of reliance on rice imports in average about 24% for Africa as whole (AfricaRice, op cit.).

Rice is playing a key role in providing food security for low-income households of rural and urban populations. It is clear since 2008 crisis that rice is no longer a luxury food, but a staple food which is the leading provider of food calories in West Africa and Madagascar and it is now the third largest source of food energy in Africa as a whole (AfricaRice, 2011).

With consistent increases in rice demand, several brands of rice from various sources are observed in most of African markets. These brands of rice include both those of locally produced and imported rice. The various types of local rice consumed in Africa come from a range of traditional and improved rice varieties developed by research and adopted by rice farmers. The research efforts made in the past decades around the world to increase rice productivity, have led to the creation of many improved rice varieties with high potential yield and good characteristics that can prevent or mitigate the effects of the various biotic and abiotic stresses (Diagne *et al.*, 2014). According to AfricaRice (2011), an average of nearly 200 local improved rice varieties were released and grown in Africa by the small farmers. These improved varieties include those of NERICA grown in rainfed and lowland ecologies and the Sahel varieties cultivated in irrigated ecology. In addition to these, there are the traditional varieties which are widely grown by African rice farmers. At least, the half of their production is consumed in rural area and they sold the surplus on the outside food markets. In Senegal for instance, Demont (2005) showed that less than half of the local commercialized rice reaches the urban and semi-urban markets and the other half is sold in rural areas further inland.

However, according to Diagne *et al.*, (2013), the adoption of the ñimprovedò varieties remains so far low in SSA probably due to other characteristics than previous mentioned. It has been observed and documented that farmersô selection criteria for adopting varieties include many other attributes of varieties and some variety traits are often more preferred than yield potential (Diagne *et al.*, 2013; Dalton, 2004; Seidi and Adesina, 1995; Adesina and Zinnah, 1992a). In fact, one strategy used by some many subsistence farmers is to mix grow several varieties in a small plots because of the impossibility to find all desired characteristics in one single variety. Thus, any portfolio of adopted varieties implies some preference for particular set of varietal characteristics relative to others. In fact, any new variety can be viewed as a bundle of characteristics (Lancaster, 1971). According the new approach to consumer demand of Lancaster (1966), consumers derive utility from attributes of goods rather than the goods itself. This means that it is product characteristics that explain why consumers prefer certain products to others in the same category. The consumers can be outside person of production unity or directly involve in the production. The farmers are the first consumers of the rice they produce. Then, the choice of farmers as consumers for any types of rice consumed is supposed to depend on the product characteristics that give them the high level of satisfaction. Among these characteristics, those of cooked rice are key determinants. This study contributes to the literature on consumersô preferences analysis by focusing on the determinants of farmersô criteria for the choice of rice varieties they grow firstly for their own consumption. The main objective of the study was to identify the preferred cooking characteristics of types of local rice by the communities of farmers in rice sector development hubs of 10 African countries namely Benin, Cameroun, Cote dôIvoire, Ghana, Gambia, Mali, Nigeria, Senegal, Sierra Leon and Togo.

The rest of the paper is organized as follows: Section 2 presents the material and the method through one hand, the description of the concept of "Hub" and its implementation by AfricaRice, and also the description of the area study. Methods of sampling, data collection and data analysis are presented in Section 3. Section 4 in turn, presents the main results of the study and discussion. Finally, the main conclusions and some recommendations are made.

2. Material and methods

2.1. Study area

The study focused on *Rice Sector Development Hubs* in selected African countries. Hubs are the third mechanism of Africa Rice Center through of which it research program is being conducting. They are key rice growing environments where research products are integrated across the rice value chain to achieve development outcomes and impact. Hubs include key rice ecologies and different market opportunities across African countries and are linked to major national or regional rice-development efforts to facilitate broader uptake of rice knowledge and technologies. The geographic positioning of each hub was determined in national workshops, convened by the NARS. Large groups of farmers and other value-chain actors, such as rice millers, input dealers and rice marketers were involved in the hubs. National scientists, extension workers and NGOs are also strongly involved in the hubs activities by introducing, evaluating and validating new rice technologies, and facilitating training of farmers, dissemination of technologies and establishment of linkages among actors along the rice value chain. The main idea behind the strategy is to focus on producing sufficient quantities of the right quality of rice and rice-based products of interest to national or regional markets (or both). They serve as field laboratories where research outputs and products are being tested, adapted and integrated ð with feedback provided to researchers on technology performance. A total of 68 hubs were selected in 25 AfricaRice member countries after consultation with various stakeholders (Fig 1).

