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Effect of Ivorian Taro (*Colocasia esculenta* L. cv *yatan* and *fouê*) Corm Flours Addition on Anti-nutritional Factors and Mineral Bioavailability of Wheat (*Triticum aestivum* L.) Flour

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Abstract The objective of this study was to evaluate the effect of ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm flours (TCF_{yf}) addition on anti-nutritional factors and mineral bioavailability of wheat (*Triticum aestivum* L.) flour (WF). WF was substituted with TCF_{yf} at increasing levels [0% (control), 1%, 3%, 6%, 9% and 12%] in the formulation. Compared to WF, calcium, potassium, magnesium, phosphorous, sodium, copper, zinc, iron, manganese, phenolic compound, oxalate and flavonoid contents of wheat/ivorian taro (*Colocasia esculenta* cv *yatan*) corm composite flour (WF-TCF_y) gradually increased with increasing the level of taro (*Colocasia esculenta* cv *yatan*) corm flour (TCF_y) in WF-TCF_y. The same trend was observed in potassium, phosphorous, copper, zinc, iron, manganese, phenolic compound, oxalate and flavonoid contents of wheat/Ivorian taro (*Colocasia esculenta* cv *fouê*) composite flour (WF-TCF_f) increased with increasing of taro (*Colocasia esculenta* cv *fouê*) corm flour (TCF_f) in WF-TCF_f. Inversely, substitution of WF with TCF_f caused gradual decreased in sodium, magnesium and calcium contents of WF-TCF_f. Substitution of WF with TCF_{yf} decreased phytate and tannin contents in the WF-TCF_{yf}. The K/Na ratios were greater than 27. When WF substitution was achieved by TCF_{yf}, the Ca/P ratio of the WF-TCF_y did not change while that of WF-TCF_f decreased. In all cases, the Ca/P ratios were below 0.3. The levels of the toxic substances were not high enough to cause concern as about 80 mg /g diet is detrimental to health. These results could encourage the use of TCF_{yf} for the development of food products.

Keywords: *anti-nutritional factor, composite flour,* Colocasia esculenta*, mineral, taro corm*

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1. Introduction

Taro (*Colocasia esculenta* L.) belongs to the genus Colocasia, within the sub-family Colocasioideae of the monocotyledonous family Araceae. It reproduces by vegetative propagation [1] and grown exclusively in the tropical and semitropical regions of the world [2]. This plant is cultivated mainly in developing countries, rarely on large plantations but on small farms with little technology [2]. Taro produces edible corms [3] and the leaves are also used as a vegetable [4]. It is one of the oldest major [5] and an important food staple for millions of people [2].

Taro (*Colocasia esculenta* L.) chemical composition is variable depending on the cultivar [6,7], growing conditions, kind of soil, moisture and fertilizer application, maturity at harvest, post-harvest management, storage [6] and corm parts [7,8]. In general, protein and fat content at corm are low but it is high in carbohydrates, fiber and minerals [6]. Taro corm has been reported to have 70-80% (dry weight basis) starch with small granules [9].

The free glucose content of corm is less than 1%. Whereas, the 60% of dry matter is composed of starch. The taro corms'starch is highly digestible and higher than the 50% of the starch is composed of rapidly digestible starch fractions [10]. Thanks to its high carbohydrate content, corm of taro is especially useful to persons allergic to cereals and can be consumed by children who are sensitive to milk [2].The glycemic index (GI) of taro corm is 63.1 ± 2.5, indicating taro corm as a medium GI food estimated glycemic index and a good dietary carbohydrate alternative especially for diabetic people [10] and athletes to reduce fatigue. According to [11], t*his* food may exert its anti-diabetic action by delaying/regulating the rate at which dietary starch is hydrolyzed to glucose or possibly through inhibition of acute pancreatitis. Taro starch is also good for peptic ulcer patients, patients with pancreatic disease, chronic liver problems and inflammatory bowel disease and gall bladder disease [12].

