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Biochemical composition of soy-enriched fermented tiger nut milk

Abstract: The problem of food availability is a considerable reality in sub-Saharan Africa, but this is compounded by deficiencies in protein, vitamins, iron, zinc and folic acid **[1]**. Yet Africa has a wealth of under-exploited agricultural resources, including nutsedge tubers. The general aim of this study was to assess the influence of fermentation on the nutritional profile of improved tiger nuts milk. Our material, composed of fermented tiger nuts and soy milk, was subjected to biochemical analysis **[2-3]**. Nutrient levels in soy-enriched tiger nuts milk ranged respectively from 34.33 ± 0.03^{de} to 53.17 ± 0.02^{e} mg EAG/100 g for total polyphenols, from 9.88 ± 0.016^{d} to 13.17 ± 0.016^{a} mg EQ/100g for total flavonoids, from 86.67 ± 0.01^{cd} to 97.67 ± 0.01^{d} g glucose/100g total sugars, 2.48 ± 0.01^{ab} to 4.05 ± 0.01^{e} g glucose/100g reducing sugars, 29.33 ± 1.98^{g} to 34 ± 1.98^{bc} mg/100g protein and 59.79 ± 0.013^{b} to 65.63 ± 0.013^{e} mg EC/100g total tannins. These results show a significant increase in available nutrients and a reduction in anti-nutrients in soy-enriched fermented tiger nut milk. Following this formulation, sensory evaluation tests should be considered.

Key words: Deficiency; underexploited foods; tiger nut; fermentation.

INTRODUCTION

Protein-energy malnutrition and micronutrient deficiencies remain a major public health and socio-economic problem in both rural and urban areas. Numerous epidemiological surveys have revealed the extent of micronutrient deficiencies in African populations **[4]**. Several studies have already been carried out to define strategies for combating this problem. These strategies include enhancing and promoting the consumption of local foods rich in protein and/or micronutrients in the human diet **[5]**. Plant-based feeds are favored because they are generally easy to produce, short-cycle and inexpensive to purchase [6]. Soy and tiger nuts are good examples. About soy, the nutritional composition of soy-based food products varies according to their type and the manufacturing process usedSome products will be composed mainly of fibre, others of protein, while others will retain all the components of the seed, modified by industrial processes. Several studies have looked at their value in human nutrition [7], [8].

Soybeans contain 18% fat, 36% protein, 18% fibre, 4.5% minerals and 14% carbohydrates. Most nutritional studies focus on the isolated components of soy, with the aim of better highlighting their properties and avoiding interactions between them [7]. The components of soy have nutritional properties that can help to make soy-based food products a positive contribution to a balanced diet.

Tiger nuts is the tuber of the Cyperus esculentus L. plant, renowned for its high quality and health benefits. It contains lipids (22.14 to 44.92%), proteins (3.28 to 8.45%), starch (23.21 to 48.12%), fibre (8.26 to 15.47%), vitamins (1.60 to 2.60%), as well as minerals and bioactive compounds [9], [10]. Tiger nuts is an excellent source of edible oils rich in monounsaturated fatty acids, with a nutritional value comparable to that of olive oil [11]. Although its protein content is relatively low, it is suitable for people with diabetes or digestive problems and can help prevent heart disease after consumption [9The dietary fibre in this tuber is recommended for preventing colon cancer, obesity and gastrointestinal disorders. Thanks to its flavonoid content, tiger nuts have strong antioxidant properties and can be used as a natural source of antioxidants [12].

We were therefore interested in adding value to tiger nuts (*Cyperus esculentus*) tubers, given their richness in micronutrients and/or macronutrients and their therapeutic properties. Despite the remarkable interest of these plants, very few studies have addressed the question of their physicochemical and biochemical characteristics. The aim of the present study is to optimize the nutritional quality of Tiger Nuts milk (*Cyperus esculentus*) by fermentative means.

MATERIALS AND METHODS

The plant material consists of nutsedge tubers and soybeans. Tiger nut (*Cyperus esculentus*) is a plant belonging to the Cyperaceae family, and its distinctive feature compared with other species in the same family is the clearly visible scales on its rhizomes and terminal tubers **[13]**.

Samples were separately washed three times with tap water and rinsed with distilled water. They were then oven-dried at 37°C for 24 hours before being ground. A quantity (1 Kg) of each sample was then ground separately using a Binatone® brand blender. The milk obtained after pressing is kept in sterile polystyrene jars and stored in the refrigerator at 4°C for the various analyses.

