Processing and quality attributes of gowe: a malted and fermented cereal-based beverage from Benin

LAURENT ADINSI, GÉNÉROSE VIEIRA-DALODE, NOËL AKISSOE, VICTOR ANIHOUVI, CHRISTIAN MESTRES, ANNALI JACOBS, NOMUSA DLAMINI, DOMINIQUE PALLET and D. JOSEPH HOUNHOUIGAN

Gowe is a sweetish paste of malted, fermented, and cooked sorghum and/or maize flour, consumed in its pure state, but preferentially as a beverage after homogenizing with water, sugar, milk, and ice. A survey was carried out at different localities in the traditional gowe producing areas to investigate the diversity of the processing techniques, consumers' characteristics, and the quality attributes. Producers and sellers were women exclusively while consumers cut across all classes of age, socio-cultural groups, and educational levels. Gowe varied in cereal and processing techniques, with maize and sorghum being used either singly or in combination (maize/sorghum ratio varying from 1 to 3) through four processes. Apart from the alternative process which leaves out the malting step, gowe processing techniques aim at producing sweetish and acidic tasting products through malting, saccharification, and fermentation. A principal component analysis plot of quality criteria of gowe indicated that the preference of consumers was directly associated with the perceptions of producers.

Keywords: gowe, malting, fermentation, quality attributes

CEREALS CONSTITUTE A VERY LARGE part of human food and animal feed worldwide (Adeyemo et al., 1992), and many traditional cereal-based foods are part of the culture handed down over generations in Africa. A variety of cereals are used either singly or mixed to produce germinated and fermented cereal-based beverages (Muyanja, 2001). Apart from sourdough, several traditional malted and/or fermented cereal-based beverages have been documented in different African countries, including non-alcoholic or alcoholic products such as *burukutu* and

Laurent Adinsi (adinsil2003@yahoo.fr), Dr Générose Vieira-Dalode (generosev@yahoo.fr), Professor Noël Akissoe (noel.akis@yahoo.fr), Professor Victor Anihouvi (anihvic@yahoo.fr), and Professor D. Joseph Hounhouigan (hounjos@yahoo.fr) are at Département de Nutrition et Sciences Alimentaires, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi, Cotonou, Bénin. Dr Christian Mestres (Christian.mestres@cirad.fr) and Dr Dominique Pallet (Dominique.pallet@cirad.fr) are at CIRAD, Montpellier, France. Dr Annali Jacobs (AJacobs@csir.co.za) and Dr Nomusa Dlamini (NRDlamini@csir.co.za) are at the Council for Scientific and Industrial Research (CSIR), Pretoria, South Africa.

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akamu (Nigeria), *tchoukoutou*, *chakpalo*, *akpan*, and *gowe* (Benin), *uji* (Kenya), *mahewu* (South Africa), and *poto poto* (Congo), *pito*, which is common in Ghana, Togo, and Nigeria, and *dolo* in Burkina Faso and Mali (Akingbala et al., 1987; Brauman et al., 1993; Hounhouigan, 1994; Steinkraus, 1996; Michodjèhoun-Mestres et al., 2005; Sacca et al., 2012).

Gowe is a non-alcoholic cereal-based beverage, traditionally produced from malted cereal flour, which is fermented and then cooked to give a pleasant, sweet and sour paste with a specific aroma, consumed as a beverage after dilution in water. Sugar, ice or milk is added if desired. Malting, together with fermentation, is commonly used for enhancing the taste, flavour, texture, nutritional value, and shelf life. Apart from these advantages, the resulting products should be probiotic foods containing a mixed culture of microorganisms (*Lactobacillus* species) that are beneficial to the consumer's health by improving their intestinal microbial balance (Fuller, 1989). Gowe is included among these products and its processing is of expanding interest and further development. Different types of gowe have been identified based on the processing techniques and the cereal grains used (Michodjèhoun-Mestres et al., 2005; Glidja et al., 2006; Vieira-Dalodé et al., 2007). Gowe was originally produced in the centre of Benin (Bohicon, Abomey and surroundings) but nowadays it is produced and sold as street food in the main cities of Benin. Previous studies were conducted in Cotonou (southern region) and Parakou (northern region) (Michodjèhoun-Mestres et al., 2005; Glidja et al., 2006; Vieira-Dalodé et al., 2007), however information from the original region (central Benin) was inadequate or non-existent. Additionally, in recent years, interest has been renewed in indigenous processing techniques leading to innovative forms of the product. Up to now, there has been little research on indigenous knowledge of processing techniques and quality attribute perception of gowe in the most important production sites in Benin. This study aimed to gather information on the processing techniques, consumption, and quality attributes of gowe through stakeholder knowledge and perception.