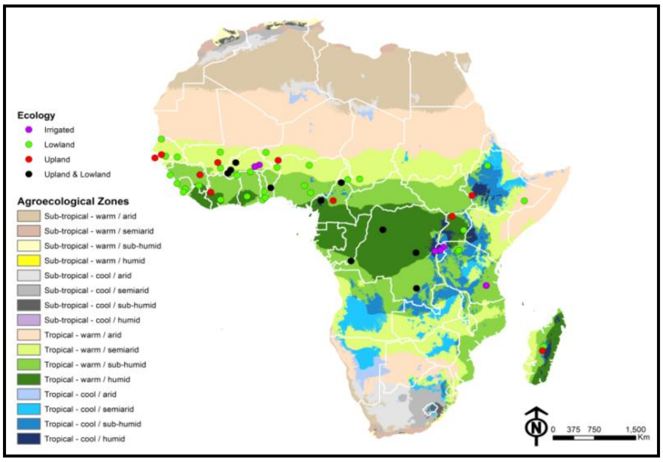

Figure 1: Rice Sector Development Hubs in Africa
Source: AfricaRice, 2012

The study convers 19 hubs in 10 selected African countries. Detailed information of selected hubs is presented in Table 1. The choice of these countries was based on the availability of proceeded data. The number of hubs considered in the study depended also to the progress on baseline data collection expected for Benin where only one hub has been retained for the baseline study according to the NARS partners. The number of hubs selected for this study and per country was one for Benin, Cote dôIvoire and Mali; two for Cameroun, The Gambia, Nigeria, Senegal and Togo; 3 hubs for Ghana and Sierra Leon, respectively given a total of 190 communities. Two type of local growing varieties of rice were assessed by the selected communities: Improved local rice (NERICA, Non-NERICA, Improved-NARS, Other-Improved) and Traditional local varieties of rice were evaluated by the selected communities based on 6 characteristics of cooked rice such as easiness of cooking, stickiness, taste, aroma, conservation and swelling capacity after cooking.

Table 1: Description of rice sector development hubs selected for the study

Countries	Hub name	Ecology	N. of hubs	N. of hubs for baseline study	Studied hub
Benin	Glazoue	Upland and lowland	2	1	1
	Malanville	Irrigated			
Cameroun	Ndop	Lowland (upland & Irrigated)	3	2	2
	Lagdo	& Irrigated upland)			
	Mbam	Rainfed			
Côte dôIvoire	Man	Rainfed	2	1	1
	Gagnoa	Irrigated lowland			
Gambia	West Coast Region	Upland	2	2	2
	Central River Region	Irrigated			
Ghana	Navrongo	Irrigated lowland	4	3	3

	Kumasi Afife Savelugu	lowland Irrigated Lowland			
Mali	Sikasso Zone de Kourouari (Niono) Béléko	lowland Irrigated Upland	3	1	1
Nigeria	Kano State Benue/Nassarawa States	Irrigated lowland Lowland	2	2	2
Senegal	Dagana C.R. Ngayene Bagadadji	Irrigated Upland Lowland	3	3	2
Sierra Leon	Manbolo in the North and Rotifunk in the South	Mangrove swamp	3	3	3
	Bo in the South and and Kenema in the East	Lowland			
	Tormabum and Gbondapi in the Southern region	Floodplain / Deep Immersion			
Togo	Région Maritime Région des Plateaux	Irrigated Lowland	2	2	2
Total			26	19	19

