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Optimization of Dockounou Manufacturing Process Parameters

Akoa Essoma Flore Edwige[1], Kra Kouassi Aboutou Séverin[1], Mégnanou Rose-Monde[1], Kouadio Natia Joseph[1] & Niamké Lamine Sébastien[1]

[1] Laboratoire de Biotechnologies, UFR Biosciences, Université Félix Houphouet-Boigny, République de Côte d'Ivoire

Correspondence: Kra Kouassi Aboutou Séverin, Laboratoire de Biotechnologies, UFR Biosciences, Université Félix Houphouet-Boigny, 22 BP 542 Abidjan 22, Côte d'Ivoire. Tel: 225-0839-3331. E-mail: kra_severin@yahoo.fr

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Abstract

The present study aimed to determine optimum values of the process factors to obtain a standard method of preparation with best quality of dockounou.

Several samples of dockounou were prepared with different proportions (75 to 95%) of senescent plantain, cooking time, fermentation time and temperature of oven. Sensorial characteristics of the samples were investigated. Optimal values (scores) of both boiled and baked dockounou prepared with maize or rice flour were identified through tasters' evaluation. Hence, the best scores were recorded with 90 and 85% of plantain paste proportion, respectively with maize and rice flours. Concerning cooking time, optimal values were registered at 60 minutes with maize-dockounou, and at 75 minutes with rice-dockounou flour. About fermentation time, the best sensorial characteristics were obtained at 4 hours for rice or maize-dockounou, but at 0 hours for the boiled rice one. Results revealed moreover that 160 °C would be the optimal baking temperature.

The optimized maize-dockounou would be better than the rice one on sensorial basis. Optimized maize-dockounou uses a larger quantity of plantain paste than optimized rice dockounou. This optimized dockounou uses shorter fermentation time than the traditional one. In general, the optimized dockounou is better than the traditional. It presents better characteristics and is more appreciated. Thus, optimized-dockounou is a real opportunity to convert rejected senescent plantains into foodstuff to help to feed the populations. That could be a way of food security.

Keywords: senescent plantain, dockounou, flour, sensorial characterization, optimization

1. Introduction

Plantain (*Musa* spp.) is a major food crop in the humid and sub-humid parts of Africa and valuable source of energy for millions of people in these regions (John & Marchal, 1995; Bakry et al., 2002). In fact, plantain constitutes the fourth most important global food commodity after rice, wheat and maize (Bakry et al., 2002). It contributes significantly to food and income security of people engaged in its production and/or trade in developing countries. Many African countries use plantains as an inexpensive source of calories (Akubor, Adamolekun, Oba, Obari, & Abudu, 2003) because it is an important starchy staple food, and an invaluable source of carbohydrates (IITA, 1998).

Nearby its importance, plantain is a highly perishable fruit, which requires processing into a more stable and convenient form. Indeed, the difficulties of plantain preservation result from its easy ripening at ambient temperature leading to a qualitative and quantitative degradation along the distribution chain (Chia & Huggins, 2003). According to Emaga, Walhet and Paquot (2008), most of these losses might be due to the natural reaction of maturation of plantain fruits. Moreover, about 35 to 60% post harvest loss was attributed to lack of storage facilities and inappropriate technologies for food processing (Atanda, Pessu, Agoda, Isong, & Ikotun, 2011). To face the problem of short shelf life of plantain, its fingers are rapidly consumed boiled, roasted and fried (N'Guessan, Yao, & Kehe, 1993; Honfo, Tenkouano, & Coulibaly, 2011). Plantain is also converted into less perishable derivate products such as chips and flour and then traded for house consumption (Dzomeku, Dankyi, & Darkey, 2011). As another solution to post-harvests losses, over-ripe fruits of plantain are transformed into a traditional dish called "Dockounou" in Côte d'Ivoire (Koffi, 2007; Flore, Rose-Monde, Severin, & Sebastien,

2013) and "Ofam" in Ghana (Dzomeku et al., 2011), using an empiric process. The resulting dish wrapped in plant (*Thaumatococcus danieilii, Musa sp.* or *Cola nitida)* leaves before its cooking, constitutes an inestimable food aid for farmers during camp works.