Materials and methods

Sampling of stakeholders and data collection

A survey was conducted in two localities of the centre of Benin (Zou and Collines, latitude 2°36′N and longitude 7°45′E). The municipalities covered in Zou were Abomey, Bohicon, and Covè while those in Collines were Dassa-Zoumè, Glazoué and Savalou. The sample size was determined according to Dagnelie (1998) as described by Chadare et al. (2008). Eligible interviewed stakeholders were selected by ranking producers and consumers of gowe. A total of 109 producers and 300 consumers were interviewed.

Data related to socio-cultural information and academic qualifications were collected through individual or focus group discussions (2–3 interviewed) with both producers and consumers. Information was also collected on the cereal grains used, processing techniques, quality attributes, quantity produced, storage period, and frequency and place of gowe consumption.

Data analyses

Descriptive statistics were calculated using the Sphinx plus2 software (SphinxSurvey Plus2, Eureka). In addition, multivariate analyses were performed on the types of gowe and quality attributes as perceived by stakeholders using XLSTAT 2011.

Results and discussion

Socio-cultural profile of producers and consumers

The production and the commercialization of gowe are traditional activities undertaken exclusively by women, most of whom are married (96.3 per cent of respondents, N=109). The dominant position of women in cereal-based beverage preparation seems to be characteristic of this sector, presumably a cultural attitude (Sacca et al*.,* 2012). Most producers are 36–50 years old, representing 55 per cent of the interviewed producers, followed by the group of 26–35 year-olds, accounting for 33 per cent (N=109). If the production of gowe is mostly the activity of people with non-academic qualification (86.2 per cent), it is also an income-generating activity for 13.8 per cent of women with some academic qualification. As far as consumers are concerned, gowe is consumed by all classes of people and most of them are from the same socio-cultural groups, in similar percentages as the producers. About 57 per cent of the consumers (N=300) don't have any academic qualification, while about 42.7 per cent are academically qualified, with 11.3 per cent having secondary level and 0.7 per cent university level qualifications.

Variability and territorial segmentation of cereal grains used for gowe production

The cereals used for gowe production are sorghum (*Sorghum bicolor*), maize (*Zea mays*) or a mixture of sorghum and maize. Another study (Michodjèhoun-Mestres et al*.,* 2005) pointed out that the gowe made from sorghum (*Sorghum bicolor (L). Moench*) is encountered in several cities of Bénin, notably the red variety which is preferred by consumers. In our study, the preference for the use of these grains was 32.1 per cent of respondents for sorghum (N=109), 32.1 per cent for maize and 55 per cent for 'sorghum and maize'. There seems to be a trend in the territorial segmentation of the cereal grains used, with the Zou region using a single cereal grain (maize or sorghum) and the Collines, a mixture of cereal grains. In Zou municipality, the majority of producers from Abomey (n=18) and Bohicon (n=11) (94.4 per cent and 100 per cent, respectively) produce sorghum-based gowe whereas 50 per cent and 54.5 per cent, respectively, produce maize-based gowe. In Covè (Zou municipality), all the respondents (100 per cent, n=20) produce maize-based gowe; only 35 per cent produce sorghum-based gowe. Conversely, in the Collines municipality (130 km to Bohicon), all the producers use the mixture of cereal grains; the mixing ratio of cereal grains differs from one locality to another and between individuals at the same locality. This variation in ratio of cereal grains between localities and producers should affect product quality. According to processors, the reasons for mixing the

