



Influence of Organic Fertilization on the Physico-Chemical and Organoleptic Quality of Attiekés of Three Varieties of Cassava (*Manihot esculenta* C.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AFSJ/2021/v20i1030370

Editor(s):

(1) Dr. Surapong Pinitglang, University of the Thai Chamber of Commerce, Thailand.

Reviewers:

(1) Nilaykumar M. Vaidya, Charotar University of Science and Technology (CHARUSAT), India.

(2) E. S. Anooj, India.

Complete Peer review History: <https://www.sdiarticle4.com/review-history/75304>

Original Research Article

Received 12 August 2021

Accepted 24 October 2021

Published 26 October 2021

ABSTRACT

Cassava occupies an important place in the food security of populations in Côte d'Ivoire. There are many products derived from cassava but «attiéké» remains the flagship product in Côte d'Ivoire. Faced with the productivity challenges, organic fertilization is increasingly used by farmers in order to sustainably increase cassava production. The perspective of our study is to assess the effects of the uncombined use of cowpea and poultry manure as organic soil fertilizers on certain physicochemical and sensory characteristics of «attiékés» of three varieties of cassava. To do this, on an experimental plot installed, cowpea fertilization was tested at planting densities of 62,500; 250,000 and 125,000 plants/ha and poultry manure at rates 5; 15 and 5 t/haon, respectively, the cassava varieties Yavo, BoCou1 and Yacé. The results obtained show that cowpea and poultry manure increased the dry matter content respectively by 3.99 and 3.53 % in the Yavo variety by 3.57 and 18.06 % in the BoCou 1 as well as by 17.43 and 17.64 % in the Yacé. For the other

parameters of pH, titratable acidity, total carbohydrates and free glucose, the variations depended on the variety and the level of fertilization. The sensory attributes of attiékes from these varieties grown on fertilized soil have been accepted by consumers in terms of color, smell, taste and consistency. In addition, they were rated less good than the controls obtained without fertilizer due to color, taste and consistency, while in terms of odor, it would be the same rating.

Keywords: «attiéké»; fertilization; cassava; physico-chemical; sensory.

1. INTRODUCTION

Cassava (*Manihot esculenta* C.) is one of the main subsistence crops, widely cultivated in tropical and subtropical countries, mainly for its tuberous roots, high in carbohydrate, used for human consumption and animal feed [1,2]. Cassava plays a key role in the fight against large-scale food insecurity as it is increasingly used as a raw material for food industries [3]. In the world, cassava is the fifth food crop after corn, rice, wheat and potatoes [4]. In Africa, it ranks third in food production after rice and maize [5]. In Côte d'Ivoire, cassava is ranked second among food crops produced after yams, with an annual production of 5,608,044 tonnes [6]. There are many products derived from cassava. However, «attiéké» remains the flagship product because it is the most popular of all foods derived from cassava in Côte d'Ivoire [7,8,9]. This fermented and steamed cassava semolina [10] is consumed by all social strata and at all ages at a rate of 29 kg per capita per year [11].

Cassava cultivation, as important as it is in the food security of populations in Côte d'Ivoire, is mainly practiced in an extensive system [12]. The result is the impoverishment of the soil in the face of which organic fertilization is increasingly used by farmers [13]. Organic fertilizers like cowpea legume (*Vigna unguiculata* L.) and poultry manure are biodegradable, durable and more environmentally friendly than their chemical counterparts [14,12]. The agronomic interest of poultry manure lies in its relatively high organic matter content (206 to 472 Kg of organic matter per tonne of raw product) allowing better production to be obtained [15]. Poultry manure represents pure brown excrement produced by poultry raised without litter [16]. Under good breeding conditions, the average production of poultry waste varies between 130 to 150 Kg/m²/year [16]. Likewise, fertilization with cowpea optimizes yields [17]. The main advantage of cowpea is its ability to meet its nitrogen needs from nitrogen in the air and to enrich the soils [18]. Cowpea is widely cultivated

in association with other crops with a relatively longer growing cycle such as cassava in many tropical and subtropical regions [19]. Its dry seeds are eaten as a pulse or its young leaves and immature pods are eaten as a fresh vegetable. Average yields vary between 350 and 600 kg per hectare and the volume of cowpea production in Côte d'Ivoire is estimated to be between 20,000 and 30,000 tonnes per year [20].

cowpea legume and poultry manure as soil fertilizers certainly contribute to obtaining better yields, but the extent to which they would impact the physicochemical and sensory quality of cassava and its «attiéké» is not well known.