This traditional dish is more and more introduced in urban habit and is widely offered on markets. Today, this preparation is much popularized and the products are sold in almost all the markets of big cities and consumed by all the Ivorian society levels. The general production process (Figure 2) which involves seven (7) steps (washing, peeling, crushing, mixture with flour, fermentation (facultative), wrapping and cooking) depend on many factors that influences more the final dish. In consequence, urban producers/sellers of "Dockounou" offer on the markets different products which are prepared with various methods and various sensorial characteristic. Thus, consumers often complain about its taste, color, texture and flavor. Hence, the present study aimed to propose an optimal process of dockounou. Therefore, the optimum values of process factors to obtain best quality of dockounou were determined.

2. Materials and Methods

2.1 Samples Collection

Senescent plantains fingers, maize flour and rice grains used in the production process were purchased from Adjame market (Abidjan). The traditional dockounou used for the comparison with the optimized dockounou were also purchased at the same market.

2.2 Preparation of Rice Flour

The rice grains were soaked in water for two hours. After drying, the grains were crushed in a home wooden mortar, and the flour was sieved (500 µm) before mixture with plantain paste.

2.3 Empiric Process of Dockounou Production

Senescent plantain fingers were washed with potable water to eliminate all impurity and peeled manually using ordinary knife. Pulp crushing was made in traditional hygienic wood mortar. The mushy pulp was mixed with a few quantity of rice or maize flour. The mixture, wrapped in *Thaumatococcus daniellii* or *Cola nitida* leaves, was boiled or baked as reported Akoa, Kra, Mégnanou, Akpa and Ahonzo (2012).

2.4 Experimental Design for Dockounou's Empiric Process Parameters Optimization

The important parameters of dockounou production process were optimized using a variation of four (4) factors reveled by consumer (Flore et al., 2013): quantity of plantain's paste, fermentation time, cooking time and oven temperature. They were identified as independent variables and were not quantified in empiric production process. The source data levels of these parameters were based on preliminary survey results (Flore et al., 2013). As regards boiled dockounou, the effect of three parameters was study excepted oven temperature. However, the fourth factors were all studies in case of baked dockounou.

2.5 Influence of Senescent Plantain Paste Quantity

The method uses an experimental determination of optimum variables base on many values of parameters registered with producers preparation. It consisted to varied one parameter and sticks the others. Quantity of plantain paste was varied in inverse proportion to quantity of maize or rice flour. The paste quantity was varied from 75 to 95% in proportion without fermentation and cooking time occurs at 90 min (base on values of parameters registered with producer's preparation).

2.6 Influence of Fermentation Time

The fermentation time was varied from 0 to 10 hours however cooking time occurs at 90 min and plantain paste quantity was sticked at optimal value.

2.7 Influence of Cooking Time

The cooking time was varied from 30 to 120 min however fermentation time and plantain's paste quantity were sticked at optimal value.

2.8 Influence of Oven Temperature

It concerns only baked product preparation. The temperature of oven was varied from 130 to 190 °C however fermentation time, cooking time and plantain's paste quantity were sticked at optimal value.

2.9 Process of Optimized Dockounou Preparation

A final dockounou were cooked following the empiric method with applying specifically, optimal values obtained, at each level concerned (ratio of plantain paste/cereal flour, fermentation time, cooking time,

temperature of oven heating).

All experiments were carried out in randomized order and organoleptic tests were done on the products.

2.10 Sensorial Evaluation

A test of sensory evaluation was carried out on products obtained from different preparations and also, a comparison test was carried out between optimized and traditional dockounou. A total of 30 semi-trained panelists (tasters) were recruited from staff and students of Félix Houphouët Boigny University (Abidjan). They received instructions on the mode of evaluation to be made. Criteria of their selection were that: "they were regular consumers of dockounou and were not allergic to any food". Panelists were instructed to evaluate color, taste, texture and flavor of the dockounou. These characteristics were chosen base on data collected in a survey according Akoa et al. (2012). Each panelist estimates all the samples prepared with the treatment of one session. An hedonic scale of five-point was used as follow: 1 = very bad, 2 = bad, 3 = acceptable, 4 = good and 5 = very good (Sauvageot, 1981). Samples were identified with three-digit code numbers and presented in a random sequence to panelists. The panelists were instructed to rinse their mouths with water before tested each dish simple and not to make comments during evaluation to prevent others panelist influencing. They were also asked to comment freely the samples with the questionnaires given to them.

3. Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA). Means were separated using Duncan's multiple range test using the Statistical Package for the Social Sciences (SPSS) version 17.0 (SPSS Inc., Chicago, IL).

4. Results

4.1 Influence of Senescent Plantain Paste Proportion

Table 1 shows the mean of sensory scores for the different samples of dockounou according to the nature of the adding flour and the cooking mode. There were significant differences ($P < 0.05$) between samples appreciation relatively to sensorial characteristics such as the taste, texture, flavor and the color. Indeed, with the maize-dockounou, considering the taste, the highest score were recorded with the plantain paste proportion of 90%, either by boiling or baking mode. The same proportion led to the best (choice) texture (3.60 and 3.23), color (3.97 and 3.17) and flavor (3.27 and 3.23). As for the rice-dockounou, the whole scores ranged from 1.70 to 3.43, with the highest topped the dockounou made with the plantain paste proportion of 85% texture. The other characteristics (color, taste and flavor) of the same dockounou boiled and baked, also registered the most important (3.23 and 3.10, 3.33 and 3.27, 3.20 and 3.43, respectively) score with this previous plantain paste proportion.

In summary the whole results revealed that the dockounou appreciation increased in phasis with the plantain paste proportion, and the best scores for each sensorial characteristic were recorded by the boiled dockounou. And the plantain paste and cereal flour best ratio at the whole is 90/10%.

4.2 Effect of Fermentation on Dockounou Sensorial Quality

In Table 2 were presented the mean of sensory scores for paste fermentation time according to the nature of the adding flour and the cooking mode. The whole samples presented relatively good acceptance for all the sensorial characteristics, from zero (0) to ten (10) hours of fermentation. Indeed, in this interval of fermentation, the scores ranged from 3.73 to 2.60. However, concerning maize-dockounou, the best scores were recorded by the samples resulting from four (4) hours of fermentation. As for the rice-dockounou, they topped the most important scores at zero, four and ten hours of fermentation for boiled samples, and at four hours of fermentation for the baked ones.

In summary, the results revealed that whatever the flour was the texture, all the boiled dockounou and all of those prepared without fermentation (0 hour) registered scores superior to 3.00. Values under 3.00 were observed with baked dockounou only after 4 hours of fermentation.

Table 1. Sensory evaluation means according plantain paste/maize or rice flour quantity composite dockounou

Samples		Texture		Taste		Color		Flavor	
		Boiled	Baked	Boiled	Baked	Boiled	Baked	Boiled	Baked
With maize flour	A	2.93^{b}	2.97^{ab}	2.63^{b}	2.57^{a}	2.87^{b}	2.93^{a}	2.77^{b}	3.10^{a}
	B	3.03^{b}	2.97^{ab}	2.70^{b}	2.87^{a}	2.90^{b}	3.03^{a}	2.80^{b}	3.17^{a}
	C	3.57^{a}	3.23^{a}	2.97^{b}	2.73^{a}	3.13^{b}	2.80^{a}	2.83^{b}	3.07^{a}
	D	3.60^{a}	3.23^{a}	3.70^{a}	3.00^{a}	3.97^{a}	3.17^{a}	3.27^{a}	3.23^{a}
	E	3.00^{b}	2.73^{b}	3.00^{b}	2.90^{a}	3.67^{a}	2.83^{a}	3.00^{ab}	3.07^{a}
With rice flour	A	3.23^{a}	3.17^{a}	3.03^{a}	2.57^{c}	3.13^{a}	3.00^{a}	3.30^{a}	2.97^{a}
	B	3.27^{a}	3.27^{a}	3.20^{a}	2.97^{ab}	3.17^{a}	3.00^{a}	3.27^{a}	3.13^{a}
	C	3.43^{a}	3.43^{a}	3.20^{a}	3.43^{a}	3.23^{a}	3.10^{a}	3.33^{a}	3.27^{a}
	D	2.63^{b}	3.30^{a}	3.03^{a}	3.03^{ab}	2.97^{a}	3.03^{a}	3.03^{a}	3.10^{a}
	E	1.70^{c}	3.07^{a}	2.50^{b}	3.07^{ab}	2.97^{a}	2.87^{a}	3.00^{a}	3.20^{a}

Values with the same superscript within the same column do not differ significantly ($P > 0.05$).

