Production, consumption, and quality attributes of Akpan – a yoghurt-like cereal product from West Africa

CAROLE SACCA, LAURENT ADINSI, VICTOR ANIHOUVI, NOEL AKISSOE, GENEROSE DALODE, CHRISTIAN MESTRES, ANNALI JACOBS, NOMUSA DLAMINI, DOMINIQUE PALLET and DJIDJOHO JOSEPH HOUNHOUIGAN

Akpan is a high-potential, traditional yoghurt-like product made from fermented cereal starch, and consumed as a thirst-quenching beverage in Benin. This study investigated the characteristics of consumers, the traditional processing techniques and constraints, and the quality attributes of the product in order to find out the best options for possible industrial development. For this purpose, a survey was carried out in different municipalities using a questionnaire administered to stakeholders. While the production and commercialization of Akpan are undertaken exclusively by women, consumption cuts across all classes of people, with consumers in a wide range of socio-cultural groups, ages, and educational levels. Four types of Akpan were encountered, varying in their raw materials and processing technologies. Maize and sorghum were used either singly or in combination through submerged or solid-state fermentation processes. Among the product types, Akpan from maize ogi was the most preferred, mainly because of its long-established history, white colour, sour taste, and pronounced ogi aroma.

Keywords: maize, sorghum, Akpan, ogi, quality attributes, dough

Cereals are grown on over 73 per cent of the world's total harvested surface area and contribute to over 60 per cent of world food production, providing dietary fibre, proteins, energy, minerals, and vitamins required for human health (Charalampopoulos et al., 2002). Cereals are used in various ways, and one of these is as fermentable substrates in food preparation. Traditional fermented cereal foods

Carole Sacca, Laurent Adinsi, Victor Anihouvi, Noel Akissoé, Générose Dalodé and Djidjoho Joseph Hounhouigan (joseph.hounhouigan@gmail.com) are with the Département de Nutrition et Sciences Alimentaires, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi, Bénin. Annali Jacobs and Nomusa Dlamini are with the Council for Scientific and Industrial Research (CSIR), Pretoria, South Africa. Christian Mestres and Dominique Pallet are with CIRAD, Montpellier, France.

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are known all over the world, especially in developing countries where they are valued for the taste, aroma, bioactive components, and texture. Fermented cereal products vary from region to region according to the processing technique and the type of cereal. Examples include:

- ogi, a West African fermented maize/sorghum/millet starch or porridge (Banigo and Muller, 1972; Nago et al., 1998);
- mawè, a West African fermented maize dough (Hounhouigan, 1994);
- gowé, a non-alcoholic cereal beverage traditionally produced from malted sorghum flour (Michodjehoun-Mestres et al., 2005); Hounhouigan, 1994);
- similar fermented cereal products in other African countries such as *akamu* in Nigeria (Akingbala et al., 1987), *uji* in Kenya, *mahewu* in South Africa or *poto poto* in Congo (Steinkraus, 1983, 1996; Brauman et al., 1993).

Ogi is used for Akpan preparation, obtained by fermentation of a suspension of wet-milled cereals

Ogi is a starchy product obtained by fermentation of a suspension of wet-milled cereal (commonly maize in Benin and Nigeria). Besides the stiff dough (*akassa*, *makume*), ogi is consumed as a cooked porridge which is commonly used as a traditional food for weaning infants and an important breakfast cereal for adults (Banigo and Muller, 1972). Ogi is also used for Akpan preparation, a starchy fermented cereal beverage, named vegetable milk or non-dairy yoghurt-like cereal product. Akpan is a thirst-quenching, ready-to-serve beverage that is pre-cooked and then mixed with milk, sugar, and ice as required (Mestres et al., 2001). Akpan is produced all year round and although it enjoys widespread consumption, popularity and high demand, especially during the dry season, there is little information on processing techniques or quality attributes (Madodé, 2003).