Source: AfricaRice, 2013

2.2. Sampling design and data analysis

The data used for the analysis comes from a survey conducted for various projects from 2013 to 2014 by Africa Rice Center (AfricaRice) and its National Agricultural Research Systems and the National Agricultural Statistics Systems (NASS) partners in ten countries. Detailed questionnaires were administrated to value chain actors (farmers, processors, traders, etc.) in the hubs using an automated web-based application on smartphones to minimize errors and inconsistency. Multistage stratified random sampling was used by each country to select nationally representative sample communities and rice value chain actors in and around the hubs. In the first stage, a given number of communities (villages, semi urban and urban areas) were randomly selected among rice growing regions in each stratum (the strata are usually regions or other administrative divisions above the village). In the second stage, rice value chain actors were randomly selected. In the selected hubs of each country, the survey collected household, farmer, trader, restaurants and processor-level data on socio-demographic and economic characteristics, using or not using contractual arrangements, the characteristics of contracts, determinants of contracts, as well as the marketing constraints, farmer preferences for rice characteristic, etc. in the selected hubs. This article presents the results of analysis covering one actor of the value chain, the rice farmers from the nineteen (19) selected hubs in ten (10) different countries namely Benin, Cameroun, Côte dôIvoire, Gambia, Ghana, Mali, Nigeria, Senegal, Sierra Leon and Togo. The sample sizes ranged from 15 to 100 per country for the farmerôs communities with a total of 459 communities (Table 2).

Table 2 : communities and varieties evaluated by country

Country	N. community	Types of rice					
		Nerica	NNerica	NARS-imp	ImpOther	Tradit	Total
Benin	**40**	51	13	15	46	32	**157**
Cameroun	**26**	35	7	22	12	44	**120**
Côte d'Ivoire	**31**	7	29	60	10	296	**402**
Gambia	**65**	71	42	72	10	204	**399**
Ghana	**43**	11	8	41	23	52	**135**
Mali	**57**	23	6	176	14	281	**500**
Nigeria	**54**	11	19	30	27	155	**242**
Senegal	**100**	65	95	95	40	251	**546**
Sierra Leon	**15**	8	1	25	0	158	**192**
Togo	**28**	24	4	25	25	29	**107**
Total	**459**	306	224	561	207	1502	**2800**

Source: AfricaRice, 2014

The table 3 provides information on the different types of rice that have been evaluated by the community of farmers. 280 rice varieties on average were submitted to the appreciation of each community in the selected countries. Among these varieties, more than half (150) consists of traditional varieties. This number reflects the importance that farmers affect to traditional varieties. Improved varieties of NARS ranks the second with an average of 56 varieties followed by NERICA varieties (31) subject to the appreciation of farmers in each country. However, minima and maxima of the number of varieties evaluated showed a wide disparity between the number of varieties constituting each of the five types of rice studied, within each country and between countries. Thus, the lowest number of varieties studied is 107 registered in Togo against a maximum of 546 varieties in Senegal while the minimum number of NERICA varieties is 7 in Cote dôIvoire with a maximum of 71 ranked in the Gambia.

Table 3: Descriptive statistics of types of rice evaluated by farmerôs communities in selected hubs

Types of rice	Mean	Standard error	Min	Max
NERICA	30,6	7,59	7	71
NNERICA	22,4	9,01	1	95
NARSImp	56,1	15,58	15	176
ImpOther	20,7	4,54	0	46
Traditional	150,2	33,51	29	296
All types of rice	280	52,61	107	546

Source: computed by the authors

Legend:

NERICA: NERICA rice varieties developed by AfricaRice

NNERICA: improved rice varieties but Not NERICA

NARSImp: improved rice varieties of the National Agricultural Research Systems

ImpOther: other improved rice varieties do not belong to any of the categories listed above

Traditional: Traditional rice varieties

To generate the preferences of rice farmers for the culinary characteristics of locally growing varieties of rice in the selected hubs, the Principal Component Analysis (ACP) was used for the analysis. First to ACP, the sphericity test of Bartlett was conducted to ensure that the determinant of correlation matrix is non-zero, and different from unity. Furthermore, it may be useful to exclude from the analysis, variables that have no correlation with others. To do this, the Measure of Sampling Adequacy of Kaiser-Meyer-Olkin (KMO) was performed. Finally, the ACP analysis was performed with SPAD 5.0

3. Results

3.1. KMO index and Bartlett Test

Bartlett test and Kaiser-Meyer-Olkin (KMO) index which allow testing the capacity of data to be factorized was done. In fact, KMO tests wither correlation between variables is sufficient to search principal component, while the Bartlett test is used to test variables correlation. The results in Table 4 indicate that the variables can be factorized for each characteristic, since the precision of Bartlett test is high and signification almost zero. In addition, the KMO index of all characteristic is greater than or equal to 0.8 which gives them a "very good" ability to be factorized according to the scale of Kaiser (1974)[1].