Sample A: 75% plantain paste and 25% maize flour, sample B= 80% plantain paste and 20% maize flour, sample C = 85% plantain paste and 15% maize flour, Sample D = 90% plantain paste and 10% maize flour, sample E= 95% plantain paste and 5% maize flour. Maize, Rice = Dockounou made with maize and rice flour, respectively

Table 2. Sensory evaluation means of different fermentation times

Samples		Texture		Taste		Color		Flavor	
		Boiled	Baked	Boiled	Baked	Boiled	Baked	Boiled	Baked
With maize flour	A	3.16^{ab}	3.30^{a}	3.03^{bc}	3.23^{a}	3.46^{a}	3.07^{ab}	3.16^{a}	3.07^{bc}
	B	3.43^{a}	3.40^{a}	3.30^{ab}	3.23^{a}	3.46^{a}	3.27^{ab}	3.40^{a}	3.27^{ab}
	C	3.53^{a}	3.46^{a}	3.53^{a}	3.36^{a}	3.70^{a}	3.43^{a}	3.46^{a}	3.63^{a}
	D	3.36^{ab}	3.40^{a}	3.30^{ab}	3.13^{a}	3.46^{a}	3.13^{ab}	3.13^{a}	3.17^{bc}
	E	3.33^{ab}	3.33^{a}	2.90^{bc}	3.06^{a}	3.36^{a}	3.03^{ab}	3.10^{a}	3.03^{bc}
	F	3.00^{b}	3.23^{a}	2.60^{c}	3.00^{a}	3.33^{a}	2.93^{b}	3.30^{a}	2.77^{c}
With rice flour	A	3.73^{a}	3.17^{ab}	3.40^{a}	3.53^{a}	3.47^{a}	3.17^{a}	3.47^{a}	3.43^{a}
	B	3.67^{a}	3.10^{a}	3.30^{a}	3.43^{a}	3.33^{a}	3.00^{a}	3.30^{a}	3.23^{ab}
	C	3.70^{a}	3.53^{a}	3.36^{a}	3.53^{a}	3.40^{a}	3.33^{a}	3.20^{a}	3.50^{a}
	D	3.37^{a}	3.23^{ab}	3.13^{a}	3.40^{a}	3.37^{a}	2.97^{a}	3.17^{a}	3.20^{ab}
	E	3.37^{a}	3.07^{b}	3.13^{a}	3.37^{a}	3.27^{a}	2.90^{a}	3.10^{a}	3.30^{ab}
	F	3.73^{a}	3.03^{b}	3.33^{a}	2.73^{b}	3.37^{a}	2.93^{a}	3.33^{a}	2.97^{b}

Values in the same line with different superscript are significantly different at $P < 0.05$. A, B, C, D, E and F= 0, 2, 4, 6, 8 and 10 hours of fermentation; Maize, Rice= Dockounou made with maize and rice flour, respectively.

4.3 Effect of Cooking Time

Figure 1 presents the evolution of tasters' scores attributed to dockounou cooking time. At the whole, for each sample, all the sensorial characteristics presented identique evolution according to the cooking time. Concerning baked and boiled rice-dockounou (Figures 1A and 1D), the scores were superior to 2.00 and the highest were obtained at 75 min of cooking time. Figures 1B and 1C shows that both boiled and baked maize-dockounou registered scores superior to 2.50 for all parameters. Thus, both samples recorded their best or maximum scores at 60 min of cooking time.

