academicJournals

Vol. 8(31), pp. 4254-4261, 15 August, 2013
DOI: 10.5897/AJAR2013.6908
ISSN 1991-637X ©2013 Academic Journals
http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full length Research paper

Endogenous methods for preservation of wagashi, a Beninese traditional cheese

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Accepted 29 April, 2013

Traditional cheese locally called wagashi is a good proteins source with high water content (60%) which is favorable for microorganism's growth that affects its quality. This work summarizes the endogenous methods used for wagashi preservation in Benin. Data have been collected during a survey toward 318 producers, 164 retailers and 464 consumers of Wagashi randomly selected from six agroecological zones. . Sun drying (62.26%), whey storage (21.07%) soaking in untreated water (8.49%) are the methods mostly used by producers to preserve wagashi. Daily cooking of wagashi at 80 to 100°C is the main method used by the sellers (86.58%) whereas traditional smoking was practiced by consumers (28.8%).Globally, these methods cannot preserve the product no more than 12 days of conservation, except for smoking method. In addition, cooking of spoiled wagashi with or without leaves of *Vitellaria paradoxa*, *Pennisetum polystachion* or *Piliostigma thonningii* by the producers, sellers or consumers for microbial decontamination and deodorization of the product could not avoid hazards inside the product. Probably, consumption of wagashi in Benin could be associated with microbial contamination.

Key words: Fulani, milk, whey, wagashi, pathogens, microbial decontamination.

INTRODUCTION

The economies of most African countries in the south of Sahara, including Benin, is mainly based on agriculture and livestock takes an important place (Diao et al., 2006). Among livestock products, cow's milk has a great socio-economic importance. Indeed, in Benin, milk contributes more than 50% of annual household income of Fulani ethnic group (Dossou et al., 2006). Because of its high water content and nutrients, fresh milk undergoes rapid degradation by pathogenic microorganisms. Due to the lack of a cold chain, many traditional methods of preservation of wagashi have been developed in Africa, particularly in Benin (Kèkè et al., 2008). In Benin, the milk is processed into various products such as yoghurt, curd and wagashi, a traditional cheese from an artisanal process developed by the Fulani ethnic group. The wagashi is the most popular and most consumed milk derivate products (Aïssi et al., 2009). Wagashi is an important source of animal protein, especially for people with low incomes and could efficaciously contribute to solving problems related to proteins deficiency in the

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Table 1. Geographical distribution of investigation's areas.

Agro-ecological zones	Provinces	Municipality	Latitude of municipality	Longitude of Municipality
Zone A	Atacora	Pehunco	10° 13' 42.00'' N	2° 00' 7.00'' E
Zone B	Donga	Djougou	9° 42' 0.00'' N	2° 18' 57.00'' E
Zone C	Alibori	Gogounou	10° 47' 20.36'' N	2° 37' 8.14'' E
		Kandi	11° 07' 43.36'' N	2° 56' 13.00'' E
Zone D	Borgou	Parakou	9° 21' 00.00'' N	2° 37' 0.00'' E
	Collines	Savè	8° 01' 48.00'' N	2° 29' 24.00'' E
Zone E	Atlantique	Abomey-Calavi	06° 27' 0.00'' N	2° 21' 0.00'' E
Zone F	Littoral	Cotonou	6° 21' 45.00'' N	2° 25' 31.80'' E

Zone A = Foodstuff Zone of Southern Borgou; Zone B = Western Zone Atacora, Zone C = Cotton zone of northern Benin; Zone D = Cotton Zone of centre Benin, Zone E = Land area bar; Zone F = Area of fisheries.

diets in Africa (Kèkè et al., 2008). Unfortunately, wagashi creates a favorable environment for the growth of microorganisms, which may negatively affect its quality. Several research studies have essentially focused on wagashi process and its microbiological quality.