Akpan is a ready-to-serve beverage that is mixed with milk, sugar, and ice before consumption

Apart from the long-established processing technology based on the ogi process, new forms of Akpan have been developed in recent years, varying in processing technologies and raw materials used, for example, fermented kneaded sorghum and/or maize flour. Thus, variability in the processing techniques and raw materials used can lead to variation in the nutritional, microbiological, and sensory qualities of Akpan. A cursory investigation indicated major constraints related to product quality, such as lack of a reproducible process (fermentation, cooking) and short product shelf life. To overcome these constraints, information on traditional processing techniques, problems associated with processing, and quality profiles was needed with a view to improving the quality of Akpan. An analysis of the production, commercialization, and consumption of Akpan was needed. However, there was limited information on

Information on processing techniques and quality profiles was needed to improve Akpan quality

the production processes, the perception of quality attributes by processors and consumers, and knowledge of other ingredients used. Additionally, information on the quality profiles of Akpan, and the frequency and forms of consumption has to be considered in order to find the basic characteristics of the types of Akpan. This study was therefore undertaken with the aim of collecting useful information on the processing, consumption, and quality attributes of Akpan as perceived by producers, sellers, and consumers.

Materials and methods

Survey area and sample selection

A survey was carried out on the producers, sellers, and consumers of Akpan in the Cotonou and Porto-Novo municipalities in southern Benin. A preliminary survey was conducted to gather information on the production areas, and to test the questionnaire. The sample size was set according to Dagnelie (1998) as described by Chadare et al. (2008). Stakeholders eligible for interview were selected by ranking Akpan producers/sellers and a total of 145 producers/sellers and 607 consumers (Table 1) were interviewed.

Survey instrument design

A validated questionnaire was designed to collect data on Akpan production, commercialization, and consumption. Demographic data related to gender, age, religion, marital status, and academic qualifications were collected. Then, technical data on the process were gathered, including equipment, the type of Akpan, cereal grains and additives used, and the degree of preference for each type of Akpan. Other information collected included quality criteria for cereal grains used, quality attributes of Akpan, quantity produced, shelf life, frequency, and time of Akpan consumption. The survey was carried out through individual interviews or in focus group discussions of 2–3 interviewees.

Table 1. Distribution of interviewees per municipality

Survey area	*Total interviewed*	*No. interviewed*	
		Producers/sellers	*Consumers*
Cotonou	337	73	264
Porto Novo	415	72	343

Data analysis

Descriptive statistics were calculated using the Sphinx plus2 software (SphinxSurvey plus2, Eureka). In addition, multivariate analyses were performed on the types of Akpan and quality attributes as perceived by respondents, using Statistica 7 (StatSoft, Tulsa, USA).

Results and discussion

Socio-cultural characteristics of the subjects

The production and the commercialization of Akpan were traditional activities undertaken by women (100 per cent of respondents; N=145), primarily married women (89 per cent) (Table 2). The majority of respondents were 26–50 years old, representing 92 per cent of all the producers/sellers (N=145). The major socio-cultural groups were Goun (47 per cent) and Fon (26 per cent). Christians accounted for 84 per cent of the respondents and Muslims for 7.5 per cent. A relatively high proportion of the producers or sellers (54.5 per cent) were illiterate, of which 48 per cent did not complete primary school and only 1.4 per cent had attended secondary school. Fifty-four per cent had less than five years' experience as producers/sellers, which indicates that the production of Akpan could be a sustainable activity since these were new stakeholders that had joined the sector, while 26 per cent had from 5 to 10 years' experience and 19 per cent more than 10 years. There seems to be a high and negative correlation between the number of years' experience and the number of producers involved.

The production and commercialization of Akpan are traditional activities undertaken by women

Akpan consumption cut across a wide range of socio-cultural groups and educational levels: it was consumed mainly by the Goun socio-cultural group (43 per cent of respondents; N=607) followed by the Fon (27 per cent) and the Yoruba (14.5 per cent). Other minor socio-cultural groups representing 0.2 to 2.9 per cent were also encountered (Torri, Bariba, Mina, Anago, Mahi, Aïzo). The greater proportion of consumers were from the Goun socio-cultural group, which is in agreement with Adande (1984), who described the origin, preparation, and consumption of Akpan as coming from this socio-cultural group. The majority of respondents attended primary school (46 per cent; N=607), followed by secondary school (29 per cent), and university (10 per cent). Concerning the age category, 82 per cent were between 15 and 50 years, 16.5 per cent were younger than 15 years and only 1.3 per cent were older than 50 years. Almost 60 per cent of the respondents were unmarried and 42 per cent were married, while only 0.3 per cent were divorced. According to some respondents, pregnant and nursing women consumed less Akpan than other classes of people, perhaps because of the popular belief that Akpan might be indigestible to pregnant and nursing women. Indeed, 20–29 per cent