Table 4: KMO index and Bartlett test

Bartlett test and KMO index		**Aroma**	**Cook**	**Stick**	**Storage**	**Swell**	**Taste**
Precision measurement of the sample Kaiser-Meyer-Olkin		0.85	0.79	0.80	0.87	0.80	0.80
Bartlett's test of sphericity	Approximated Khi-square	122.6	95.73	148	123.6	86.52	104.5
	Bartlett signification	0.0	0.0	0.0	0.0	0.0	0.0

Source: computed by authors

3.2. Choice of the axis

The Table 5 shows eigenvalue and percentage of information explained by each axis. For all cooking characteristics, the two first components were kept. The percentages of the explained variance show that the first component explains more than 65% of information for all of cooking characteristics. This latter component was retained for interpretations since it is only its eigenvalues which are more than unity. However, in order to have a better visualization of information (individuals and variables) on the scatter plot and accuracy in interpretations, we added the second component. The total percentage of information explained by the two first

[1] Interpretation of the KMO as characterised by Kaiser. Meyer & Olkin (1974): 0.00 to 0.49 “Don't Factor”; 0.50 to 0.59 “Miserable”; 0.60 to 0.69 “Mediocre”; 0.70 to 0.79 ”Middling”; 0.80 to 0.89 “Meritorious”; 0.90 to 1.00 “Marvelous” (http://peoplelearn.homestead.com/Topic20-FACTORanalysis3a.html).

components is 88.16 %; 82.84%; 89.39%; 87.43%; 80.75% and 87.37% respectively for Aroma, Cook, Stick, Storage, Swell and Taste.

Table 5: Inertia associated to axis: eigenvalue

	Aroma		Cook		Stick		Storage		Swell		Taste	
Axis	**E-val**	**Perc**	**E-val**	**Perc**	**E-val**	**Perc**	**E-val**	**Perc**	**E-val**	**Perc**	**E-val**	**Perc**
1	3.9	78.12	3.51	70.15	4.0	79.92	3.82	76.49	3.44	68.83	3.77	75.48
2	0.5	10.04	0.63	12.69	0.47	9.47	0.55	10.94	0.60	11.92	0.60	11.89
3	0.35	6.91	0.49	9.64	0.31	6.26	0.36	7.22	0.52	10.42	0.33	6.51
4	0.20	3.93	0.24	4.84	0.13	2.69	0.16	3.17	0.34	6.69	0.22	4.35
5	0.05	1.01	0.13	2.68	0.08	1.67	0.11	2.18	0.11	2.14	0.09	1.77

Source: computed by the authors

3.3. Results from principal component analysis

Aroma

The first axis on Figure 1 is positively correlated with Traditional, NARS-improved and NERICA while the second axis is negatively correlated with the NNERICA and Improved-others. Therefore, there is no opposition between the different types of rice in terms of aroma. The figure emphasizes that farmers have preference for these varieties because of their aroma. Specifically, Improve-other and NNERICA rice have a good aroma in Sierra Leone and fair aroma in Benin, and Mali while Traditional, NERICA and NARS-improve rice have good aroma in Ghana, Nigeria, Gambia, Cameroon, Togo, Mali and Benin.

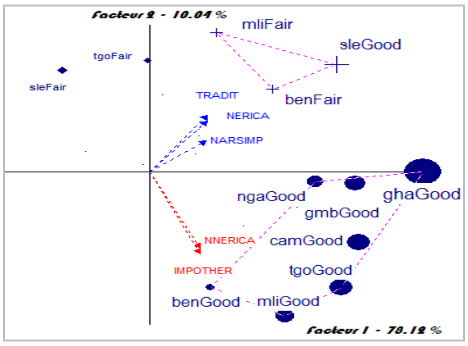

Figure 2: Aroma appreciation of different varieties of rice in selected hubs

Cooking

Figure 2 shows that all of the five rice cooking characteristics except NNERICA are positively correlated with the first axis. These types of rice have a better contribution on the first axis than the one of NNERICA. Then, the second axis is the one of the NNERICA rice which one is negatively correlated. These types of rice are easy to cook in the selected countries but the farmers have not the same appreciation about the rice types in all the countries. According to the farmerǒs appreciation, Improve-other, NERICA, traditional and NARS-Improved are easier to cook in Ghana, Togo, Cote dƠIvoire, Nigeria and Senegal, while Non-NERICA was easy to cook in Benin, Mali, Gambia, and Cameroon.