grains included interest in improving colour, increasing nutrient content, and net profit improvement. The majority of the producers of sorghum-based gowe use the red variety because it gives the final product a red colour that is highly appreciated by consumers. About 81 per cent (n=95) of the producers using sorghum mentioned the red colour of the grains as a quality attribute of the final product, whereas only 28.4 per cent (n=95) of the producers using maize consider the white colour as a quality criterion. Similar results were reported by previous studies (Michodjèhoun-Mestres et al., 2005; Glidja et al., 2006). Among sorghum gowe producers, some (9.1 per cent, n=35) combine the red sorghum variety with the white sorghum variety to adjust the colour (reduce red chromaticity). Another important quality criterion for the choice of cereal grains is the absence of weevil. This quality criterion was cited by 77.9 per cent of the 95 respondents using sorghum and 81 per cent (n=95) of respondents using maize, and is necessary for the germination of the grains, the high yield, and the quality of gowe. Indeed, according to producers, gowe smells bad when the grains are damaged by weevil. Similar observations were reported by previous investigations (Kayodé et al., 2005; Glidja et al., 2006). For 45.4 per cent of the producers using sorghum and 52.6 per cent of those using maize, the grains should not contain pesticides residue because the final product may have an unpleasant smell.

Quantity of grains used per week and frequency of production

Gowe is produced throughout the year with the quantity of cereal grains used varying from 1 to 50 kg per week and per processor. This range varies throughout the year with the figure peaking during the dry season (hot) with a maximum of 50 kg/week versus 35 kg/week for the other periods. During the dry season, the modal value for sorghum and maize ranges between 15 and 25 kg of grains for the weekly production (Table 1). Conversely, during the wet or cold season, the mode falls to around 5 to 15 kg weekly for both cereal users.

As far as the maize-sorghum mixing ratio is concerned, there is 1–3 times as much maize as sorghum (ratio 1:1 to 3:1) in the Collines municipality

Due to the short storage duration of gowe, no large-scale production is expected. As a result, gowe is produced by the majority of the respondents more than once a week. The producers (60 per cent from sorghum (n=35), 68.6 per cent from maize (n=35) and 66.7 per cent from a mixture (n=60)) produce gowe two to three times per week (Table 1) while 11.4 per cent of producers of gowe from sorghum and 25.7 per cent of those from maize and 26.7 per cent from the mixture produce only once a week. Only 28.6 per cent, 5.7 per cent, and 6.7 per cent of producers from sorghum, maize, and mixture, respectively, produce more than three times per week.

Diversity of the processing techniques

Four processing techniques were identified: 1) gowe from malted single cereal (two types of sorghum gowe and one type of maize gowe); 2) steam cooked gowe (gowe from maize); 3) gowe from the mix of sorghum malted and maize non-malted; and

Table 1 Quantity used, frequency of production, and shelf life (% of the respondents)

Usage patterns	*Sorghum gowe*	*Maize gowe*	*Mix 'sorghum and maize' gowe*
Quantity (kg/week – hot weather or hot season N= 109)			
1–5	0.9	3.7	2.8
5–15	11.0	8.3	34.9
15–25	15.6	15.6	13.8
25–35	2.8	3.7	2.8
35–50	1.8	0.9	*
Quantity (kg/week – wet weather or wet season N =109)			
1–5	5.5	4.6	28.4
5–15	10.1	15.6	24.8
15–25	3.7	3.7	*
25–35	1.8	0.9	*
	(N= 35)	(N= 35)	(N=60)
Frequency (times/week)			
4 to 5	28.6	5.7	6.7
2 to 3	60.0	68.6	66.7
Once	11.4	25.7	26.7
Shelf life (days)			
3 to 4	94.3	25.7	16.7
5 to 6	5.7	60.0	66.6
7 to 8	–	11.4	11.7
9 to 10	–	2.8	5.0

