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Reducing the atypical odour of *dawadawa*: Effect of modification of fermentation conditions and post-fermentation treatment on the development of the atypical odour of *dawadawa*

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ABSTRACT

Dawadawa, an indigenous African alkaline fermented condiment has a distinct atypical odour which is often described as strong, pungent, and ammoniacal, but sometimes also as unpleasant, undesirable, objectionable, offensive. To improve the marketability of *dawadawa*, procedures capable of reducing the atypical odour were assessed. These were addition of humectants, NaCl (1.5 mol/kg) and glycerol (1.7 mol/kg), or irradiation by gamma radiation (2.5 kGy) partway through fermentation, and also steaming of the fermented product. The sensory profiles of the products were determined by Quantitative Descriptive Analysis (QDA). Changes in microbiological and chemical characteristics were monitored on Nutrient Agar, and by measurement of pH, titratable acidity, proximate composition, and elemental analysis by atomic absorption spectrophotometry. All treatments applied significantly reduced the population of *Bacillus* species and also pH during fermentation. The pH at end of fermentation for the control was 8.9, NaCl-treated sample 7.6, glycerol-treated sample 7.5, and irradiated-sample 7.3 indicating suppression of ammonia formation which is responsible for the rise in pH and pungent odour in *dawadawa*. Steaming for 25 min also resulted in loss of ammonia as indicated by slight reduction in pH from 8.8 to 8.3. Apart from the ash content, significant differences were observed in the concentration of protein, fat, carbohydrate, Fe, Mn, Zn, Na, K and Cu in most of the treated samples in comparison to the control. Odour descriptors generated by the semi-trained panel for *dawadawa* were ammoniacal, stink fish, faecal, urine, old smoked fish, marmite, shea butter, rancid palm kernel oil, corned beef, beany, and damp cocoa beans. In two sets of QDA, the control scored higher intensities for the undesirable descriptors, ammoniacal, faecal, stink fish and urine than the treated samples. In a difference from-control-test based on intensity of undesirable descriptors a semi-trained panel scored 5.61 for steamed-sample, 6.11 for irradiated-sample, 7.17 for NaCl-treated sample, and 7.5 for glycerol-treated sample on a scale of zero (no difference) to ten (extreme difference).

1. Introduction

Indigenous foods play a central role in the eating habits of people in many parts of Africa. In West Africa many of such foods are fermented and include food condiments which are used to flavour soups and stews. Similar condiments are also known in some parts of Asia (Amoa-Awua, Terlabie, & Sakyi-Dawson, 2006; Beaumont, 2002; Parkouda et al., 2009). The West African condiments are produced from tree seeds, the most popular being *dawadawa*, a culinary product that can be used to enhance flavour and intensify meatiness in soups, sauces and other prepared dishes (Beaumont, 2002). *Dawadawa* is reportedly often used by low income families as a low-cost meat substitute (Dakwa, Sakyi-Dawson, Diako, Annan, & Amoa-Awua, 2005; Odunfa, 1985a).

Dawadawa is known by various names in different parts of Africa, and is traditionally produced from the seeds of the African locust bean (*Parkia biglobosa*). However it can also be produced from soybeans. The other names of *dawadawa* include *soumbala*,

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netetu, iru, afitin, sonru, or *kinda*. Other West African condiments include *ogiri owoh, ogiri-saro, okpehe, ugba, owoh*, and *bikalga* which are produced from melon, sesame, mesquite, African oil bean, African yam bean and roselle seeds respectively (Odunfa, 1985a; Parkouda et al., 2009). The West African condiments often have a very local character, an alkaline pH and an unmistakable atypical odour which is variously described as strong, pungent, ammoniacal, distinct, or even objectionable. Usually the atypical odour mellows when the condiment is used in cooking (Beaumont, 2002; Campbell-Platt, 1980; Odunfa, 1986).

Dawadawa is produced by cooking and dehulling locust bean seeds. The cotyledons are cooked again and fermented in baskets and other containers for 3–4 days. The fermented beans give the distinct odour which is always accompanied by an ammoniacal odour (Campbell-Platt, 1980; Diawara, Sawadogo, Amoa-Awua, & Jakobsen, 1998; Odunfa, 1981; Sawadogo-Lingani et al., 2003).

Many authors have suggested that the widespread use of *dawadawa* and other African condiments is due to their pleasant taste, distinct peculiar odour and important nutritional qualities (Azokpota, Hounhouigan, Annan, Nago, & Jakobsen, 2008; Dirar, 1993; Owens, Allagheny, Kipping, & Ames, 1997; Ouoba, Diawara, Annan, Poli, & Jakobsen, 2005). However, in spite of the pleasant taste of *dawadawa*, it is the view of the authors that many consumers find the odour of *dawadawa* and some of the other condiments objectionable, hence do not use them. The use of the condiments, therefore, appears to be confined to persons who have been used to the products from infancy. As such market opportunities for the West African condiments can be expanded if the intensity of their peculiar odour can be reduced. This has been the rationale for carrying out this work.