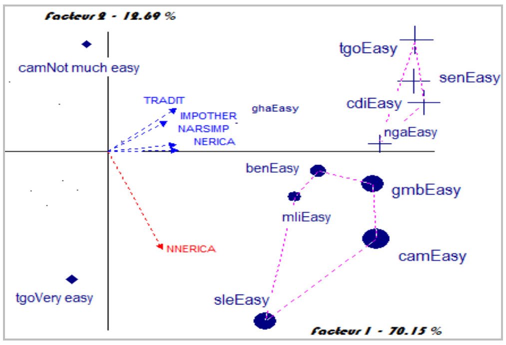

Figure 3: cooking appreciation of different varieties of rice in selected hubs

Sticky of rice after cooking

The figure 3 shows that NERICA, NARS-Improved, Non-NERICA and traditional rice are positively correlated with the first axis while improved-other is negatively correlated with the second axis. It is observed that Non-NERICA, traditional and NARS-Improved rice were not much sticky in Sierra Leone, Mali and Benin. Also, NERICA and Improved-Other rice are not much sticky in Togo, Senegal and Cameroun while it was sticky in Cote dƠIvoire.

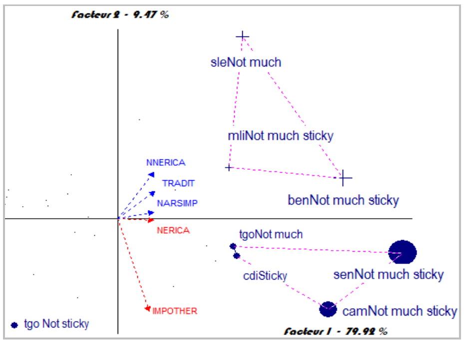

Figure 4: Stickiness of different varieties of rice in selected hubs

Storage of rice after cooking

The first axis on the Figure 4 is the one of NERICA, NARSimp, NNERICA and Traditional. These types of rice are positively correlated with the first axis while improved-other is positively correlated with the second axis. According to the community of rice farmers, the Improved-other rice is very easy to store in Ghana and Cameroon, while it stores well in Senegal, Togo and Nigeria. The others types of rice namely NERICA, Non-NERICA, NARS-Improved and traditional are store well in Gambia, Cameroon and Benin while in Sierra Leone they are very easy to store.

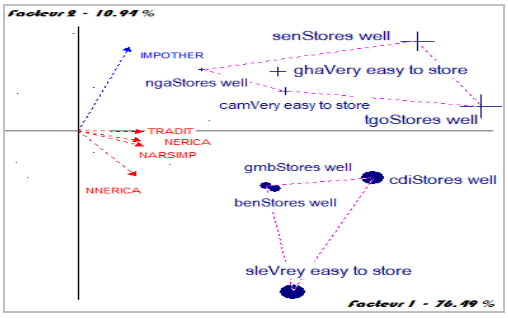

Figure 5: Storage capacity of different varieties of rice in selected hubs

Swell capacity of rice after cooking

The first axis on Figure 5 is positively correlated with four of five types of rice namely NARS-improved, NERICA, NNERICA and traditional while Improved-other is positively correlated with the second axis. The results from farmerȏs appreciation shows that in Cote dȏIvoire, Mali, Benin, and Nigeria, Improve-other rice were qualified to have a fair swell. They have good swell in Senegal, Gambia, Ghana and Cameroon while the others type of rice have good swell in Mali, fair good in Togo, Cote dȏIvoire and Sierra Leone.