* not observed

4) alternative gowe from non-malted cereal (sorghum gowe, maize gowe, and gowe from mixed 'sorghum and maize'). The latter excludes the malting step from the process; so the sweet taste from the malt is compensated for by adding commercial sugar (sucrose) to the product. Apart from this distorted process, gowe processing techniques aim at producing sweet and acidic tasting products through malting, saccharification, and fermentation operations. In total, eight forms of gowe were identified during the survey depending on the cereal grains and/or processing technique. In Zou municipality, the technique using malted grains exclusively was identified (1): for 57.1 per cent of producers of sorghum-based gowe (n=35) and 28.6 per cent of maize-based gowe (n=35), the grains are cleaned, washed, and soaked (10 to 20 h) at room temperature (26–35°C). The soaked grains are drained and left for germination for 48 to 72 h with frequent spraying of tap water (Figure 1). The germinated grains are sun dried (5 to 20 h) and milled (3 to 4 times) in a disc

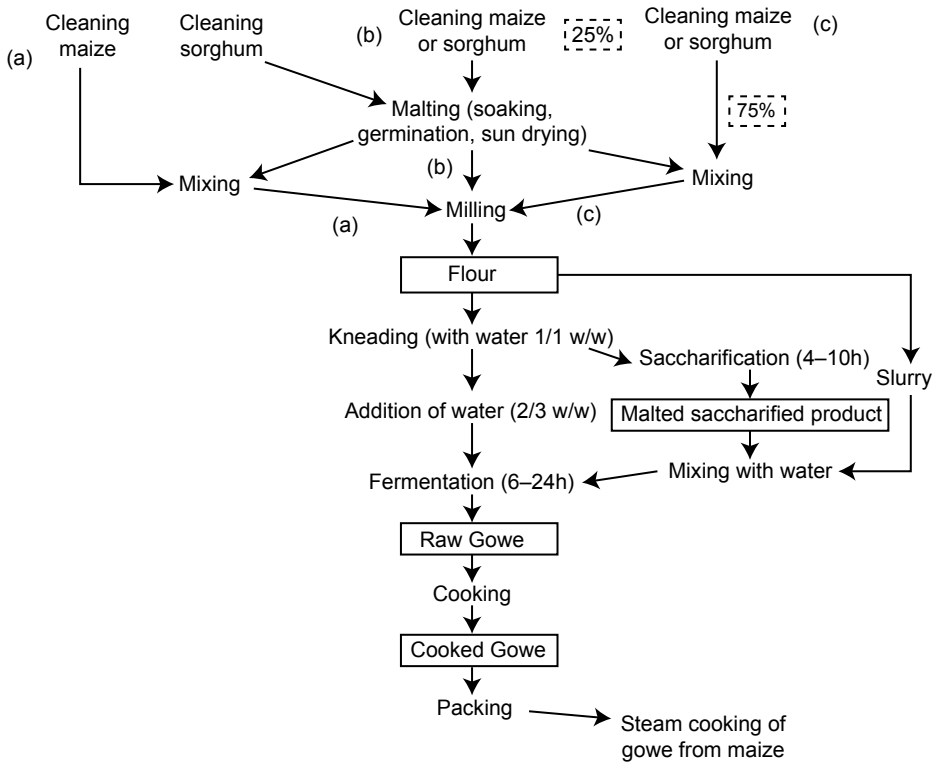

Figure 1 Flow diagram of gowe processing from malted grains

attrition mill to obtain the malted flour. This flour is optionally mixed/kneaded with tap or hot water or supernatant of a previous production and left to ferment at room temperature (26–35°C) for 6 to 20 h. The resulting dough is cooked to obtain gowe which is then wrapped in vegetable leaves (e.g. *Tectona grandis* or *Thalia welwitchi*) for sale.

Additionally, this processing technique can include a saccharification step. In this respect, and for some producers (11.4 per cent from sorghum and 2.8 per cent from maize), a part of malted sorghum or maize flour is kneaded with water and left for saccharification for 5 to 10 h. Thereafter, hot slurry of the rest of the malted flour is added to the dough previously obtained for mixing. The mixture is allowed to undergo fermentation for 10–13 h. The fermented product obtained is cooked for 15 to 80 min to obtain gowe which is packed in vegetables leaves (e.g. *Tectona grandis* or *Thalia welwitchi*).