Moreover, Aworh and Egounlety (1985) and Kees (1996) reported the processing technology of wagashi and its stabilization by heat treatment and using chemical additives such as propionic acid and sorbates. In addition, Kèkè et al. (2008) reported a method of conservation of wagashi using strains of *Lactobacillus plantarum*. Furthermore, the conservation of wagashi by chemical method has a negative effect on the sensorial quality of the product (Kèkè et al., 2008). Traditional practices for preservation of wagashi, used on-farm persist over time and allow preserving the sensorial quality of the product for a relatively long time. The exhaustive inventories of all these practices so far are not well documented. The present work aims to inventory the traditional methods used by the producers, the sellers and the consumers to preserve wagashi in Benin, with a view to access these methods in order to improve the quality of the product.

MATERIALS AND METHODS

Study area

The study was conducted in eight municipalities located in six agro-ecological areas of Benin (Table 1 and Figure 1).

Selection of survey areas

Pehunco, Gogounou, Kandi and Djougou areas are known to be big regions of milk production and wagashi processing (Chopra and Ouaouich, 2009; FAO, 2012). Parakou, Cotonou and Abomey-Calavi are cosmopolitan municipalities where wagashi is more consumed (Dossou et al., 2006).

Choosing of respondents

Due to the lack of database during the survey respondents were randomly selected according to the criteria of accessibility and availability to provide the information. A total of 318 producers, 164 sellers and 464 consumers of wagashi in the study areas were interviewed.

Methods of data collection

An individual survey by interviewing the respondent was performed. The data collected were related to the traditional conservation methods, the shelf life of wagashi preserved by traditional methods, the source of additives used, the quality of the water used for production and / or conservation of wagashi, the transportation conditions of wagashi.

Statistical analysis of data

The data collected were analyzed using SAS (1996). The percentages of respondents for each conservation methods were calculated by actor in the chain (producer, retailer and consumer) and study area. To show differences between these percentages calculated, pair wise comparison were made using Z bilateral test. Shelf life of wagashi were calculated by category of actor (producer, retailer and consumer). The significativity of conservation methods was determined by the F test after analysis of variance (ANOVA). The means shelf lives were calculated by method of storage for each category of actor and pair wise compared using student t test.

RESULTS

Preservation methods

Several traditional methods were used for wagashi conservation by producers, sellers and consumers in Benin (Table 2). Among these methods, the main practices were sun drying, used by 62.26% of respondents, followed by when conservation by 21.07% of the producers investigated. Sun drying of wagashi was especially used by producers of Pehunco and Djougou, whereas the whey conservation was the main method used by 100% of respondents in Save. Wagashi conservation by soaking in colored water with *Sorghum vulgaris* or *Sorghum caudatum* was also used by 8.49% of producers. This practice of preservation of wagashi