The study already conducted Allou et al. [21] on the impact of three cowpea planting densities (62,500; 125,000 and 250,000 plants / ha) on the agronomic properties of cassava varieties Yavo, BoCou1 and Yacé have shown that this is the density 62,500 plants / ha which allowed to obtain the best effect on the agricultural yield of the Yavo variety. As for the treatments with 250,000 and 125,000 plants / ha, they had the best effect on this yield, respectively, for the varieties BoCou 1 and Yacé. By the way, the study on the effect of 5; 10 and 15 t / ha of poultry manure showed that the best impact of these three doses on the agricultural yield of the Yavo and Yacé varieties is that of 5 t / ha [21]. These authors also indicated that for the BoCou 1 variety, the dose of 15 t / ha has the best effect on this parameter.

Therefore, the present study proposes to assess the impact of the best levels of fertilization mentioned above on the physico-chemical and organoleptic quality of «attiékés».

2. MATERIALS AND METHODS

2.1 Cultivation Soil

The study was carried out in the field of the National Agronomic Research Center (CNRA) in Anguédédou between May 2015 and August

2016. This site is located at 05 ° 19 ' 48.60" North latitude and 04 ° 07 ' 50.22" West longitude and at an average altitude of 39 m [22].

2.2 Experimental Setup

Cassava cultivation was done according to the split-plot plan with two factors: the main factor "soil fertilization" and the secondary "cassava variety". For the "soil fertilization" factor, seven levels were considered: F1 (without fertilization), F2 (cowpea at the planting density of 62,000 plants / ha), F3 (125,000 plants / ha), F4 (250,000 plants / ha), F5 (poultry manure at 5 t / ha), F6 (10 t / ha); F7 (15 t / ha). The local cowpea cultivar *touba* was selected as an intercropping legume because of its agronomic performance and its considerable economic interest. Poultry manure has also been used as a manioc fertilizer due to its availability in the region. The nutrient content of the droppings was 14.9 g N.kg⁻¹, 5.6 g P.kg⁻¹ and 4.3 g K.kg⁻¹ (dry matter). The "cassava variety" factor includes three levels: the improved cassava genotypes Yavo and BoCou 1 and the widespread local variety Yacé. Each planting density (F2, F3 and F4) and dose of poultry manure (F5, F6, F7) chosen was identified as the one that had the best impact on crop yield of any of the three varieties [21].

The number of trials (fertilization level X cassava variety) for this experiment is 21 with three repetitions. The elementary plots were sized at 12.2 m² per unit.

2.3 Physico-Chemical and Sensory Analysis Methods

2.3.1 Method of preparing the «attiéké»

A amount of 15 kg of tuberous roots of the varieties of cassava Yavo, BoCou 1 and Yacé from plantations treated with cowpea and poultry manure were peeled with a stainless steel knife and crushed using a HONDA 65 G X 200 grinder type [10].

The various pastes obtained were mixed with a small quantity of previously fermented cassava. The resulting mixture was fermented again for 12 hours at 30-32°C. At the end of the fermentation time which removed a large part of the hydrocyanic acid which the cassava naturally contained, the pasta was partially dehydrated by dewatering with a screw press. The solid pasta was crumbled and then sifted manually using a

raffia sieve to preform the granules. These reformed granules were made into small, firm, rounded granules by rotating them several times in small plastic tubs. The grains obtained were subjected to a brief drying in the sun for about 15 min on racks. They were winnowed using homemade vans to remove fibers, then steamed in traditional couscous makers for 30 to 40 minutes before packaging. The Fig. 1 shows steps in the manufacture of attiéké.