Another technique integrates germinated and non-germinated grains (1). In such a case, producers (25.7 per cent from sorghum and 60 per cent from maize) divided the cleaned grains into two parts (Figure 1). One part (25 per cent) is soaked, germinated, and sun dried. These malted grains are mixed with the second part

(75 per cent), and then the mixture is milled (3 to 4 times) using a disc attrition mill. In some cases, both types of grains are milled separately and then producers achieve the mixing after the milling operation. In each case, a part of this flour (12–20 per cent) is kneaded with tap water for 4 to 10 h for saccharification. The second part is used to make hot slurry which is then mixed with the saccharified product and left to ferment for 10 to 13 h. A similar processing technique but with the slurry production from non-malted flour was described in a previous study on gowe from sorghum in Cotonou (Michodjèhoun-Mestres et al., 2005).

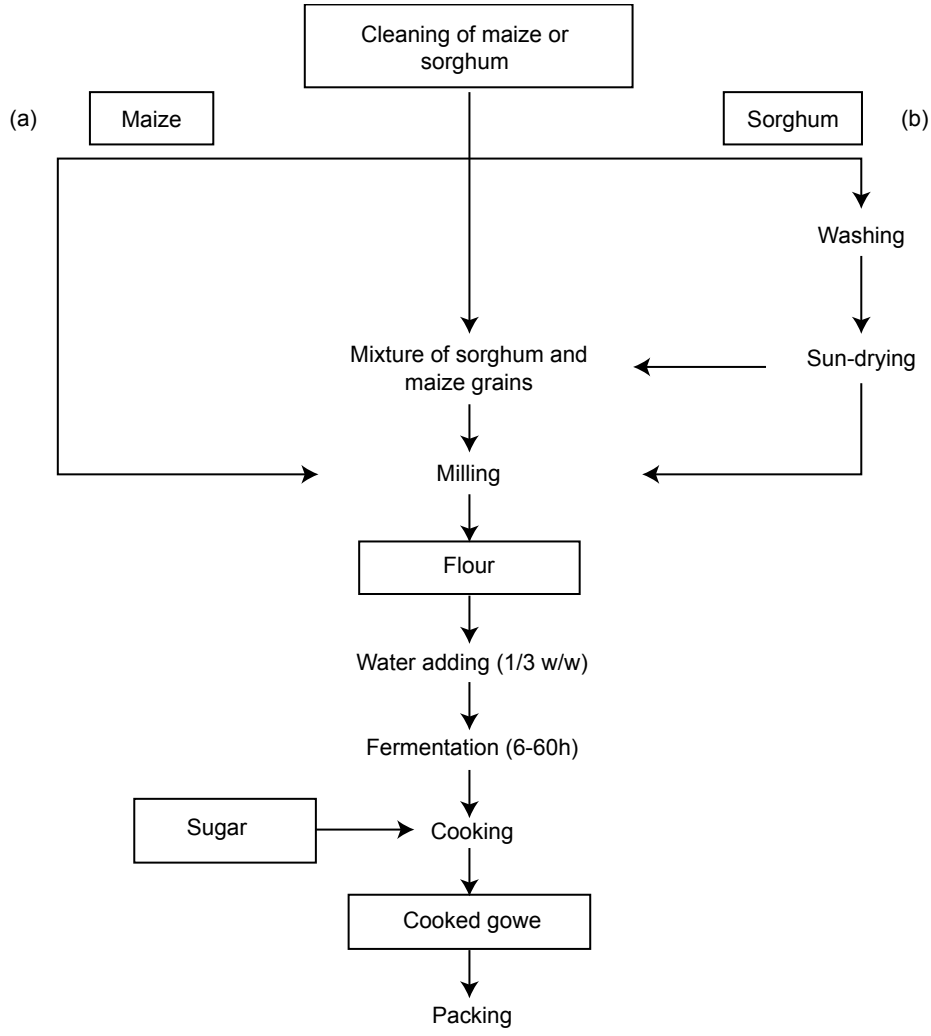

Figure 2 Flow diagram of gowe processing from non-malted grains

In Zou municipality, mainly Abomey and Bohicon localities, another processing technology was identified excluding the malting operation (4) (Figure 2). The gowe is obtained by fermentation of non-malted grain flour for 6 to 15 h, and then commercial sugar (sucrose) is added to obtain the sweet taste. This process is a distortion of the original germination technique for gowe production (Michodjèhoun-Mestres et al., 2005). Thus, changes in nutritional composition of this processed gowe can be expected since malting and saccharification operations contribute to render starch more digestible through enzymatic activities.