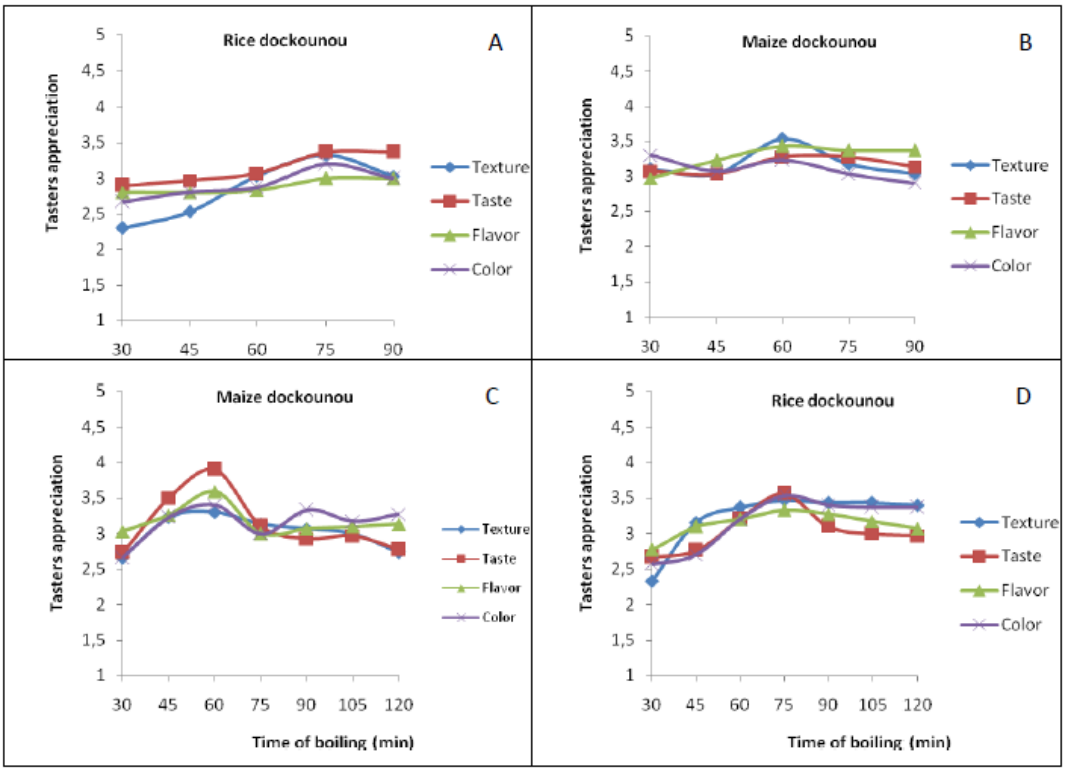

Figure 1. Sensorial evaluation of tasters about cooking time variation

4.4 Oven Temperature Influencing on Sensorial Evaluate

The whole results of sensorial analysis for baked dockounou with either maize or rice flour revealed the best scores at 145, 160 and 175 °C as baking temperature. Indeed, at these temperatures, texture, taste, flavor and color data were the highest (Table 3). Moreover, the statistical analysis showed significantly differences between the scores attributed to samples according to the baking temperature. Hence, the maximal values were obtained at 160 °C of oven temperature.

Table 3. Sensorial evaluation means of different oven temperatures

Oven samples	Texture		Taste		Color		Flavor	
	Maize	Rice	Maize	Rice	Maize	Rice	Maize	Rice
A	2.20^{c}	2.60^{b}	2.63^{b}	2.83^{b}	2.97^{a}	3.00^{ab}	3.03^{a}	3.13^{b}
B	3.17^{ab}	3.03^{a}	3.17^{a}	3.10^{ab}	3.23^{a}	3.20^{a}	3.20^{a}	3.20^{ab}
C	3.37^{a}	3.20^{a}	3.40^{a}	3.47^{a}	3.27^{a}	3.27^{a}	3.30^{a}	3.53^{a}
D	3.30^{a}	3.03^{a}	3.37^{a}	3.40^{a}	2.87^{a}	3.10^{a}	3.17^{a}	3.27^{ab}
E	2.83^{b}	2.90^{a}	3.10^{a}	2.80^{b}	2.77^{a}	2.63^{b}	3.07^{a}	3.23^{ab}

Values in the same line with different superscript are significantly different at $P< 0.05$. A, B, C, D and E= 130, 145, 160, 175 and 190 °C of baking temperature.

4.5 Optimized Dockounou Level of Appreciation

The optimized dockounou were obtained according to the final process describes in Figure 2.