Taro (*Colocasia esculenta* L.) corm is also a valuable source of essential mineral nutrients [13]. Potassium is the most abundant mineral [8,14] (763-1451 µg/100 g) with appreciable amounts noted for zinc (17-51.1 µg/100 g), magnesium (46.7-85.0 µg/100 g) and phosphorus (41.6-63.1 µg/100 g) [8]. The upper part, which plays a critical role in vegetative propagation based on headsets, contains high levels of P, Mg, Zn, Fe, Mn, Cu and Cd. The central part, which is essential for human nutrition, is characterized by higher concentrations of K, P, Mg, Zn, Fe, Cu and Cd. Calcium is concentrated in the lower and marginal parts [13].

Taro (*Colocasia esculenta* L.) corm contains also anti-nutritional factors include oxalates, proteinase inhibitors, phytates, tannins, alkaloids, steroids and cyanogenic glucosides [15,16,17,6]. This food is very rich in oxalates (the fresh samples are in the range of 328–460 µg/100 g, [8]. In connection with this, it causes limited utilizations of taro (*Colocasia esculenta* L.) as a food material. The insoluble oxalates, especially needle like calcium oxalate crystal may cause irritation, swelling of mouth and throat [18]. It is a major factor contributing to the anti-palatability and anti-nutritive effects of raw colocasia corms [19]. Consumption of a large amount of oxalate could be fatal to humans because of oxalosis or the formation of calcium oxalate deposits in vital tissues or organs of the body [20]. The patients with kidney stone problems should control dietary oxalate intake to less than 40-50 mg per day [21]. Removal of *anti-nutritional factors* in food can be done by physical processes, such as washing, peeling, dicing, blanching, drying, soaking overnight and cooking [18,22,23] or chemical process by converting them into soluble phases [18].

Due to its high moisture content, fresh taro corm is difficult to store and is vulnerable to deterioration during storage. One of the best ways to preserve it is by processing it into flour and/or starch [24,25]. According to [26], taro flour is stored much longer than the unprocessed corm. It can then be used with wheat (*Triticum aestivum* L.) floor in food formulations such as biscuit [27,28], cake [29], bread [30] [31,32], baby food [33], pasta [34], or other products [29]. Wheat is the third most produced cereal in the world after maize and rice [35]. It is a very important food crop for the daily intake of proteins, vitamins, minerals and fibers in a growing part of the world population [36]. Wheat flour, the main ingredient of the foods production is imported by countries with unfavourable climates for growing wheat. This importation has placed a considerable burden on the foreign exchange reserves of the economies of such importing countries. This has led to the development and use of composite flours for production of biscuit, bread, baby food, pasta, or other products [37]. Therefore, the objective of this study is to evaluate the effect of ivorian taro (*Colocasia esculenta* L. cv *yatan* and *fouê*) corm flours addition on anti-nutritional factors and mineral bioavailability of wheat (*Triticum aestivum* L.) flour. This is done because the nutritional value of a food depends upon its nutritional contents and their digestibility and the presence or absence of anti-nutrients and toxic factors [23].

2. Materials and Methods

2.1. Materials

Taro (*Colocasia esculenta*, cv *yatan* and *fouê*) corms were used in this work. They were randomly harvested at maturity (9 months after planting) from a farm in Affery, South-East portion of Côte d'Ivoire (West Africa) in May 2013. They were immediately transported to the Laboratoire de Biocatalyse et des Bioprocédés (Université Nangui Abrogoua, Abidjan, Côte d'Ivoire) and stored under prevailing tropical ambient conditions (19-28°C, 60-85% RH) for 24 h before the preparation of flours from raw taro corms [14]. The commercially available soft wheat flour was purchased from local suppliers at Bonoua market in Bassam, Côte d'Ivoire. The flour was cleaned of foreign materials and sieved through 75 µm. All chemicals and reagents used were of analytical grade and purchased from Sigma Chemical Company (USA).