As far as Covè locality is concerned, steam cooking completes the processing of gowe produced from malted and non-malted maize (2). In this case, the producers steam cook the packed end product for 3 to 5 h (Figure 1). The steam cooking is a cultural habit to increase the consistency and the shelf life of the final product.

Regarding Collines municipality, about 85 per cent of producers (n=60) use the mixture of non-malted maize and sorghum for gowe production (4) (Figure 2). The mixture is milled (1 to 2 times) and the flour obtained is dry sieved to separate the bran and coarse portion. In some cases, producers (36.7 per cent) achieve a first fermentation of 5 to 13 h, and then water is added to the fermented product and left for a second 20–48 h fermentation. In both cases of fermentation, only the addition of water differs. The fermented dough obtained is cooked for longer (1.5–2.5 h) and packed in plastic material or vegetable leaves. In Collines municipality, another technique (15 per cent of producers), integrating the malting of sorghum before mixing with the cleaned maize grains, was identified (3).

The processing technique using a mixture of malted grains and non-malted grains seems to be interesting from nutritional and economic points of view. Indeed, the malting process has the advantage of reducing the phytate content (Svanberg et al., 1993; Mahgoub and Elhag, 1998) and improves the bioavailability of minerals (iron, calcium, zinc, phosphorus, etc.). The use of malted grains also reduces the viscosity of the gowe beverage. In contrast, the use of non-malted grains improves the yield of gowe due to the great swelling power of native starch. Consequently, the fermentation of a mixture of malted and non-malted grains should give gowe both nutritional and economic advantages.

Shelf life of gowe and safety problems

The shelf life of gowe varies depending on the process and the type of cereal grains. According to the producers of the sorghum-based gowe (94.3 per cent respondents, n=35), the product can be stored for three to four days (Table 1). For 60 per cent of respondents (n=35), maize-based gowe can be stored for five to six days. Indeed, in Covè municipality, all producers (n=20) of maize gowe complete gowe cooking by steaming. As a result, the product should be free from any biologically damaging agent. The same duration was mentioned by 66.6 per cent of producers (n=60) from 'maize and sorghum'. For the same purpose, the majority (73.3 per cent) of producers of gowe from 'maize and sorghum' use a long cooking operation (1.5–2.5 h) instead of additional steam cooking. Consequently, gowe seems to be a wholesome or healthy beverage as pointed out by 97.2 per cent of the interviewed

producers (n=109) for whom gowe is not contaminated by moulds. According to 18.3 per cent of them, mould appears when gowe is wrapped in vegetable leaves without any heating treatment. For 29.4 per cent of producers, the plastic material used as packaging avoids contamination but leads to an increase in sour taste and decreases the shelf life and the consistency of the final product.

Furthermore, the major problems with gowe production using traditional processes are linked to the high variability of unit operations and the unhygienic conditions of the processing environment. The soaking and germination parameters (temperature, duration, moisture) vary within and between processors. During soaking and germination, the grains can be infested by fungi with potential development of mycotoxins (aflatoxins) (Gernah et al., 2011). In addition, the germinated grain is sun dried, so success depends on the weather, mostly the intensity of the sunshine. Consequently, there is a need to standardize the malting operation. Another major problem for gowe production is spontaneous fermentation which often results in unpredictable microbial flora, and delayed fermentation, misfermentation or even failure of fermentation (Sanni et al., 2002). Processors usually pack gowe in leaves or plastic material. The unhygienic nature of these materials could be potential sources of microbial contamination.