Table 2. Socio-cultural characteristics of Akpan producers/sellers

Characteristic	*% (N=145)*
Age (years)	
15–25	4.8
26–35	59.3
35–50	33.1
>50	2.8
Gender	
Female	100
Socio-cultural groups	
Fon	26.2
Goun	46.7
Yoruba	6.6
Torri	2.2
Adja	5.1
Bariba	2.9
Mina	3.6
Evé	0.7
Anago	5.1
Academic qualifications	
Illiterate (no schooling)	54.5
Primary school	44.2
Secondary school	1.4
Marital status	
Married	88.9
Unmarried	9.7
Divorcee	1.4
Religion	
Animism	8.5
Christian	83.7
Islam	7.5
Household status	
Head of household	1.4
Dependant	98.6

of sorghum-based Akpan consumers, and 28–30 per cent of mixed maize and sorghum Akpan consumers supported this point of view.

Quality and quantity of cereal grains used in Akpan production

Cereal grains used in Akpan production included maize (*Zea mays*) and sorghum (*Sorghum vulgare*), singly or in combination. Preference, in decreasing order, in the use of these grains was for maize (100 per cent of the respondents; N=145), sorghum (21 per cent) and a mixture of maize and sorghum (1.4 per cent). The ratio of maize/sorghum favoured by respondents varied from 1:1 to 1:3 (w/w).

Similar information was gathered on *kunu*, a Nigerian non-alcoholic cereal beverage, for which the grains were used singly or combined; the possible grain combinations were maize/millet, sorghum/millet, maize/sorghum and millet with the mixing ratio varying between 1:1 and 2:1 (w/w) (Gaffa et al., 2002). According to the respondents, the colour of the raw material for Akpan production was the most important quality criterion. In the survey, it was observed that 98 per cent of maize-based Akpan producers/sellers used white maize varieties while all the sorghum-based Akpan producers/sellers preferred the red sorghum varieties. The grains should be well dried (12 per cent of respondents; N=145), and free from weevils (83 per cent) and stones (80 per cent). The grains must be floury in order to produce higher starch yields. According to 59 per cent of producers/sellers, small kernel grains have more floury endosperms. The information obtained is consistent with previous work which reported that small maize grains such as *gnonli* (local maize variety) are floury and yield more starch during ogi production (Nago et al., 1997).

The colour of the raw material for Akpan production is the most important quality criterion

The quantity of raw material used ranged from 3 to 120 kg per week and per producer depending on the type of Akpan, the season (hot or cold weather) and category of producers (Table 3). This range varies throughout the year with the figure peaking during the hot dry season, at a minimum of 10 kg/week versus 3 kg/week for the other periods. Indeed, during the dry season, the interviewed producers/sellers (91.5 per cent respondents, N=118) of Akpan from ogi maize use from 10 to 120 kg versus 3 to 72 kg per week for the wet season (100 per cent respondents; N=36). The distribution of processors of each type of Akpan, with respect to the quantity of raw material used, seems to indicate two categories of producers: those who use less than 20 kg per week and those who use more than 20 kg per week. Irrespective of the type of Akpan, 47 per cent of respondents use more than 20 kg of raw material per week.

Technology of Akpan production

Irrespective of the raw materials, two processing technologies were observed: Akpan made from ogi or Akpan from kneaded flour, using submerged and solid-state fermentation, respectively (Figure 1). The predominant technology remains that of Akpan from ogi, which was used by 100 per cent of respondents. In this technology, Akpan is prepared from ogi mash, a process that has been described previously (Banigo and Muller, 1972; Nago et al., 1997). The grains are cleaned of dust, sand, and plant debris. Grains may be steeped in water for three days at ambient temperature (25–35°C), steeped in water at 85°C for one day, or cooked in boiling water for 10 minutes and then steeped at ambient temperature for 12–48 hours (Nago et al., 1998). Where

hot or warm water is used, the purpose is to reduce the steeping time and to enhance softening of the kernels. Thereafter, grains are wet milled and wet sieved, using muslin cloth, followed by submerged fermentation for 24–72 hours. For Akpan production, two procedures were encountered: in the first, the ogi mash is made into slurry and it is then slightly cooked, with low levels of gelatinized starch. In the second procedure, ogi mash is divided into two parts: one part is made into slurry, cooked, and then mixed with the uncooked part (raw ogi). The final product is a moderately free flowing gruel, which can be sweetened to taste by adding sugar, milk, and ice. According to