Only very few studies have been carried out to try and suppress the atypical odour in *dawadawa*. The notable work was by Allagheny, Campbell-Platt, Owens, and Obanu (1996) who were able to control ammonia formation in *dawadawa* by modifying fermentation conditions during production. In 2002, Beaumont reported of another approach by Nestle in which a process had been patented by Heyland, Dac, Rose, and Wood (1995) for a flavourant which imparts a basic meaty flavour with a reduced yet characteristic *dawadawa*-like aroma. The current authors have also observed a procedure at a production site in Bamako, Mali, where fermented locust beans were steamed before sundrying to reduce the intensity of the pungent odour in the dried product.

The work by Allagheny et al. (1996) on controlling ammonia formation during *dawadawa* fermentation has been the basis for our study. In *dawadawa* fermentation, *Bacillus* spp are responsible for degrading proteins into peptides and amino acids (Odunfa, 1985b; Ouoba et al., 2003). The *Bacillus* spp then utilize the free amino acids as carbon and nitrogen sources leading to the production of ammonia/ammonium hydroxide

$$RCH\left(NH_3^+\right)COO^- + nO_2 \rightarrow nCO_2 + nH_2O + NH_4^+ + OH^-$$

The ammonia produced causes a rise in pH. Above pH levels of about 8–8.3, sufficient ammonia is present in addition to other volatile compounds and gives the strong ammoniacal odour, which readily reaches objectionable levels (Campbell-Platt, 1980; Ohta, 1986; Odunfa, 1986; Sarkar, Cook, & Owens, 1993; Ouoba et al., 2005). Production of ammonia can, therefore, be restricted by limiting the growth and metabolism of the bacteria whilst not inhibiting the action of flavour-generating proteolytic enzymes (Allagheny et al., 1996). In the production of Japanese natto this is achieved by holding the fermented soybeans at a temperature sufficiently low to restrict bacterial growth, whilst allowing the proteolytic action to continue during the maturation stage (Ohta, 1986).

Allagheny et al. (1996) achieved a reduction in the level of ammonia in *dawadawa* by fermenting at a low temperature, reducing water activity through addition of humectants, fermenting under high CO_2 concentrations and under limiting O_2 supply. All these methods restricted bacteria growth during fermentation.

The objective of this work was to assess the effectiveness of different methods to reduce the intensity of undesirable odour notes in the sensory profile of *dawadawa*. The focus of the work was on sensory descriptive analysis of untreated and treated *dawadawa* samples. The methods investigated were addition of humectants and application of gamma radiation to restrict bacterial growth, and steaming as a post fermentation treatment to reduce the intensity of the atypical odour in *dawadawa*.

2. Materials and methods

2.1. Sample preparation and treatments

African locust bean seeds were soaked in water for 24 h and autoclaved at 121 °C for 20 min, cooled and dehulled by rubbing between the palms in water. The hulls were separated from the cotyledons by mixing in water and allowing the hulls to float. The cotyledons were boiled for 2 h and packed into baskets lined with clean plantain leaves. A little maize flour was sprinkled on the cotyledons, covered with more plantain leaves, and the cotyledons left to ferment for 96 h. To control the development of the atypical *dawadawa* odour during fermentation, the following treatments were applied to the beans during fermentation. One post-fermentation treatment was also tried.

2.1.1. Addition of humectant

NaCl or glycerol was added to 500 g of the cotyledons at 15 h of fermentation to restrict bacteria growth based on concentrations which had been used by Allagheny et al. (1996) in their work. The concentrations tested were 0.5 mol/kg (59 g), 1.0 mol/kg (117 g), 1.5 mol/kg (176 g) of NaCl and 0.3 mol/kg (55 g), 1.0 mol/kg (184 g) and 1.7 mol/kg (313 g) of glycerol. The cotyledons were allowed to ferment for a total of 96 h, but sampled at 0 h, 15 h, 24 h, 48 h, 72 h and 96 h for microbiological and chemical analysis. After fermentation the seeds were sundried for 2 days to a moisture content of about 10% and used for sensory analysis.

2.1.2. Gamma irradiation

At 48 h of fermentation, 500 g of cotyledons were collected and subjected to gamma radiation using a cobalt-60 source at the Ghana Atomic Energy Commission. Irradiation doses tested were 2.5 kGy, 4 kGy and 6 kGy. The irradiated sample was packed in a small basket and allowed to ferment for a further 48 h, then sundried for 2 days to a moisture content of about 10% and used for sensory analysis.

2.1.3. Steaming

A sample of 500 g of locust beans which had been fermented normally for 96 h was steamed for either 45, 65 or 85 min as post-fermentation treatment. This method had been observed by the authors at a *soumbala* (*dawadawa*) production site in Bamako, Mali, where the fermented locust beans were steamed before sundrying and gave a product with a mild odour.

2.2. Sensory analysis

2.2.1. Qualitative descriptive analysis

A semi-trained sensory panel consisting of 14 trained assessors from the CSIR-Food Research Institute and the Ghana Atomic Energy Commission, both in Accra, Ghana, were used for the sensory