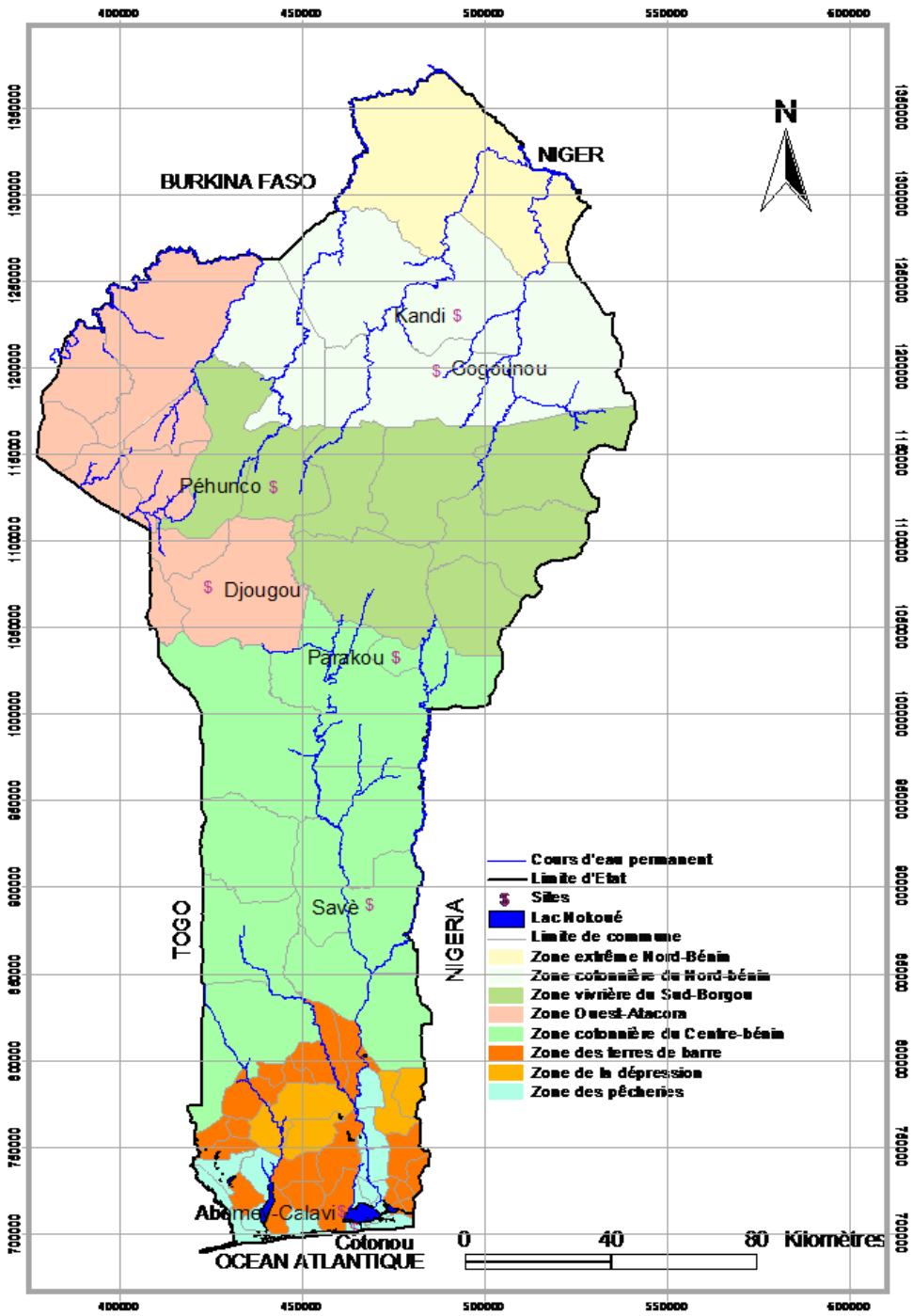

Figure 1. Benin's map showing the survey areas.

dominated in Gogounou. The method of storage of the product soaking in untreated water was, used especially by Fulani etchnic group of Parakou camping's by 8.17% of the producers. Daily cooking of wagashi at 80 tob100°C was practiced by 86.58% of respondents of the sellers followed by preservation of wagashi in untreated water (8.54% of respondents) and sun drying which is applied by 3.66% of sellers. In the category of consumers, it appeared that the sun drying of wagashi practiced by 35.13% of respondents especially in the northern., remained the most widely used method, followed by traditional smoking, daily cooking and frying of wagashi by 28.8, 25.86 and 6.03% of consumers, respectively. Figure 2 illustrates sun drying and whey

Table 2.Proportion of respondents (%) using different traditional methods for wagashi preservation in Benin.

% at the level of area	Producers					Retailers				Consumers				
	N	SD	WP	CUW	CCW	N	DC	CUW	SD	N	F	DC	TS	SD
Pehunco	143	97.20^{a}	2.80^{b}	0.00	0.00	22	100^{a}	0.00	0.00	50	2.00^{b}	36.00^{b}	28.00^{a}	30.00^{b}
Djougou	49	95.92^{a}	0.00	0.00	4.08^{b}	21	95.24^{a,b}	4.76^{a}	0.00	36	5.56^{a,b}	5.56^{c}	27.78^{a}	52.78^{a}
Parakou	33	27.70^{b}	3.03^{b}	69.70^{a}	0.00	60	86.66^{a,b}	8.32^{a}	3.33^{a,b}	104	4.80^{b}	32.69^{b}	27.50^{a}	25.96^{b}
Gogounou	33	9.09^{b}	6.06^{b}	9.09 b	75.76^{a}	03	100^{a}	0.00	0.00	52	0.00	1.92^{c}	28.8^{a}	67.31^{a}
Kandi	-	-	-	-	-	09	77.78^{b}	0.00	22.22^{a}	59	0.00	0.00	32.20^{a}	67.80^{a}
Save	60	0.00	100^{a}	0.00	0.00	16	81.25^{b}	06.25^{a}	12.50^{a,b}	38	0.00	57.89^{a}	26.31^{a}	21.05^{b}
Abomey-Calavi	-	-	-	-	-	04	75.00^{b}	25.00^{a}	0.00	49	14.28^{a}	44.90^{a,b}	30.60^{a}	8.16^{b,c}
Cotonou	-	-	-	-	-	29	79.31^{b}	20.69^{a}	0.00	76	17.10^{a}	27.63^{b}	28.94^{a}	19.74^{b,c}
Mean	318	62.26	21.07	8.17	8.49	164	86.58	8.54	03.66	464	6.03	25.86	28.88	35.13