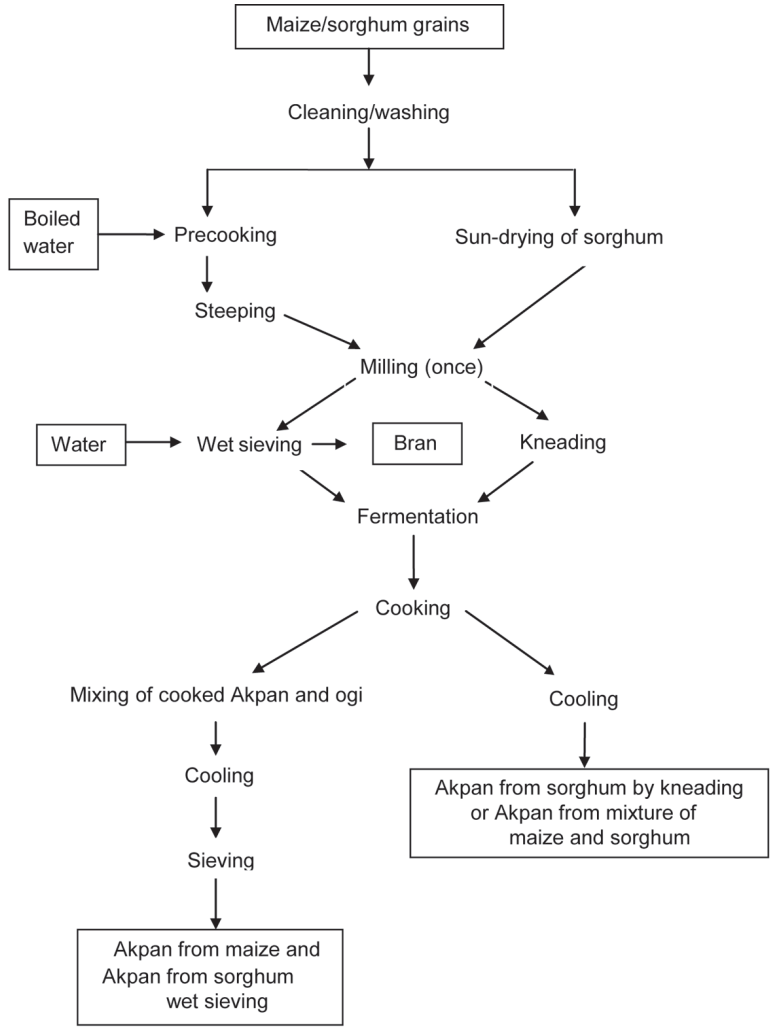

Figure 1. Flow diagram of Akpan processing

processors (92 per cent of respondents), the overcooking of ogi leads to another product named *akassa* which is a stiff dough obtained after starch gelatinization and gelation. Additionally, Akpan starch never retrogrades when it is well prepared. The technology of Akpan from kneaded flour involves the grains being cleaned as described above and washed and dried before dry milling. The flour is kneaded with tap water and undergoes fermentation for 18–24 hours. The dough is made into slurry and precooked into gruel, which is treated as described above.

Storage of Akpan

According to processors/sellers, natural Akpan without added ingredients can be stored for about four to seven days (48–73 per cent respondents within each type of Akpan) depending on the type of Akpan (Table 3). The storage duration also varied with the skill or experience of producers/sellers. An average storage period of two to five days is observed by 65 per cent of producers of Akpan from maize ogi (N=145), 60 per cent of producers of Akpan from sorghum ogi (N=15), and 74 per cent of producers of Akpan from kneaded sorghum flour (N=31). The producers of Akpan from maize and sorghum mixture and some producers of other types of Akpan (19–40 per cent of respondents) cited a storage time of six to seven days. A shelf life of 8–14 days was observed by 4 per cent of Akpan producers using maize. There was generally a lack of appropriate packaging materials in traditional practice except for the use of plastic buckets and plastic or glass bottles. When sold in the markets, Akpan was packaged in small transparent polyethylene sachets. Such practices were reported for a similar product, *kunu*, for which the shelf life did not usually exceed 24 h at room temperature or four days under refrigeration (Gaffa et al., 2002).