2.3.2 Physico-chemical and sensory analyzes

The physico-chemical characteristics of the «attiékés» have been determined. Dry matter, pH and titratable acidity were determined by the methods described by AOAC [23]. The contents of total carbohydrates and free glucose were also determined by YAO et al. [24].

The sensory analysis was carried out according to the method described by Ebah et al. [25]. The sensory factors (color, smell, taste and consistency) of «attiéké» prepared with these three varieties of cassava were assessed through a hedonic test. The hedonic test consisted of rating each sample on a five point hedonic scale with the score: 1 = very bad, 2 = bad, 3 = acceptable, 4 = good and 5 = very good.

2.3.3 Statistical analyzes

A General Linear Model was used to analyse the data on the quality with the software STATISTICA 7.0 (Statsoft Inc, Tulsa-USA Headquarters). This software was used to know the level of meaning of observed differences. The homogeneity of the studied parameters was determined by the comparison of the averages according to the test of Duncan at the threshold of 5%.

3. RESULTS

3.1 Effects of Fertilizers on the Physico-Chemical Characteristics of «attiéké»

Organic fertilizers gave the highest dry matter content for the three varieties of cassava. Indeed, as shown in Table 1, cowpea and poultry manure made it possible to obtain respectively 51.58 ± 0.19 % of dry matter with 62,500 plants / ha (F2) and 51.30 ± 0, 40 % with 5 t / ha (F5) against 49.60 ± 0.02 % obtained without fertilizer for the Yavo variety. This represents increases of 3.99 % for cowpeas and 3.53 % for poultry manure. For the BoCou 1 variety, Table 2 shows

increases of 3.57 and 18.06 % respectively with the action of 250,000 plants / ha (F4) of cowpea (49.85 ± 0.19 %) and 15 t / ha (F7) of manure poultry (56.82 ± 0.40 %) compared to the control (48.13 ± 0.02 %). Regarding the Yacé variety, the best values are obtained with 125,000 plants

/ ha of cowpea ($56.52 \pm 0.19\%$) and 5 t / ha of poultry manure ($56.62 \pm 0.40\%$). This represents respective increases of 17.43 and 17.64% compared to the value $48.53 \pm 0.03\%$ of the treatment without fertilizer (Table 3).