Percentages in the same column followed by different letters are significantly different (p< 0.05), SD : Sun Drying ; WP : Whey Preservation ; CUW : Conservation in Untreated Water ; CCW : Conservation in Colored Water with *Sorghum* ; DC : Daily Cooking ; F : Frying ; TS: Traditional Smoking. N= Sample's size; -: no respondent surveyed or null.

(a) (b)

Figure 2. (a) Sun drying and (b) whey preservation of wagashi during selling.

preservation of wagashi methods.

Shelf life of wagashi

The shelf life of wagashi preserved by the different methods collected did not exceeded one month. However, some methods, based on information from stakeholders, seem to be more effective than others, depending on the stakeholder group. In addition, according to the producers, shelf life time of wagashi preserved by sun drying (8.48 ± 0.49 days) was the most efficient method of wagashi preservation. Daily cooking with a shelf life about 8.26 ± 0.42 days was the most practiced and effective method used by the retailers, whereas smoking of wagashi whose shelf life is one month, was recognized

Table 3. Shelf life of wagashi preserved with different methods.

Actor	Preservation methods	Sample's size	Shelf-life	Standard deviation	Significativity
Producers	Solar drying	198	8.48[a]	0.49	***
	In untreated water	26	2.57[c]	1.37	
	In whey	67	3.04[b,c]	4.74	
	In coloured water	27	4.74[b]	1.34	
Sellers	Daily cooking	142	8.26[a]	0.42	NS
	In untreated water	14	5.50[b]	1.34	
	Solar drying	6	6.16[b]	2.06	
Consumers	Frying	28	4.62[c]	2.01	****
	Traditional smoking	134	30.00[a]	0.00	
	Solar drying	163	11.73[b]	9.77	
	Daily cooking	120	7.14[c]	2.82	

Means in the same column by actor followed by different letters are significantly different ($p < 0.05$).

as the most effective method for wagashi preservation by consumers. A significant difference ($p < 0.001$) between the shelf life of the different methods of wagashi preservation by the producers and consumers was observed.

Moreover, none of the methods used by producers and sellers did not contribute to enhance the quality of wagashi for more than twelve days (Table 3). The factors involved in relation to the short shelf life of wagashi by these different methods were related to the rapid decay of wagashi, the quality of the milk used , the lack of appropriate method for conservation of wagashi, the contamination by moulds, the quality of feed of animals from which the milk is obtained.

Quality of water used to process or preserve wagashi

The water used by producers, consumers and sellers for the production or storage of wagashi is often of poor hygienic quality. In fact, about 70% (69.81%) of the producers used poor quality of water for wagashi processing. Moreover, water from wells was used by producers of Pehunco for wagashi manufacturing, whereas water from backwater at Sambo-gah in Djougou was used and water from river was used by producers of Savê. About 76.22% of retailers, declared using good quality of water against 91.59% of consumers for preservation of wagashi.

Conditions of transporting and saling of wagashi

Wagashi is packaged and transported under poor hygienic conditions. Packed in stored fortune bags and in bowls or baskets and cut containers, wagashi was transported at ambient temperature (25 to 45°C) from the production area to the sellers' home, sometimes during several times (8 h).