The storage duration varied with the skill or experience of producers/sellers

Preference of consumers for the types and forms of Akpan

The majority of respondents (89 per cent; N=607) preferred Akpan from maize ogi, followed by Akpan from sorghum ogi (18.5 per cent), and Akpan from a mixture of both cereals (2.5 per cent). The main ingredients used before consumption were sugar, milk, and ice, giving Akpan with sugar, Akpan with sugar and milk, Akpan with milk, and natural Akpan. The interviews revealed that Akpan must be consumed with 'milk and sugar' (56–84 per cent of respondents, N=607); sometimes with only sugar (12–15 per cent) or milk only (6–25 per cent). Only 3–6 per cent of respondents consumed Akpan without added ingredients (natural Akpan). Furthermore, some consumers used secondary ingredients as accompanying dishes

The majority of respondents preferred Akpan from maize ogi

Table 3. Quantity of raw material, frequency of production, and storage duration of Akpan

		Akpan from maize ogi	*Akpan from sorghum ogi*	*Akpan from sorghum dough*	*Akpan from maize and sorghum dough*
Quantity of raw material (kg/week, N=145)					
[3–20]	DS	38.6[1]	6.2	20.0	1.4
	WS	13.8	2.1	1.4	Ni
[20–40]	DS	26.2	Ni	0.7	Ni
	WS	9.0	Ni	Ni	Ni
[40–60]	DS	12.4	Ni	3.5	Ni
	WS	1.4	Ni	Ni	Ni
[60–120]	DS	4.1	Ni	Ni	Ni
	WS	0.7	Ni	Ni	Ni
Frequency of production (times/per week)					
		N=145	(n=15)	(n=31)	(n=2)
1–2		33.8	6.2 (60.0)[2]	9.7 (45.2)	0.7 (50)
3–5		43.4	2.8 (26.7)	9.0 (41.9)	0.7 (50)
6–7		17.2	2.1 (20.0)	2.1 (9.7)	Ni
Storage duration (days)					
2–3		33.1	2.8 (26.7)	9.6 (45.1)	Ni
4–5		32.5	3.5 (33.3)	6.2 (29.0)	1.4 (100)
6–7		24.1	4.2 (40.0)	4.1 (19.4)	Ni
8–14		4.1	Ni	Ni	Ni

1 percentage of all interviewed producers (N=145)
2 value in brackets is percentage of respondents within each type of Akpan (n variable)
Ni = not indicated; DS = dry season (hot period); WS = wet season (relatively cold period)

(Table 4) such as roasted groundnut (2–14 per cent of respondents, N=607) or tapioca (steeped in tap water for swelling/softening) (13–50 per cent of respondents).

Frequency of Akpan production and consumption

Akpan from maize ogi is the most frequently produced, more than three times per week

The frequency of production varies depending on the type: Akpan from maize ogi is the most frequently produced, with 61 per cent of producers (N=145) making it more than three times per week (Table 3); 43 per cent of producers (N=145) made it three to five times per week; while 17 per cent of producers made it six to seven times per week. Akpan from fermented sorghum dough was made by 10 per cent of producers (N=145); 42 per cent of producers/sellers of this type of Akpan (N=31) indicated production twice per week and 9 per cent three to five times per week. For Akpan from sorghum ogi, 6 per cent and 3 per cent of producers (N=145) produced it once or twice, and three to five times per week, respectively. Overall, production of Akpan from maize ogi predominates. This Akpan

Table 4. Consumption frequency of Akpan and accompanying foods

	Akpan from maize ogi	*Akpan from sorghum ogi*	*Akpan from maize and sorghum dough*
Consumption frequency (times per week; N=607)			
Six to seven	14.8	2.5	1.0
Four to five	19.4	2.6	0.2
Twice to three	34.1	7.4	1.0
Once	13.5	4.4	Ni
Rarely	7.6	1.5	0.8
Accompanying dishes			
Tapioca	50.3	13.4	46.7
Roasted groundnut	13.7	1.8	Ni