Overall, to improve gowe processes to extend shelf life, some key operations such as malting, fermentation, and cooking steps should be upgraded. The use of salted washing solution before malting for limiting fungal growth or the use of starter culture for fermentation should be explored. The variance in cooking procedures (direct cooking process, additional steam cooking of packaged gowe) affects the texture of the end product, so cooking parameters (duration and temperature) should be improved.

Forms and frequency of consumption of gowe

The majority of respondents in Abomey (83.6 per cent, n=55) and Bohicon (95.5 per cent, n=45) consume sorghum-based gowe. Conversely in Covè, the maize gowe

Table 2 Gowe consumption (% of respondents)

Usage patterns	*Sorghum gowe (N=87)*	*Maize gowe (N=73)*	*Mix 'sorghum and maize' gowe (N=151)*
Consumption forms			
Pure gowe	17.2	35.1	23.1
Gowe with sugar	74.7	64.4	69.5
Gowe with milk and sugar	13.8	2.7	8.6
Consumption frequency (times per week)			
6–7	19.5	1.4	5.3
4–5	24.1	27.4	17.2
2–3	28.7	30.1	38.4
Once	24.1	32.9	24.5
Rarely	3.4	5.5	13.2

is the most consumed (100 per cent, n=49). In the Collines, all the respondents (n=151) consume the gowe obtained from a mixture of sorghum and maize. The consumers (64.4–74.7 per cent) drink gowe after dilution in water with sugar (Table 2) while 17.2–35.1 per cent of respondents consume gowe in its pure state, without any sugar or milk. In the latter case, the sweet taste is obtained from germination and saccharification steps during the processing. Irrespective of the type of gowe, the respondents consume gowe once to five times per week (Table 2).

Quality perception of gowe

According to consumers, gowe from sorghum is recognized as being sweeter (97.1 per cent of producers and 96.6 per cent of consumers, N=87) and slightly acidic (68.6 per cent producers and 67.8 per cent of consumers) (Table 3).

Gowe made from a single cereal is supposed to have a smooth texture (fine particle size): 65.7 per cent and 71.4 per cent for producers of sorghum gowe (N=87) and maize gowe (N=73), respectively. Conversely, the product made from the mixture of sorghum and maize should not have a sweet taste (81.7 per cent of the producers and 74.2 per cent of the consumers, N=151), but might be acidic (40 per cent and 46.7 per cent of the producers for slightly and very acidic, respectively), and should have coarse particles (71.7 per cent of the producers and 51 per cent of the consumers). Irrespective of the type of gowe, 68.6–82.9 per cent of producers and

Table 3 Sensory attributes and their importance (%) per type of gowe as perceived by stakeholders

	Producers			*Consumers*		
Sensory attributes of gowe	*Sorghum (N=35)*	*Maize (N=35)*	*Mixed 'maize-sorghum' (N=60)*	*Sorghum (N=87)*	*Maize (N=73)*	*Mixed 'sorghum-maize' (N=151)*
Sweet taste	97.1	100	18.3	96.6	93.1	13.2
No sweet taste	(*)	–	81. 7	–	–	74.2
Slightly acidic	68.6	74.3	40.0	67.8	72.6	39.7
Very acidic	31.4	17.1	46. 7	25.3	23.3	52.3
No burnt taste	11.4	11.4	–	–	–	–
Pasty	68.6	82.9	80.0	37.9	42.5	72.2
No lumps	17.1	5.7	11. 7	9.2	9.6	6.6
Smooth (fine particles)	65.7	71.4	16. 7	32.2	42.5	17.9
Coarse (bigger particles)	–	–	71. 7	–	–	51.0
White colour	–	54.3	–	–	43.8	–
Red colour	82.9	–	–	93.1	–	–
Slightly red	–	–	56. 7	–	–	31.1
Aroma of fermented product	100	100	100	100	100	100