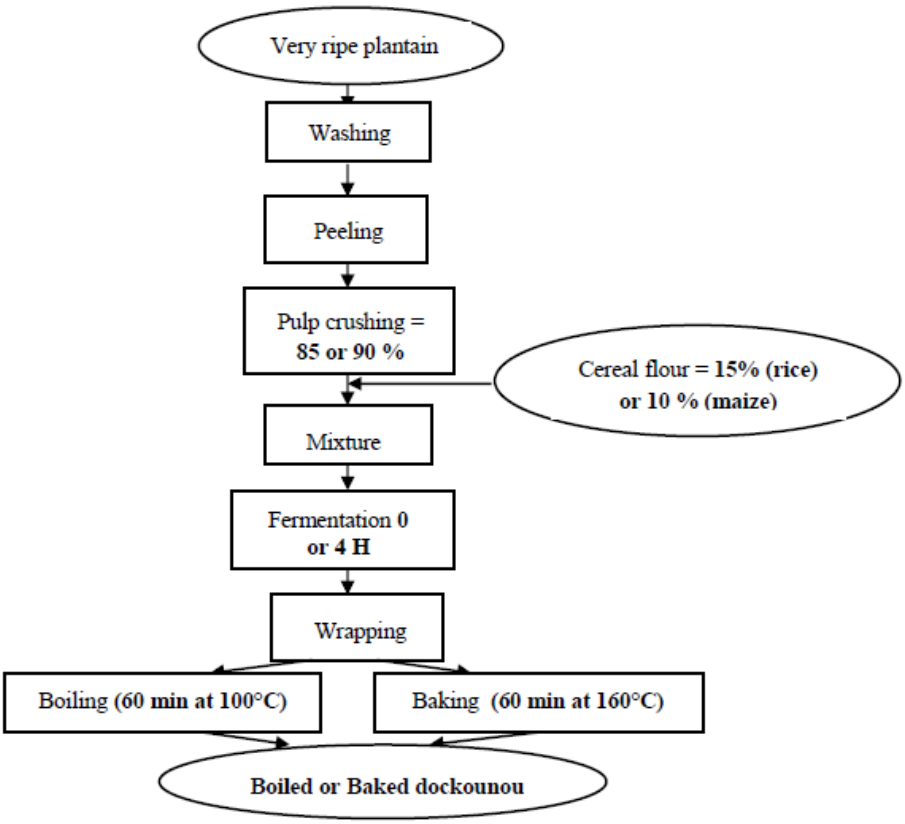

Figure 2. Process of optimized dockounou manufacturing

The Table 4 shows optimized dockounou characteristics reported by testers. Optimized rice-dockounou and maize-dockounou are sweet taste, hard texture, plantain flavor and light brown color. The Table 5 presented optimized dockounou scores attributes by testers. There were no significant differences ($P < 0.05$) between samples appreciation relatively to sensorial characteristics such as the taste, the texture, the flavor and the color. All the optimized dockounou obtained acceptable scores according testers. The whole scores ranged from 3.12 to 3.67. Indeed, with the boiled dockounou, the highest scores were recorded with the maize-dockounou for taste (3.60), color (3.32) and flavor (3.48). As for the baked products, the rice-dockounou obtained the highest scores than maize-dockounou.

Table 4. Dockounou appreciation characteristics reported by testers

	Taste		Flavor		Texture		Color	
	Boiled	Backed	Boiled	Backed	Boiled	Backed	Boiled	Backed
Maize	Sweet	Sweet	Plantain	Plantain	Hard	Hard	Light brown	Light brown
Rice	Sweet	Sweet	Plantain	Plantain	Hard	Hard	Light brown	Light brown

4.6 Comparison Between Optimized Dockounou and Traditional Dockounou

The sensory attributes of optimized boiled and baked dockounou between traditional boiled and baked dockounou were shown on Figures 2 and 3. Statistically, optimized and traditional boiled dockounou do not present significantly difference at the level of all the characteristics, but optimized dockounou texture, taste and flavor tend to be more raised than those for the traditional boiled dockounou with rice flour (Figure 2A). In opposite, the traditional boiled dockounou seems to have a good color than the optimized boiled dockounou (3.36 to 3.18 respectively). The optimized boiled dockounou with maize flour had highest score than the traditional one's in all sensory attributes (Figure 2B). The Figure 3 shows sensory attributes of optimized baked

dockounou between traditional baked dockounou. Optimized baked dockounou with rice and maize flours were more appreciated than traditional baked dockounou with rice and maize flours in all sensory attributes (Figures 3C and 3D). These samples that were concerned in Figures 2B, 3C and 3D are significantly differents.