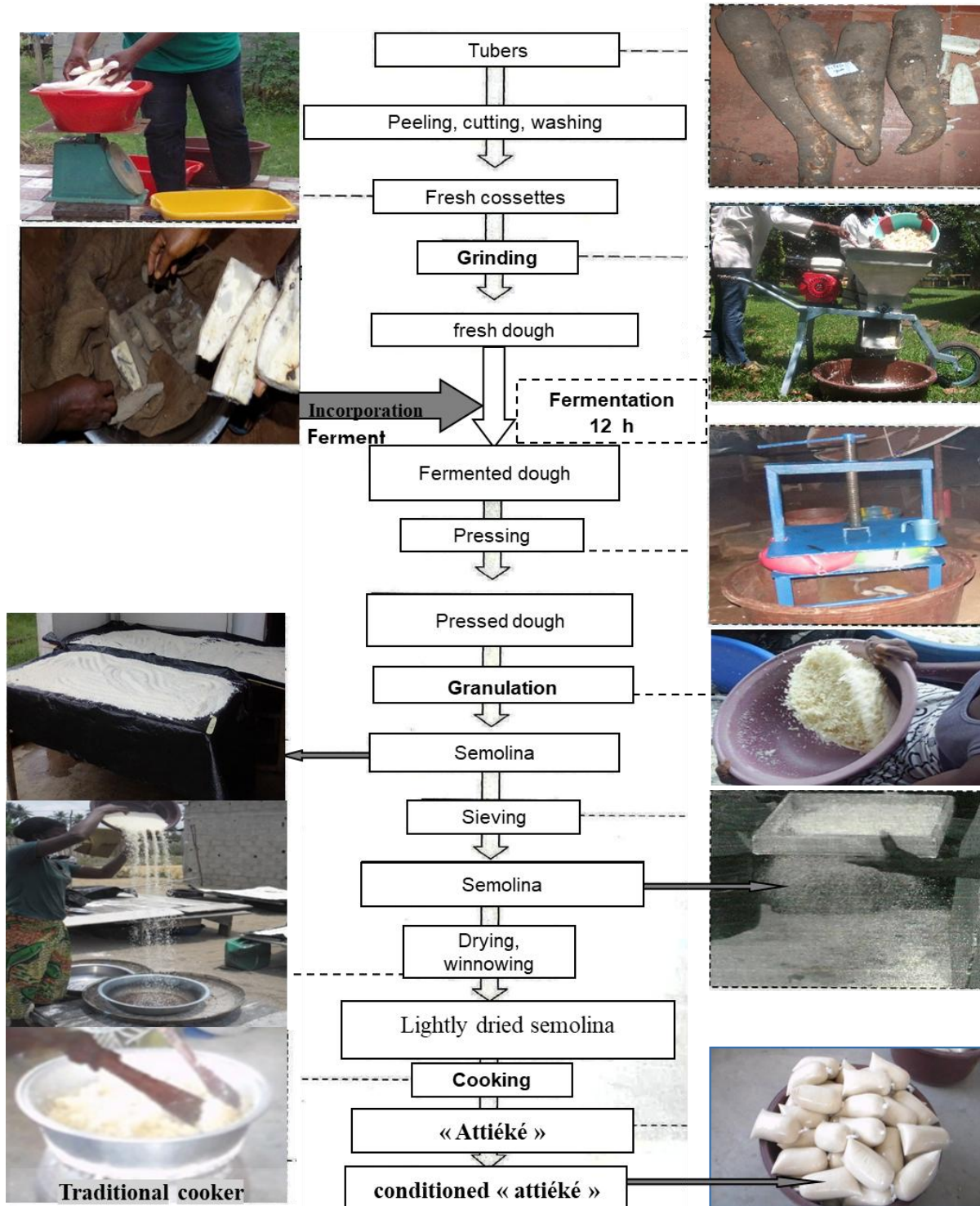


Fig. 1. Steps in the manufacture of «attiéké»

As for pH and titratable acidity, the values do not vary significantly at the 5 % threshold overall between the control and the treatments for all cassava varieties (Tables 1; 2; 3).

The results of Table 3 show that the free glucose content of the control which corresponds to 2.13 ± 0.65 g / 100 g MS (F1) increased significantly ($P \leq 0.05$) to 2.23 ± 0.51 and 2.81 ± 0.16 g / 100 g MS respectively with the contribution of 5 t / ha (F5) of poultry manure and 125,000 plants / ha of cowpea (F3) for the Yacé variety. Free glucose levels remained stable for Yavo and BoCou 1 varieties.

With regard to total carbohydrates, their content increased ($P \leq 0.05$) from 86.09 ± 0.41 g / 100 g

MS (F1) to 93.66 ± 0.15 and 92.03 ± 0.50 g / 100 g MS respectively with the cowpea treatments at 62,500 plants / ha and poultry manure at 5 t / ha for the Yavo variety (Table 2). This parameter did not vary significantly at the 5% threshold following the treatments applied to the varieties BoCou 1 and Yacé.