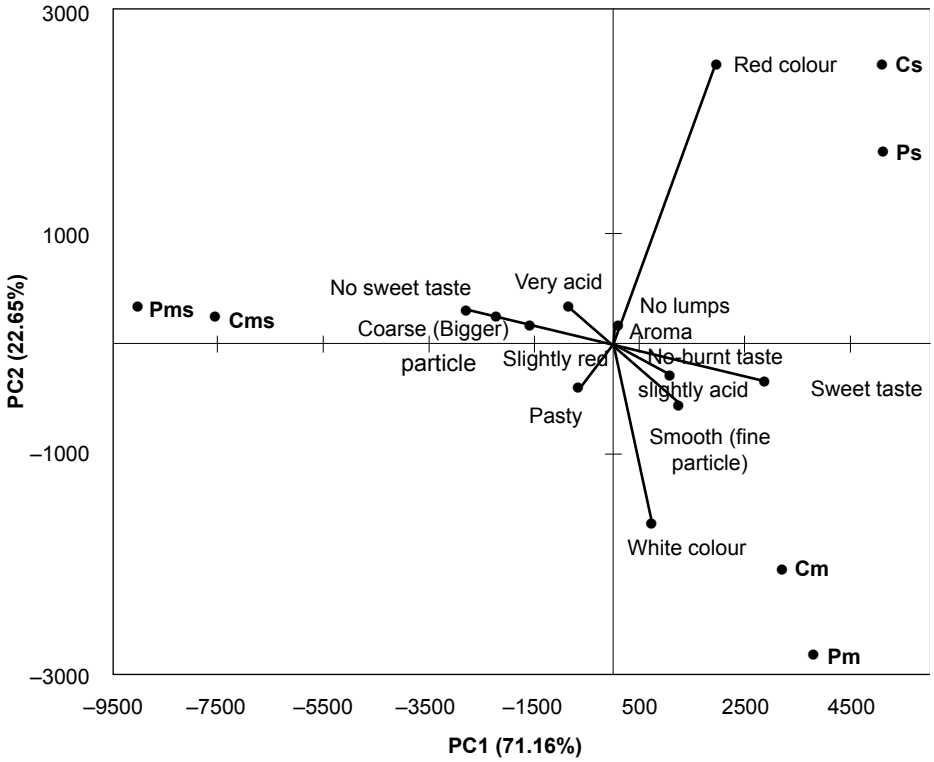

Figure 3 Relation between stakeholders with respect to sensory attributes perception of gowe
Ps = sorghum gowe producers; **Pm** = maize gowe producers; **Pms** = mix 'maize and sorghum' gowe producers; **Cs** = sorghum gowe consumers; **Cm** = maize gowe consumers; **Cms** = mix 'maize and sorghum' gowe consumers

37.9–72.2 per cent of consumers thought that gowe should be pasty/doughy. All interviewed stakeholders claimed that the final product has an aroma specific to a fermented product.

Principal component analysis (PCA) of the sensory attributes (Figure 3) explained 93.8 per cent of the variation on the first two components. The first principal component (PC1) explained 71.2 per cent of the variation while the second explained 22.6 per cent. The PC1 spanned from sweet taste, smooth texture, slightly acidic, in the right-hand segments to no sweet taste, very acidic, slightly red colour, and coarse particle. In the direction of PC2, the attributes spanned from red colour to white colour. Consequently, the PC1 represents the taste and the PC2 the colour.

The PCA plot indicated that the preference of consumers was directly associated with the perception of producers on quality criteria. Concerning the products, maize-based gowe or sorghum-based gowe were in the right-hand quadrants and were associated with the sweet taste, slightly acidic, smooth texture, and colour. The colour is the main sensory attribute that differentiates these two types of gowe.

Gowe from a mixture of maize and sorghum lay in the left-hand quadrants and was associated with no sweet taste, very acidic, slightly red colour and coarse particles.

Conclusion

Basically, malting, fermentation and cooking are common in gowe processing even if a little discrepancy is observed. The diversity of the processing techniques is the challenge for new ideas on gowe product development. The information collected will be useful in carrying out experiments and identifying the best options for re-engineering gowe processing to meet the needs of rapidly growing urban markets and exports. In this respect, efforts to characterize the processes (processing variables and parameters) are of great economic importance in the future for upgrading gowe quality.

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