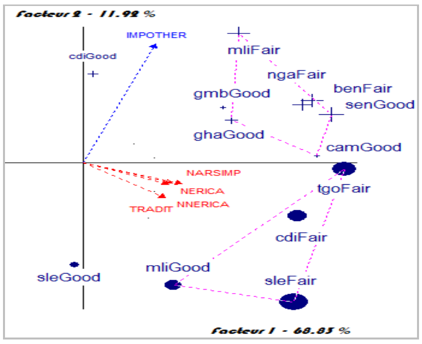

Figure 6: Swelling appreciation of different varieties of rice in selected hubs

Taste of cooking rice

As observed for the swell capacity, all cooking characteristics except for the Improve-other rice were positively correlated with the first axis. The second axis is then the axis of Improved-other, which one is positively correlated. A further analysis from Figure 6 shows that Improve-other, NNERICA and traditional rice have good taste in Cameroun, Togo, Senegal, Mali and Gambia while NERICA and NARS-improved rice have good taste in Ghana, Nigeria, Cote dȏIvoire and Sierra Leone.

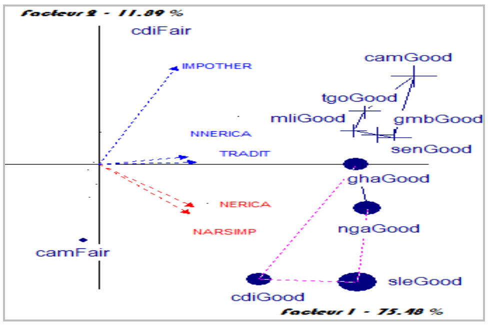

Figure 7: Taste appreciation of different varieties of rice in selected hubs

Conclusions

The results from the community-based approach reveals that rice farmers generally have a good appreciation of the cooking characteristics of the five types of rice they have evaluated. However, that assessment varies by country and type of rice. The consumers other than producers, particularly those in urban centers, being more demanding in terms of preferences than producers, continuous effort to increase local rice production taking into account the most preferred cooking characteristics of local rice in the communities of farmers in the rice sector development hub will strongly contribute to the food security in Africa. A study on the assessment of consumers (not producers of rice) cooking characteristics would take more effective actions.

Acknowledgements

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Appendix1 :

Annexe 1:

Aroma	Coordinate		Contribution	
	Axis 1	Axis 2	Axis 1	Axis 2
Nerica	0.94	0.26	0.23	0.14
Nnerica	0.82	0.39	0.17	0.30
Narsimp	0.91	0.16	0.21	0.05
Importher	0.81	0.42	0.17	0.35
Traditional	0.93	0.29	0.22	0.16

Annexe 2

cook	Coordinate		Contribution	
	Axis 1	Axis 2	Axis 1	Axis 2
Nerica	0.913	-0.005	0.24	0.00
Nnerica	0.704	0.699	0.14	0.77
Narsimp	0.890	-0.052	0.23	0.01
Importher	0.775	-0.216	0.17	0.07
Traditional	0.886	-0.310	0.22	0.15

Annexe 3

sticky	Coordinate		Contribution	
	Axis 1	Axis 2	Axis 1	Axis 2
Nerica	0.92	-0.01	0.21	0.0
Nnerica	0.90	0.30	0.20	0.19
Narsimp	0.91	0.05	0.21	0.00
Importher	0.80	-0.59	0.16	0.74
Traditional	0.94	0.18	0.22	0.07

Annexe 4

storage	Coordinate		Contribution	
	Axis 1	Axis 2	Axis 1	Axis 2
Nerica	0.90	-0.08	0.21	0.01
Nnerica	0.82	-0.34	0.18	0.22
Narsimp	0.94	-0.12	0.23	0.03
Importher	0.75	0.64	0.15	0.75
Traditional	0.94	-0.01	0.23	0.0

Annexe 5:

swell	Coordinate		Contribution	
	Axis 1	Axis 2	Axis 1	Axis 2
Nerica	0.86	-0.12	0.22	0.025
Nnerica	0.82	-0.13	0.20	0.028
Narsimp	0.95	-0.13	0.26	0.027
Importher	0.70	0.71	0.14	0.846
Traditional	0.79	-0.21	0.18	0.074

Annexe 6:

Taste	Coordinate		Contribution	
	Axis 1	Axis 2	Axis 1	Axis 2
Nerica	0.91	-0.28	0.22	0.13
Nnerica	0.86	0.05	0.20	0.00
Narsimp	0.87	-0.32	0.20	0.18
Importher	0.75	0.64	0.15	0.69
Traditional	0.94	0.01	0.23	0.00