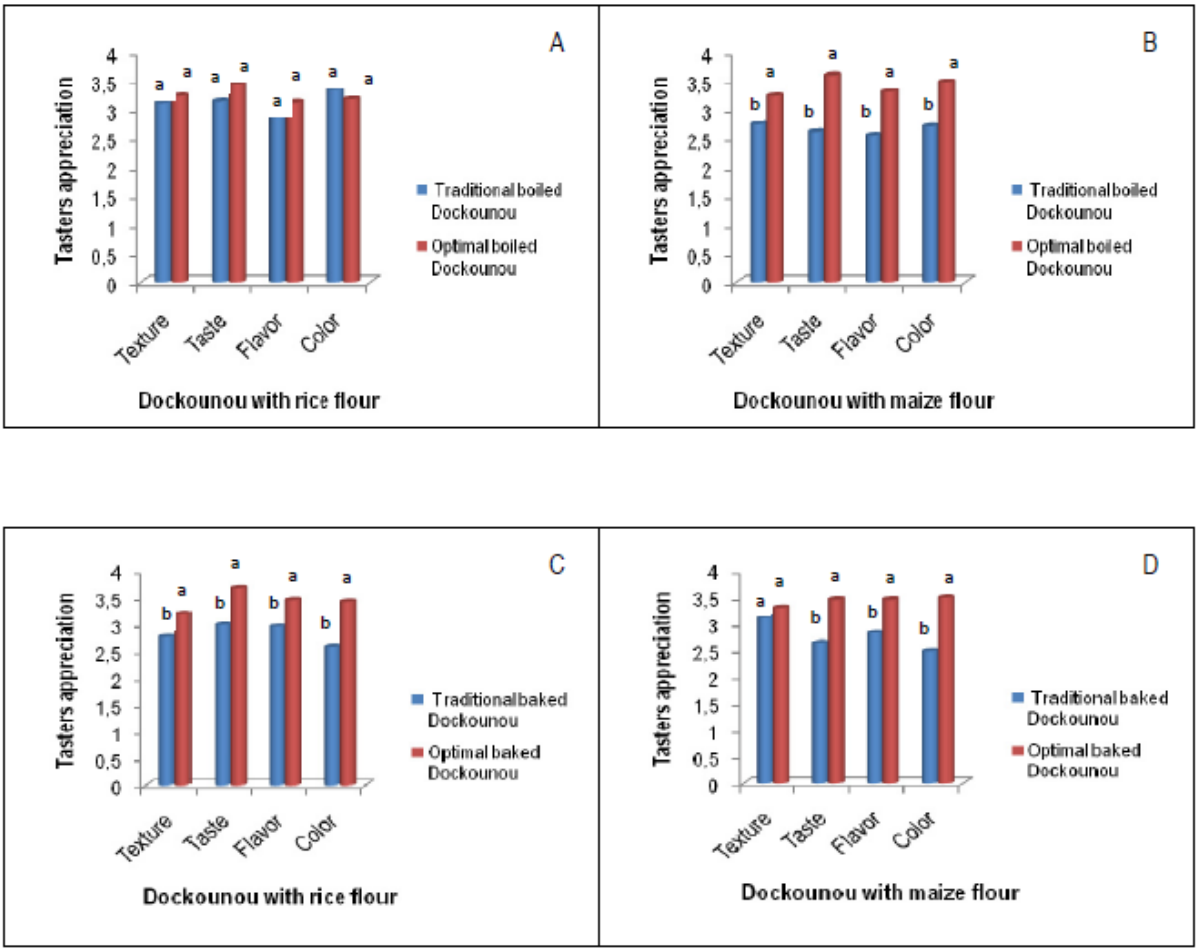

Figure 3. Comparison between optimized and traditional baked dockounou

5. Discussion

Food texture is one of the most important quality attributes that would determine its acceptability (Onayemi, 1985). That is why the flour quantity added to senescent plantain paste is very important for the dockounou texture. In fact, this dish consistency would result from flour adding in pulp paste (Dzomeku, Osei-Owusu, Akyeampong, Ankoma, & Darkey, 2005; Koffi, 2007), since plantain pulp had loose its original firmed texture at the senescence (Dadzie & Orchard, 1997; Emaga et al., 2008). Yet, the resulting texture would depend on the quantity of the additional flour (Slembrouck, Cissé, & Kerdchuen, 1991). Flour would be added to senescent plantain pulp to consolidate its mushy texture (Slembrouck et al., 1991; Emaga et al., 2008). This is why, adding maize or rice flour in plantain's paste permit to reach the consistent texture expected by tasters. Moreover, according to Akoa et al. (2012), maize flour would be added to consolidate the dockounou texture and rice flour enhances its taste. In fact, maize-dockounou presented an acceptable texture at 10% and 15% of its flour, where the taste was less acceptable. In opposite, the rice-dockounou recorded a best taste score in the same proportion (10 and 15%) without a good texture score. This result supposes that for a good texture the dockounou would need more rice flour quantity than maize flour. It was showed by Laureys (1999) that rice starch and flour can provide suitable textures for a range of foods with a high natural stability and digestibility. In addition, rice flour, starch and protein can be also used as processing aid, ingredients in health food, coating agents in confectionary, water binders in small goods, expanding agents in extrusion food, flavor carriers, emulsifiers and fat replacers in

dairy products and paper coating agents. In reality, when adding flour to plantain paste in excess (or not enough), it would result a hard (or pasty) and unappreciated dockounou; consequently, the flour might be added in adequate proportion to avoid the dish depreciation. This idea could be justified by the weak scores registered for the samples obtained with the proportion of 95:5% or 80:20%, respectively for plantain paste and flour.

About dockounou fermentation, it would contribute to soften the plantain dough and provide sourness to the dish (Toka & Dago, 2003). This role of fermentation was not apparent in the present study because the testers did not observed significant evolution in sensory attributes of boiled samples. This could be justified by the fact that this mode of cooking would not lead to flavors production (Richard, Giampaoli, Toulemonde, & Duquenoy, 