Physico-chemical analysis

A soy and Tiger Nut powder is diluted separately to 15% in 150 mL of distilled water.

The pH was determined on 20 ml of milk previously obtained by immersing the electrode of a pH meter (pH meter P604, Consort). The pH value is read directly from the device display [14]. The titratable acidity level was obtained by dosing 10 ml of milk with 0.1 N sodium hydroxide solution until the color changed to pink after adding 2 to 3 drops of phenolphthalein **[15]**. The results obtained represent the average of three tests.

Biochemical analysis

The assay of ß-carotene was carried out according to the method described by Aké et al. **[16]**. For each test, the amount of ß-carotene was calculated from a calibration curve whose regression equation was: $OD450 = 0.0163\ Q$ with $R^2 = 0.9988$. The vitamin A content of the samples was determined by dividing the ß-carotene content by 6 **[17]**. Total polyphenol content was determined by the colorimetric method using the Folin Ciocalteu reagent as described by Wood et al. **[18]**. It was expressed in milligrams of gallic acid equivalent per 100 grams of nutsedge (mgEAG/100g). Total tannin content was determined by the colorimetric method using the Folin Ciocalteu reagent as described by Ci and Indira **[19]**. Contents are expressed in micrograms of tannic acid equivalent per 100 grams of tiger nuts (mgEAT/100g).

Lipid content was determined in accordance with ISO-659 using the Soxhlet extraction method **[20]**. Protein content was determined using the Kjeldahl method in AFNOR standard NF V03-050 (AFNOR, 1970). The conversion factor used is 6.25. Total sugars were determined by the method of Dubois et al [21] using phenol and sulfuric acid. The determination of reducing sugars was carried out

according to the Bernfeld method [22] using 3,5-dinitro-salicyclic acid (DNS). Flavonoids were
18 determined using the aluminum chloride colorimetric method described by Marinova et al. [23].

RESULTS AND DISCUSSION

21 **Titratable acidity and pH of Tiger Nut milk**

Analysis of the various tiger nut milk samples (in
13 table 1) showed pH values ranging from 6.4 to 6.8.

values are significant at the 5% level. The lowest titratable acidity (0.021%) in Tiger Nuts milk was the differences observed between titratable acidity recorded in samples from Odiénné, while those from Yamoussoukro had the highest titratable acidity (0.03%). Odienné and Yamoussoukro are two cities in Côte d'Ivoire, in the north and center respectively. Growing location, climate, harvesting period and storage conditions are all parameters that could influence the chemical characteristics of Tiger Nut tubers [24].

Tab. 1. Titratable acidity and pH of Tiger Nut milk

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Samples	E1	E2	E3	E4	E5	E6	E7
Titratable acidity (%)	0.025± 0.004^{bc}	0.03±0.004^{c}	0.021±0.004^{ab}	0.03±0.004^{bc}	0.025±0.004^{b}	0.023±0.004^{a}	0.03± 0.004^{ab}
pH	6.7	6.8	6.6	6.4	6.5	6.4	5.9

E1: Tiger Nuts 1 fermented + 2% soy milk**; E2:** Tiger Nuts 2 fermented + 2% soy milk**; E3:** Tiger Nuts 3 fermented + 2% soy milk**; E4:** Tiger Nuts fermented**; E5:** Soy Nuts 1 fermented**; E6:** Soy Nuts 2 fermented; **E7:** Soy Nuts 3 fermented.

Biochemical composition of soy-enriched fermented Tiger Nut milk

4 The results in table 2 show that the quantities of total polyphenols recorded in Tiger Nuts milk ranged from 34.33±0.03^{de} **(E4)** to 53.17±0.02^{e} mg EAG/100 g **(E2)** and tannin levels in Tiger Nut milk ranged from 59.79±0.013^{b} **(E4)** to 65.63±0.013^{e} mg EC/100 g **(E1)**. The quantities of total flavonoids recorded in Tiger Nuts milk ranged from 9.88±0.016^{d} **(E4) to** 13.17±0.016^{a} mg EQ/100g **(E1).**