2.2. Methods

2.2.1. Production of Taro Corm and Composite Flours

The ivorian taro (*Colocasia esculenta*, cv *yatan* and *fouê*) corms were cleaned and rinsed with copious amounts of tap water. The corms were thereafter peeled using a stainless steel knife. The peeled samples were rewashed with clean water in order to remove much mucilaginous material. After washing, they were cut into slices 0.5 cm thick and dried to a brittle texture in a convection oven set at 45±3 °C for 24 h. The dried slices were fine-milled (500 µm) into flour using an electric grinder (Cullati, Polymix, France, Kinematica, Luzernerstrasse, Germany), packaged in polyethylene bags and stored at 4°C until required for further analysis [14]. Taro corm and wheat flours were blended in various proportions to come up with different formulations of wheat/taro as 99:1, 97:3, 94:6, 91:9 and 88:12. This was done for complementation purposes between the two flours. The different blends were named WF-TCF 1, WF-TCF 3, WF-TCF 6, WF-TCF 9 and WF-TCF 12 respectively (Table 1). The composite flours were produced by mixing in a blender (Moulinex brand, Paris, France) taro flour and wheat flour using a 2×7 factorial design consisting of two cultivars of taro flour (cv *yatan* and *fouê*).

Table 1. Showing blends of wheat flour and Ivorian Taro (*Colocasia esculenta* cv *yatan* and *fouê*) Corm flours used in composite flour formulation

Sample Code	Wheat flour (%)	Taro corm flour (%)
WF [wheat flour (100%)]	100	0
WF-TCF 1 [wheat flour (99%) + taro corm flour (1%)]	99	1
WF-TCF 3 [wheat flour (97%) + taro corm flour (3%)]	97	3
WF-TCF 6 [wheat flour (94%) + taro corm flour (6%)]	94	6
WF-TCF 9 [wheat flour (91%) + taro corm flour (9%)]	91	9
WF-TCF 12[wheat flour (88%) + taro corm flour (12%)]	88	12

Wheat Flour (WF), Taro Corm Flour (TCF).

2.2.2. Mineral Composition

Sample product (4g) was ashed in a muffle furnance at 550°C. The ash was boiled with 10 ml of 20% hydrochloric acid in a beaker, filtered into a 100 ml standard flask and made up to the mark with de-ionized water. The blank solutions were prepared in the same manner as the samples. The minerals, such as calcium, copper, iron, magnesium, sodium, potassium and zinc of wheat/taro composite flours and wheat flour were analyzed according to the method prescribed by [38] with an atomic absorption spectrophotometer (Pye-Unicam 969, Cambridge, UK). Phosphorus was determined by the vanadomolybdate colorimetric method (UV-visible spectrophotometer, JASCO V-530, Model Tudc 12 B4, Japan Servo Co. Ltd., Indonesia) using potassium dihydrogen phosphate as the standard [39].

2.2.3. Anti-nutritional Factors

Oxalate level was estimated by the method of [40]. Oxalic acid was extracted from wheat flour and composite flour prepared by mixing wheat flour and ivorian taro (*Colocasia esculenta*, cv *yatan* and *fouê*) corm flours and precipitated as calcium salt, then dissolved in hot 25% sulphuric acid. The concentration of oxalates in the solution was determined by titration with KMnO4. Phytates content was determined by the method described by [41]. Phytate was precipitated with excess ferric chloride and the phytin was determined directly by estimating the amount of phosphorus present in the ferric phytate precipitate. The total phenolic compound contents were determined as described in [42] from the methanol extracts using Folin-Ciocalteu reagent [43]. The standard used was tannic acid. The total tannin analyzis was conducted using the method of [39]. The total flavonoid concentration was measured using a colorimetric assay developed by [39] It was calculated using quercetin as standard.

2.3. Statistical Analyzis

All data analyzes were done in triplicates and subjected to analyzis of variance (ANOVA) as described by [14]. The means were then separated with the use of Duncan's multiple range test, compared by Least Significant Difference (LSD) with mean square error at 5% probability using the statistical package for the social sciences, SPSS 19.0 software.

3. Results and Discussion

3.1. Macro Minerals

The presence of five macro minerals (potassium, phosphorous, calcium, magnesium and sodium) was investigated in the wheat flour and wheat/ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm composite flours. The results are shown in Table 2 and Table 3. Potassium was the most abundant macro mineral in the wheat flour and composite flours. Phosphorous was the second most common macro mineral, third most macro mineral was calcium and appreciable amount of magnesium was also noted. Sodium tended to be low. This sequence of abundance of the macro minerals in the wheat flour and wheat/ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm composite flours differed to the observations of [45,46,47].