3.2 Effects of soil Fertilizers on the Sensory Characteristics of «attiékés»

According to Fig. 2, the «attiéké» of the Yavo variety has undergone the most modifications. Indeed, the taste of «attiéké» de yavo has a score of 3.87 ± 0.02 when no fertilizer is applied to the soil (F1) and drops significantly at the 5% threshold to 3.47 ± 0.49 and 2.93 ± 0.69 with

Table 1. Effects of fertilizers on the physicochemical characteristics of «attiéké» of the Yavo variety

Physico-chemical characteristics	Treatments		
	F1	F2	F5
Dry matter (%)	49.60±0.02a	51.58±0.19b	51.30±0.40 b
pH	3.91±0.14ab	3.88±0.58a	3.94±0.7 b
Titratable acidity(meq-g/100 g)	22.40±0.04ab	22.43±0.02a	22.39±0.04 b
Total carbohydrates (g/100 g MS)	86,09±0,41a	93,66±0,15c	92,03±0,50b
Glucose free (g/100 g MS)	2,89±0,65a	2,92±0,16a	2,92±0,51a

F1: Control (without fertilizer); F2: cowpea 62,500 plants /ha; F5: poultry manure 5 t/ha. Data on the same line with different lowercase letters is significantly different ($P \leq 0.05$)

Table 2. Effects of fertilizers on the physicochemical characteristics of «attiéké» of the BoCou1 variety

Physico-chemical characteristics	Treatments		
	F1	F4	F7
Dry matter (%)	48.13±0.02a	49.85±0.19b	56.82±0.40c
pH	4.09±0.14a	4.11±0.58a	4.13±0.76a
Titratable acidity (meq-g/100 g)	22.37±0.07a	22.35±0.05a	22.33±0.09a
Total carbohydrates (g/100 g MS)	93.66±0.41a	94.63±0.15a	94.48±0.50a
Glucose free (g/100 g MS)	2.89±0.65a	2.93±0.16a	2.92±0.51a

F1: Control (without fertilizer); F4: cowpea 250,000 plants /ha; F7: poultry manure 15 t/ha. Data on the same line with different lowercase letters is significantly different ($P \leq 0.05$)

Table 3. Effects of fertilizers on the physicochemical characteristics of «attiéké» of the yacé variety

Physico-chemical characteristics	Treatments		
	F1	F3	F5
Dry matter (%)	48.53±0.03a	56.52±0.19b	56.62±0.40 c
pH	4.08±0.14a	4.30±0.58b	4.18±0.76 ab
Titratable acidity (meq-g/100 g)	24.48±0.12a	24,26±0,12b	24,38±0,11ab
Total carbohydrates (g/100 g MS)	92.47±0.41a	92.26±0.15a	94.61±0.50 a
Glucose free (g/100 g MS)	2.13±0.65a	2.81±0.16c	2.23±0.51 b

F1: Control (without fertilizer); F3: cowpea 125 000 plants / ha; F5: poultry manure 5 t/ha. Data on the same line with different lowercase letters is significantly different ($P \leq 0.05$)

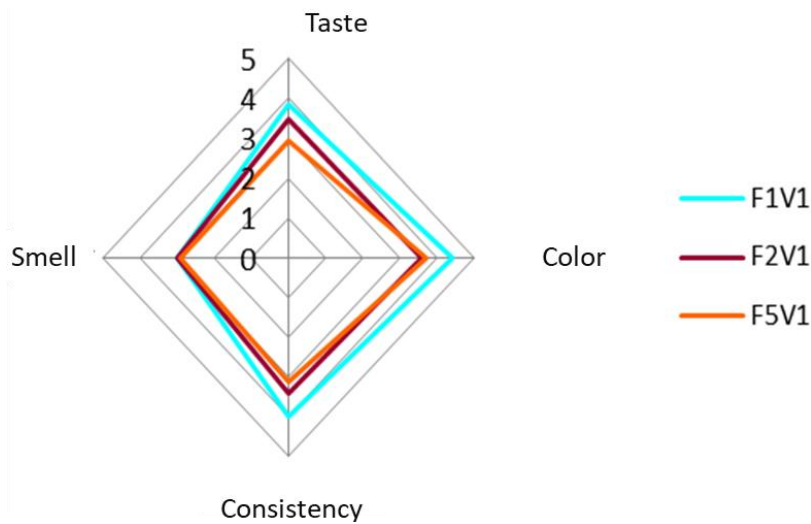


Fig. 2. Effect of fertilization on the sensory parameters of «attiékés» of the Yavo variety