Note: Ni = not indicated

is the most frequently consumed, with 82 per cent of respondents (N=607) consuming it at least once per week. Of the respondents who consumed Akpan two to three times per week (Table 4), 34 per cent (N=607) drank Akpan from maize ogi, 7 per cent Akpan from sorghum ogi, and 1 per cent Akpan from the mixed cereals. In addition, higher levels of consumption were reported for Akpan from ogi irrespective of cereal type, with 15 per cent and 2.5 per cent of respondents of maize ogi and sorghum ogi, respectively, consuming Akpan six to seven times per week. The very high level of consumption of this beverage is likely to be due to the relatively low cost of a cup (25 cl) (US$0.25/cup) since it costs three times less than conventional carbonated soft drinks (33 cl).

Akpan is a street food. It is consumed in the street (93 per cent of interviewees), at home (18 per cent), and in the workplace (1 per cent). The majority of respondents (81 per cent) consume Akpan at lunch, followed by consumption at breakfast (26 per cent), between meals (25.5 per cent), and at dinner (8 per cent).

Cross-referenced perceptions of the quality of Akpan

According to the producers or consumers interviewed (Table 5), Akpan from maize ogi should have a white colour (48.5 per cent of the producers and 88 per cent of consumers), a slightly acidic taste (54.5 per cent of the producers and 88 per cent of consumers), be very viscous (54.5 per cent of the producers and 82 per cent of consumers), with an aroma of the fermented ogi. Similar results were obtained in a previous study (Madodé, 2003). Presumably, the yellow cultivar of maize should be excluded from Akpan production. The new types of Akpan from sorghum and mixed cereals differ from the Akpan

Table 5. Sensory quality attributes as perceived by stakeholders for each type of Akpan (% respondents)

Sensory attributes of Akpan	*Producers*				*Consumers*		
	Maize ogi (N=145)	*Sorghum ogi (N=15)*	*Sorghum flour dough (N=145)*	*Maize and sorghum dough (N=2)*	*Maize ogi (N=541)*	*Sorghum ogi (N=112)*	*Maize and sorghum dough (N=15)*
Milk taste	–	–	–	–	52.9	40.2	44.4
Sweet taste	–	–	–	–	22.5	14.4	27.8
Iced taste	–	–	–	–	54.2	49.5	33.3
Slightly acidic	54.5	75	3.3	–	82.2	–	–
Very acidic	–	25	60	100	–	23.7	–
Moderately acidic	17.9	–	–	–	–	36.8	11.1
Very mushy/viscous	100	50	53.3	–	44.7	9.3	5.5
Slightly viscous	–	–	10	–	1.5	36.1	22.3
No lumps/smooth	35.1	50	26.7	–	70.1	28.9	50
White colour	48.5	–	–	–	87.7	–	–
Red colour	–	50	60	50	–	87.6	–
Slightly red colour	–	–	–	–	–	–	100
Slightly cooked	100	–	–	–	33.3	–	–
Very cooked	–	50	33.3	–	–	34.2	–
Commercial aroma	17.9	–	13.3	100	5.3	8.2	–
Citronella aroma	94.3	86.7	100	100	–	–	–

made from maize ogi in their colour and their sour taste. Akpan from sorghum ogi should be very mushy and viscous (36 per cent of consumers), have a red colour (50 per cent of the producers and 87.5 per cent of consumers), and be slightly acidic (75 per cent of producers). Moreover, Akpan from mixed maize and sorghum dough, obtained by kneading the cereal flour, is regarded as very acidic (100 per cent and 60 per cent of the producers respectively), with a red colour (60 per cent of producers) and slightly viscous (22 per cent and 36 per cent of consumers).

When plotting the stakeholders against the quality attributes, the principal component analysis (PCA) revealed that 80 per cent of variability in quality attribute perception could be explained by the first three axes (Figure 2). Except for producers of Akpan from maize ogi (Pom), all other producers (Pos, Pfms and Pfs) agreed on the required quality criteria of Akpan. However, the PCA plot indicated that the preference of consumers was not directly aligned with the perception of producers on some quality criteria. For producers, all types of Akpan should be very viscous whereas the consumers preferred the Akpan from sorghum and mixed cereal to be slightly viscous. Furthermore, the majority of producers used citronella leaves as a flavour ingredient for cooking Akpan, but none of the consumers cited this aroma among Akpan quality attributes.