2010). Moreover, the highly hydrated environment (boiling) would not induce the Maillard reactions, and the water vapor would lead to the loss of volatile compounds (Richard et al., 2010). Concerning the baked dockounou, a short fermentation time (4h) was important to ensure the best sensory qualities according testers and a long time gave a relatively poor quality of dockounou. This result is not in agreement with the literature in where fermentation improves the sensorial quality of food. In this case, consumers would only consider the tangy taste of fermented foods (Toka & Dago, 2003). Indeed, according to Mestres, Boungou, Akissoé & Zakhia-Rozis (2000), during a fermentation of maize flour (20 or 35 °C), it was a synthesis of lactic acid. This synthesis increases with time. That could explain the tester's appreciation. Therefore, the results obtained in this study could suppose that the tangy taste is not appreciated for the dockounou. It revealed that, producers of dockounou who made 10 hours for fermentation time according to Flore et al. (2012), offered certainly, on the market, tangy taste products. However, the optimized baked dockounou use a short fermentation time (4 hours). This allows reducing process time.

The highest appreciation of optimized maize-dockounou than traditional one's was in conformity with the results of Akoa et al. (2012). Indeed, consumers likes more used of maize flour in dockounou. For baked products, the rice-dockounou obtained better scores in all sensory attributes. Moreover, the rice flour was the second flour selected by consumers during the survey according Akoa et al. (2012).

6. Conclusion

Results of the present study have shown that at whole, the optimized dockounou were more appreciated than traditional dockounou. Specifically, maize-dockounou is more appreciate than the optimized rice-dockounou according cooking mode. The optimized maize-dockounou use more paste plantain quantity (90%) than optimized rice-dockounou (75%). The boiled and baked maize-dockounou are the same time (60 min) for cooking, but baked and boiled rice-dockounou are made at 75 min for cooking time. However, optimized baked and boiled dockounou need a short fermentation time than traditional baked dockounou. Relatively at fermentation time, optimized baked and boiled Dockounou with maize flour were accepted for 4 hours of fermentation and no fermentation for boiled Dockounou with rice flour. Baked Dockounou with maize and rice flours might be cook at 160 °C in oven. The final optimized dockounou obtained presents better characteristics than traditional one's. The whole results of this study show clearly that dockounou is a foodstuff which could be improved to take place in population food habits.

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