F1: Control (without fertilizer); F2: cowpea 62,500 plants /ha; F5: poultry manure 5 t/ha. V1: Yavo. Hedonic scale: 1 = Very bad; 2 = Bad; 3 = Acceptable; 4 = Good; 5 = Very good

the respective effects of 62,500 plants / ha (F2) and 5 t / ha (F5). The color of «attiéké» of the Yavo variety has a score of 4.40 ± 0.05 when no fertilizer is applied to the soil while the treatments with cowpea 62,500 plants / ha (F2) and manure of poultry 5 t / ha (F5) immediately lead to significant reductions at the 5 % threshold down to 3.57 ± 0.53 and 3.70 ± 0.07 respectively. The consistency score of his «attiéké» is 4 ± 0.12 when no fertilizer is applied to the soil against 3.43 ± 0.1 and 3.13 ± 0.05 with, respectively, the significant effects of the treatments cowpea (F2) and poultry manure droppings (F5).

Regarding the BoCou 1 variety, it was observed that the color of its «attiéké» has a score of 3.40 ± 0.11 when no fertilizer is applied to the soil (F1) and drops significantly at the threshold from 5 % to 2.60 ± 0.09 with the effect of 10 t / ha (F6) of poultry manure (Fig. 3A).

As shown in Fig. 3B, the cowpea and poultry manure treatments used for the Yacé variety did not have a significant effect ($P \leq 0.05$) on the taste appreciation scores, the color, smell and consistency of its «attiéké».

4. DISCUSSION

4.1 Physico-Chemical Characteristics of «Attiekés»

The dry matter content of the «attiékés» obtained following the impact of organic fertilizers is significantly ($P \leq 0.05$) higher than the control. The

values obtained vary from $49.60 \pm 0.02\%$ without fertilizer to $51.58 \pm 0.19\%$ with fertilizer. These results are in agreement with those of Djéni et al. [26]; Krabi et al. [10] who recorded the dry matter content of different types of «attiéké» varying between 49% and 53.5%. The author Bokanga [27], following the physico-chemical analysis of cassava roots and their «attiékés», indicated variations close to ours of the order of 39.59 to 55.07 % between the material content dry roots and that of their «attiéké». The action of fertilizers on the increase in the dry matter content could be explained by the similar action of these fertilizers on the tuberous roots which were used in the manufacture of attieké.

As for the pH and the titratable acidity, the values vary very little or not between the control and the treatments. These values oscillate around 4 for the pH and 22 meq g / 100 g for the titratable acidity. They are close to those presented by Kouassi et al. [28] which are 5 for the pH and 23 meq.g / 100g for the titratable acidity. The titratable acidity index comes from the production of lactic acid during the fermentation of crushed cassava pulp. This fermentation is the prerogative of lactic acid bacteria (*Streptococcus faecium*) which hydrolyze starch and produce lactic acid, with the corresponding drop in pH [29]. Thus, the fermentation step promotes the production of lactic acid and contributes to the drop in pH which stabilizes around 4 [29]. In this study, the conditions required for the action of bacteria would be met.