For producers, Akpan should be very viscous whereas consumers preferred Akpan to be slightly viscous

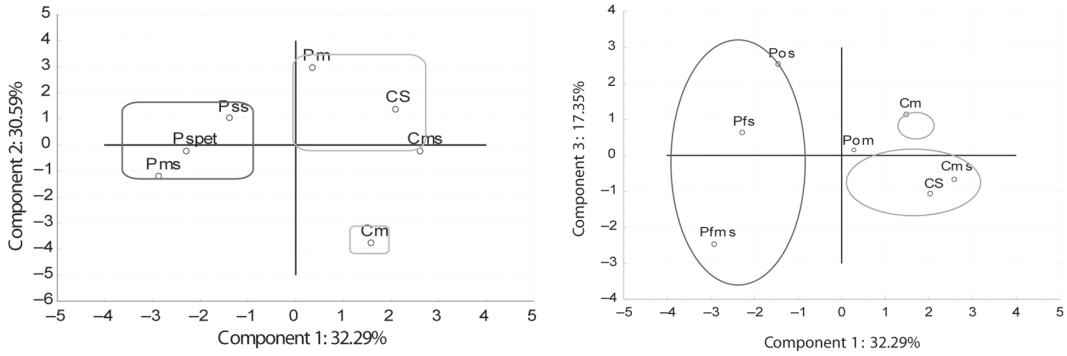

Figure 2. Relation between stakeholders: (a) plot 1 × 2 and (b) plot 1 × 3 with respect to sensory attribute perception of Akpan

Note: Pss: producer of Akpan from sorghum by wet sieving; Pspet: producer of Akpan from sorghum by kneading the flour; Pms: producer of Akpan from mixture of maize and sorghum; Pm: producer of Akpan from maize; Cs: consumer of Akpan from sorghum; Cms: consumer of Akpan from mixture of maize and sorghum; Cm: consumer of Akpan from maize

The PCA shows three classes of stakeholder in relation to perception of quality attributes of Akpan: the first relates to producers of Akpan containing sorghum (sorghum only or maize and sorghum mixture); the second group comprises consumers of Akpan from sorghum and mixed maize and sorghum, and producers of Akpan from maize ogi; and the third group, consumers of Akpan from maize ogi. They each seem to have a particular perception of the quality criteria of Akpan. This can be explained considering that Akpan from maize ogi is long established, and consumers have a historic experience and particular knowledge of it. Furthermore, the PCA revealed that some quality attributes were linked (Figure 3). Indeed, the red colour of sorghum Akpan was associated with very acidic taste (r = 0.76) while a white colour (maize Akpan) was associated with slightly acidic (r = 0.84) or with being slightly cooked (r = 0.72). In addition, a commercial/ synthetic aroma was negatively and highly correlated to very sweet (r = –0.96) and milky taste (r = –0.84). These relationships and the wide range of quality attributes, as well as the consumers' preferences will be helpful for upgrading the technology and improving the quality of Akpan.

Conclusion

This study revealed the high diversity of products and the increasing importance of Akpan as a traditional cereal beverage in Benin cities with a probable high economic importance in the future. Irrespective