The situation is the same with the consumer. During saling, the conservation of wagashi is often done by soaking the product in untreated water, especially at Cotonou markets (95% of sellers).

At Gogounou, wagashi remained immersed in colored water extracted from *Sorghum vulgaris* and/or *S. caudatum* during the saling period. About 100% of sellers from Pehunco, Parakou, Djougou and Save stored wagashi in open shelves, exposed to flies, dust, weather (rain, wind), insects and other pests during (Figure 3).

Conservation of wagashi by microbial decontamination and deodorization of spoiled wagashi

Several techniques for microbial decontamination and deodorization of altered wagashi (by visible moulds especially) were used including the boiling of wagashi at 80 to 100°C, followed by sun drying used by 62.89, 100 and 61.89% of producers, sellers and consumers, respectively.

The boiling coupled with the use of plants' leaves of *Vitellaria paradoxa* or *Pennisetum polystachion* or *Piliostigma thonningii* and sun drying was practiced by 19.18% of the producers, and the frying and smoking were practiced by 0.22% and 9.27% of consumers, respectively. The main plant used by producers for decontamination and deodorization of wagashi was *P. thonningii* followed by *V. paradoxa*.

The toxicity for human of extracts from these plants must be verified in order to evaluate hazards associated with their consumption.

DISCUSSION

From analysis of the data related to the traditional

Figure 3. Illustration of wagashi preservation under unsanitary conditions of production, transportation and selling. a: wagashi pile up in a bucket in unhygienic condition; b: wagashi in a sieve, set on the land; c: wagashi transported in a can in unhygienic condition; d: wagashi pile up in untreated water at selling in unhygienic condition, e: Palpation of wagashi by the buyer prior choice f: wagashi without packaging and subjected to rainwater, g: wagashi at early of spoilage step and covered by a transparent cloth invaded by flies in the market, h: wagashi unprotected invaded by flies.

methods used for wagashi conservation, we can put out the potential limits concerning the sun drying method of

wagashi which it used only in the dry season. In addition, sun drying method of wagashi preservation may provide microbiological contamination of the product mainly by *Bacillus* spores, moulds and others microorganisms. During processing, undesirable foreign materials may accidentally be mixed with wagashi (Shibamoto and Bjeldanes, 2009). This method, however, has the advantage of reducing the water activity (Aw) of wagashi when the drying has been conducted at term. The microbial load after an efficient sun drying time of wagashi would be drastically reduced(Medveďová et al., 2009). It would be better to improve this traditional method acting primarily on the integrity of wagashi throughout the drying time by limiting the direct contact of the product with the aforementioned contaminants and ensuring its position in relation to the direction of wind and maximum sunshine.

When conservation and untreated water have limits due to the fact that both methods involve the use of hands, utensils and water which could be a vehicle or source of contaminants affecting quality of the product. Hands (not disinfected or unprotected), constitute surely an immediate cause of microbial contamination, the water used often under poor hygiene quality can causes microbiological, physical and chemical contamination. Indeed, the backwater and the river water can carry pathogens such as *E. coli, Klebsiella, Salmonella, Citrobacter, Enterobacter and Enterococcus*, *Clostridium perfringens*, *Pseudomonas aeruginosa, Shigella* spp*, Candida albicans, Staphylococcus aureus, Giardia lamblia, Cryptosporidium* and human enteric viruses (Degbey et al., 2010, 2011).

Moreover, the water used in Benin for this activity can also be a vehicle of toxic heavy metals such as mercury, arsenic, cadmium and lead (Degbey et al., 2010) and pesticides such as endosulfan, DDT, dieldrin, heptachlor and lindane (Degbey et al., 2010; Agbohessi et al., 2012). The wholesomeness of utensils may not guarantee safety of the product given to cross-contamination that may occur during conservation in untreated water and whey storage. The whey preservation of wagashi certainly may not have all the required microbiological quality of a product whose chemical composition of carbohydrates, lipids, minerals and trace of protein is a favourable factor for microorganism's growth.