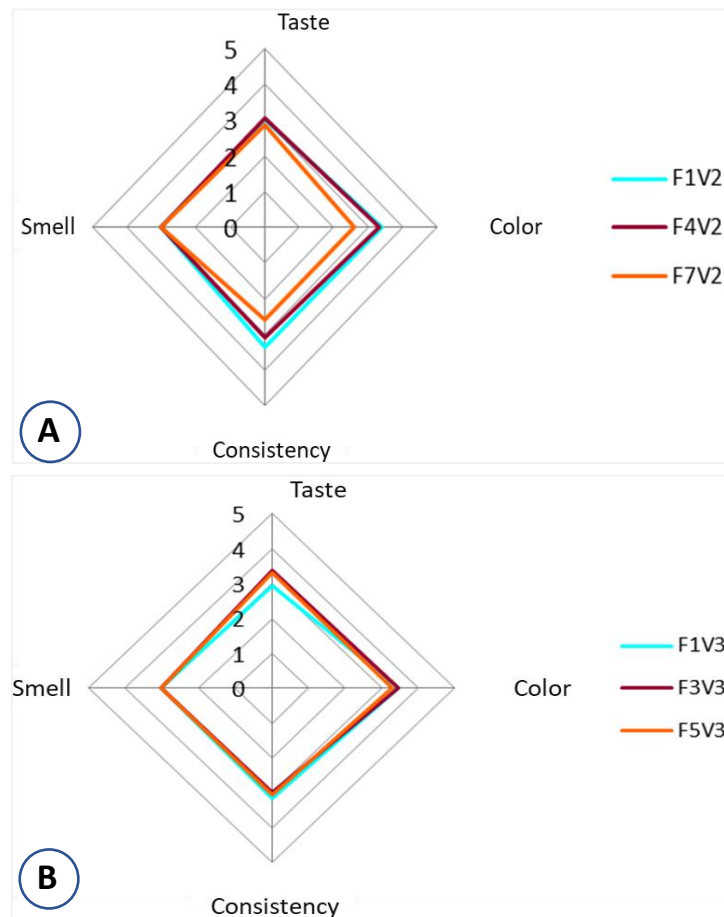


Fig. 3. Effect of fertilization on the sensory parameters of «attiékés» of varieties (A) BoCou 1 and (B) Yacé

F1: Control (without fertilizer); F3: cowpea 125,000 plants /ha; F4: cowpea 250,000 plants / ha; F5: poultry manure 5 t/ ha; F7: poultry manure 15 t/ha. V2: BoCou 1; V3: Yacé
Hedonic scale: 1 = Very bad; 2 = Bad; 3 = Acceptable; 4 = Good; 5 = Very good

For total carbohydrates and free glucose, the values tend to stabilize or increase significantly ($P \leq 0.05$) under the effect of organic fertilizers. During cassava processing, the leaching of many constituents due to the pulp washing and pressing steps had an impact on total carbohydrate and free glucose levels [30]. The action of fertilizers on the increase in the content of these parameters could be explained by the similar action of these fertilizers on the tuberous roots which were used in the manufacture of attiéké. Some authors have attempted to demonstrate the positive correlation that exists between these contents for tuberous roots and their «attiékés». This is the case with Kouassi et al. [28]; Yao et al. [24] who showed the existence of a very close link between the total carbohydrate and free glucose content of the roots of the IAC and Bonoua varieties and the different «attiékés».

4.2 Sensory Characteristics of «attiékés»

The choice of sensory attributes of «attiékés» from tuberous roots of cassava varieties having undergone fertilizer treatments focused on taste, color, smell and consistency. Analysis of variance showed that these sensory profiles differ with the impacts from one treatment to another for the same strain. Indeed, the sensory attributes of the «attiékés», following the effects of the treatments, have a similar or lower score compared to the witnesses. However, whether with or without treatment, these attributes were all judged "acceptable" because they have average scores of the order of 3. This depreciation following the action of fertilizers stems from the perception and interpretation subjective of each [25]. On this subject, the authors Mendez et al. [12], during the analysis of the cassava value chain, reported the opinion of

the actors of the sector that the use of fertilizers would deteriorate the quality of cassava. As a reminder, consumers prefer a soft, slightly acidic, clean «attiéké» with a pleasant odor according to certain authors [31,32,33].

5. CONCLUSION

The results of this study showed the level of acceptability of the attiékes of each variety of cassava grown with and without fertilizer. This level of acceptability was identified through the analysis of the pH, the contents of dry matter, titratable acidity, total carbohydrates and free glucose and the evaluation of the taste, color and consistency of the «attiékés». The physicochemical parameters of the «attiékés» with treatment remain on the whole very close to those of the control «attiékés». In addition, the results show that the sensory attributes of the «attiékés» of Yavo, BoCou 1 and Yacé, cultivated with cowpea or poultry manure, are accepted by consumers but judged to be less good than the control «attiékés».

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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