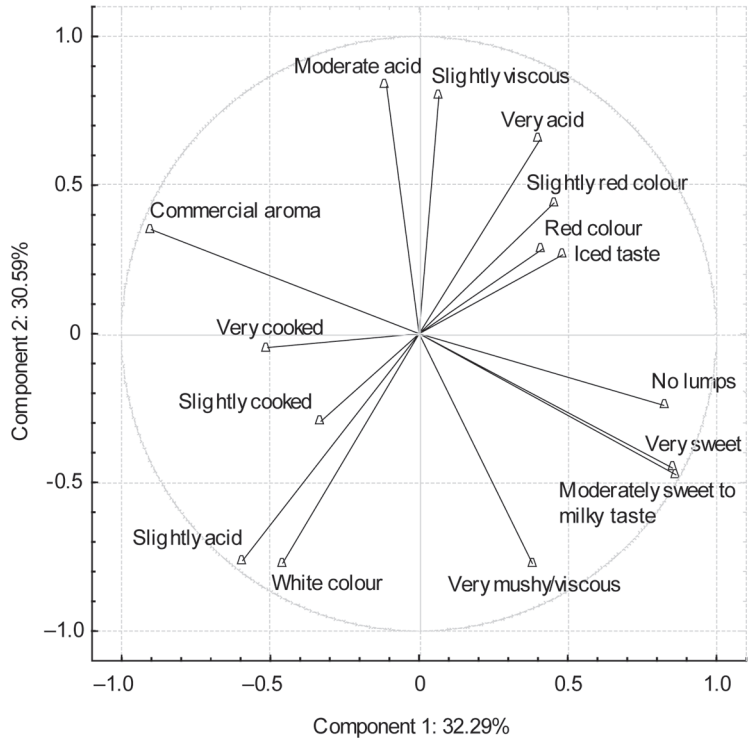

Figure 3. Principal component analysis of quality attributes of Akpan

of the raw materials used, Akpan is obtained via two processing methods, leading to two intermediate products through submerged or solid-state fermentation. The resulting diversity of Akpan types explains the large range of quality attributes of the products as perceived by producers and consumers. Whereas this diversity of product types and quality attributes is a source of constraints for product development and quality standardization, it also constitutes a potential source of product diversification for urban consumers. The cross-referenced perceptions of the stakeholders regarding the quality criteria of Akpan should be useful for future re-engineering of the process for Akpan production.

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References

Adande, S.A. (1984) *Le maïs et ses usages au Bénin méridional*, Dakar, Senegal: Les Nouvelles Editions Africaines.

Banigo, E.O.I. and Muller, H.G. (1972) 'Manufacture of ogi (a nigerian fermented cereal porridge): Comparative evaluation of corn, sorghum and millet', *Canadian Institute of Food Science and Technology Journal* 5: 217–21.

Chadare, F.J., Hounhouigan, J.D., Linnemann, A.R., Nout, M..J.R. and Van Boekel, M.A.J.S. (2008) 'Indigenous knowledge and processing of *Adansonia digitata* L. food products in Benin', Ecology of Food and Nutrition 47: 338–62 <http://dx.doi.org/10.1080/03670240802003850>.

Dagnelie, P. (1998) *Statistique théorique et appliquée: Inférence statistique à une et à deux dimensions*, Brussels, Belgium: De Boeck and Larcier S.A. de Boeck Université.

Gaffa, T., Jideani, I.A. and Nkama, I. (2002) 'Traditional production, consumption and storage of Kunu – a non alcoholic cereal beverage', *Plant Foods for Human Nutrition* 57: 73–81 <http://dx.doi.org/10.1023/A:1013129307086>.

Hounhouigan, D.J. (1994) *Fermentation of Maize (Zea mays L.) Meal for Mawe Production in Bénin: Physical, Chemical and Microbiological Aspects*, PhD thesis, Wageningen: Agricultural University of Wageningen.

Madodé, Y. (2003) *Valorisation des technologies de transformation de produits vivriers: Test de production et de marché pour le 'Akpan' une boisson fermentée à base de maïs*, Benin: Faculté des Sciences Agronomiques.

Michodjehoun-Mestres, L., Hounhouigan, D.J., Dossou, J. and Mestres, C. (2005) 'Physical, chemical and microbiological changes during natural fermentation of gowé, a sprouted or non sprouted sorghum beverage from West Africa', *African Journal of Biotechnology* 4: 487–96.

Nago, M., Akissoë, N., Matencio, F. and Mestres, C. (1997) 'End use quality of some African corn kernels. 1. Physico-chemical characteristics of kernels and their relationship with the quality of "lifin", a traditional whole dry-milled maize flour from Benin', *Journal of Agricultural and Food Chemistry* 45: 555–64 <http://dx.doi.org/10.1021/jf9507957>.

Nago, M., Tétégan, E., Matencio, F. and Mestres, C. (1998) 'Effects of maize type and fermentation conditions on the quality of Beninese traditional ogi, a fermented maize slurry', *Journal of Cereal Science* 28: 215–22 <http://dx.doi.org/10.1006/jcrs.1998.0197>.

Steinkraus, K.H. (1996) *Handbook of Indigenous Fermented Foods*, New York: Marcel Dekker Inc.