The method of colored water conservation represents a two-pronged approach: the use of water is a gap previously reported. However, the extraction and use of dyes of *S. caudatum* and *S. vulgaris* were reported by Akande et al (2010), Khalil et al. (2010), Agbangnan (2011), Kayodé et al. (2011, 2012) as a potential source of antioxidants such as polyphenols, 3-deoxyanthocyanidine and flavonoids found in the extracts. Also, these dyes possess anticancer properties and anti-cardiovascular disease (Kayodé et al., 2011, 2012), hepatoprotective and hematopoietic properties (Akande et al., 2010). Unfortunately, the extracts of these dyes do not possess antimicrobial properties (Belewu et al., 2005; Agbangnan, 2011) and microbial contamination from water can affect the quality of the final product. In addition, the dyes themselves can carry spores of *Bacillus* and some pathogenic fungi and other microorganisms.

Sellers represent the intermediate chain of wagashi conservation between producers and consumers. The method of packaging and transportation of wagashi by the retailers may have significant negative effects in maintaining the integrity of the product quality due to the use of none recommended for transporting packaging wagashi at temperature ranging between 25 to 45°C. Daily cooking at which wagashi is subjected at retailer's home, if it reduces the remaining microbial load, could destroy the most heat labiles nutrients in the wagashi. Indeed, the repeated heat treatment may destroy nutrients in the product such as protein, vitamins and minerals (Shibamoto and Bjeldanes, 2009).

The frying which is relatively a good conservation method as having the advantage of destroying the microbial flora of the product when keeping it in fat state which limits its recontamination by non-lipophilic microorganisms. However, the quality of the frying oil can be no useful for the maintenance of nutritional quality of wagashi, the composition of oil rich in saturated fatty acids could give to the product, the vehicle of triglycerides which are lipoprotein and cholesterol precursors inside the wagashi (Nout et al., 2003). In case the consumer will fry several times the same product, he could expose wagashi to benzopyrenes contamination, which may be carcinogenic to the consumer (Shuguang Li et al., 1994; Shibamoto and Bjeldanes, 2009)

The traditional smoking, while offering a long shelf life to the product, present risk of being contaminated by benzopyrenes (Garcia, 1999; Kazerouni et al., 2001). Also, this method may lead to an important loss of nutrients (fatty acids, tocopherol and vitamins especially) in wagashi (Espe et al., 2002).

Practices of microbial decontamination using the leaves of *V. paradoxa*, *P. polystachion*, *P. thonningii* for deodorization of spoiled wagashi shares of deodorization and repairing fitness of wagashi in the way of deterioration according to producers, may constitute poisoning factors to be investigated.

To summarize, endogenous practices of wagashi preservation in Benin are variable and present limits for the good preservation of the product. In fact, dialing cooking, traditional smoking and frying of wagashi are heat treatment methods of wagashi preservation which may reduce the nutritional value of this cheese. The sun drying preservation like untreated and colored water and whey preservation of wagashi may alter hygienic and sanitary qualities of this cheese due to the potential microbial and chemical contaminations of the product through these methods. Preservation of cheese wagashi by these techniques may negatively affects physical, chemical, microbial and nutritional qualities of wagashi. New technique using plants extracts with very low toxicity, antioxidant, antimicrobial and biopreservative capacity is a

good alternative method to be used at traditional scale for the preservation of wagashi regarding their biopreservative potential largely studied in literature and their security for consumer's health (Hsouna et al., 2011; Barkat and Bouguerra, 2012; Varona et al., 2013).

Conclusion

The study reported the traditional conservation practices of wagashi used by producers, consumers and sellers in Benin. Sun drying is the most used traditional method for wagashi preservation. This method could offer more guarantees for the safety of the product if the process was improved. Daily cooking although extends the shelf life of the product could harm thermolabile nutrients of wagashi and affects its nutritional quality. Sun drying and traditional smoking conservation methods are typically used by consumers, but they are not without risk to their health. Combination of traditional methods of conservation wagashi seems to ensure its hygienic and nutritional quality of the product.

ACKNOWLEDGMENTS

The authors are grateful to University Council of Development (CUD) for its financial support. They are thankful to Mrs Avocegamou Sévérin and Wabi Mabouroukath for their technical assistance.

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