These results are well below those of Lazizi and Ihadaden **[25]** in the course of their work on the biological effects of *Cyperus esculentus* L. This wide variation could be explained by differences in climate and growing conditions between regions. As for vitamin A in Tiger Nut milks values varied from 49.33 ± 16.53^{cd} **(E4) to** 59.33 ± 16.53^{b} µg / 100 g **(E1)**. The number of total sugars and reducing sugars varied from 86.67± 0.01^{cd} **(E4) to** 97.67± 0.01^{d} g glucose/100g **(E2)** and from 2.48± 0.01^{ab} **(E4)** à 4.05± 0.01^{e} g glucose/100g **(E1).** Protein and lipid values ranged from 29.33± 1.98^{g} **(E4) to** 34±1.98^{bc} mg/100g **(E2)** and from 8.76 ± 0.2^{a} to 9.46 ± 0.2^{cd} g/100g **(E2).** The values obtained in soy-enriched Tiger Nuts milk are considerably higher than those obtained in unenriched Tiger Nuts milk. These results are also superior to those of Lazizi and Ihadaden, and those of Tamboura **[26]** during its work on contributing to the improvement of tiger nut milk processing/preservation technologies, *Cyperus esculentus* L. 1753. Soy enrichment resulted in a substantial increase in the nutrients in Tiger Nut milk, underlining the major impact of this addition.

Statistical analysis revealed a highly significant difference, at the 5% threshold, between the various samples analyzed, confirming the superiority of the enriched products.

Tiger nut milk enriched with soy is an interesting combination from a nutritional point of view. This blend produces a plant-based drink that is rich in protein, fibre and minerals, yet lactose-free. This alternative to animal milk is therefore suitable for people who are lactose intolerant or following a vegetarian diet.

Tab. 2. Biochemical composition of soy-enriched fermented Tiger Nut milk

Samples	E1	E2	E3	E4	E5	E6	E7
Total polyphenols (mg EAG/100g)	35.5±0.03^{cd}	53.17±0.02^{e}	39.2±0.03^{c}	34.33±0.03^{de}	47.83±0.02^{fg}	63.5±0.02^{f}	53.5±0.02^{fg}
Total flavonoids (mg EQ/100g)	13.1±0.016^{a}	11.18±0.016^{e}	13.02±0.015^{cd}	9.88±0.016^{d}	10.9±0.011^{cd}	8.88±0.013^{de}	9.44±0.011^{e}
Total tannins (mg EC/100g)	65.63±0.013^{e}	64.69±0.013^{ab}	62.88±0.013^{d}	59.79±0.013^{b}	85.18±0.002^{f}	87.15±0.002^{ef}	87.86±0.002^{fg}
Total sugars (g glucose/100g)	88.33±0.01^{e}	97.67±0.01^{d}	92.33±0.01^{a}	86.67±0.01^{cd}	83.33±0.00^{e}	71.67±0.02^{bc}	84.84±0.01^{e}
Reducing sugars (g glucose/100g)	4.05±0.01^{e}	2.57±0.01^{a}	3.57±0.02^{bc}	2.48±0.01^{ab}	1.82±0.01^{e}	2.37±0.02^{a}	1.93±0.01^{b}
Proteins (mg/100g)	30±1.98^{a}	34±1.98^{bc}	32±1.98^{b}	29.33±1.98^{g}	63±0.6^{a}	48.67±0.6^{ef}	59.07±0.6^{c}
Lipids (g/100g)	8.86±0.19^{b}	9.46±0.2^{cd}	9.06±0.88^{ab}	8.76±0.2^{a}	2.75±0.88^{b}	4.02 ±0.88^{a}	3.77±0.88^{ab}
Vitamin A (µg / 100 g)	59.33±16.53^{b}	56.28±16.53^{a}	52.44±16.53^{e}	49.33±16.53^{cd}	55.05±9.84^{bc}	69.67±9.84^{f}	78.17±9.84^{d}

E1: Tiger Nuts 1 fermented + 2% soy milk; E2: Tiger Nuts 2 fermented + 2% soy milk; E3: Tiger Nuts 3 fermented + 2% soy milk; E4: Tiger Nuts fermented; E5: Soy Nuts 1 fermented; E6: Soy Nuts 2 fermented; E7: Soy Nuts 3 fermented

CONCLUSION

Tiger nut (*C. esculentus*) milk is a nutrient-rich plant milk that offers an alternative to cow's milk. Fermenting tiger nut tubers and adding soy to tiger nut milk production would benefit consumers by increasing the availability of nutrients for a balanced diet.

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