Analyzis on the data (Table 2 and Table 3) showed that significant differences ($p<0.05$) existed in the macro mineral contents of the wheat flour and wheat/ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm composite flours studied. Compared to wheat flour (control formula); calcium, potassium, magnesium, phosphorous and sodium contents of wheat/ivorian taro (*Colocasia esculenta* cv *yatan*) corm composite flour gradually increased with increasing the level of taro corm flour in composite flour. This may be due to the increasing of these macro mineral levels in ivorian taro (*Colocasia esculenta* cv *yatan*) corm flour. Similar observations were found by [48,49]. The same trend was observed in potassium and phosphorous contents of wheat/ivorian taro (*Colocasia esculenta* cv *fouê*) corm composite flour increased with increasing of taro corm flour in composite flour. Inversely, substitution of wheat flour with Ivorian taro (*Colocasia esculenta* cv *fouê*) corm flour caused gradual decreased in sodium, magnesium and calcium contents of wheat/ivorian taro (*Colocasia esculenta* cv *fouê*) corm composite flour. These observations could be attributed to Ivorian taro (*Colocasia esculenta* cv *fouê*) corm flour which had lower content of sodium, magnesium and calcium than those of wheat flour. These results were in close conformity with the findings of [50] in composite flour from wheat-sorghum.

The macro mineral (potassium, phosphorous, magnesium, calcium and sodium) contents were found to be higher in the wheat/ivorian taro (*Colocasia esculenta* cv *yatan*) corm composite flours than of the composite flours from wheat/ivorian taro (*Colocasia esculenta* cv *fouê*) corm. This suggested that in taro corm, the level of mineral nutrient available varied with cultivar. The ivorian taro (*Colocasia esculenta* cv *yatan*) corm contained more potassium, phosphorous, magnesium, calcium and sodium than ivorian taro (*Colocasia esculenta* cv *fouê*) corm.

Variations in the potassium content of the wheat flour and wheat/ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm composite flours were observed with values ranging from 173.16±0.11 to 206.69±0.43 mg/100g. These values were found to be higher when compared with the earlier reports of composite flours from wheat-sorghum [50], sorghum-maize [47] and sorghum-african yam bean [51]. Wheat flour and wheat/ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm composite flours were found to contain higher level of potassium when compared with RDA's of infants and children (<1550 mg) [52]. The high content of potassium can be utilized beneficially in the diets of people who take diuretics to control hypertension and suffer from excessive excretion of potassium through the body fluid [53]. Potassium is very essential in blood clothing and muscle contraction [51]. Sodium in association with potassium is useful for maintenance of body fluids [54]. It was found to be the lowest macro mineral in the wheat flour and wheat/ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm composite flours, with values ranging from 3.49±0.14 to 7.52±0.23 mg/100g. This signified that the wheat and ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm flours were low in sodium. This finding is important because much sodium in diet increases the risk of high blood pressure, stroke, heart disease and kidney disease. When wheat flour substitution was achieved by ivoirian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm flours, the K/Na ratios were greater than 27. Foods naturally higher in potassium than sodium may have a K/Na ratio of 4.0 or more [55]. The high K/Na suggested that the composite flours from wheat and ivorian taro (*Colocasia esculenta*, cv *yatan* and *fouê*) corm could be suitable in helping to ameliorate sodium-related health risk [56].

The phosphorous content of wheat flour in this study was 147.37±0.05 mg/100g while those of composite flours from wheat/ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm flours with different levels of taro corm flour substitution ranged from 147.5±0.14 to 181.13±0.02 mg/1001g. The variations of phosphorous contents in wheat flours were observed in the literature from 3 to 350 mg/100g [57,58]. Thus, in the present study, the contents of this macro mineral observed are included in these variation ranges. Probably, the factors influencing these differences are the genetic characteristics of the cultivars, the vegetal maturity and the phosphorous levels in the soil. Phosphorous helps in the formation of adenosine triphosphate in the body [59]. Its contribution to RDA ranged from 32.1-42.9%, in both adult males and females, respectively if 250g flour is eaten daily [60]. Calcium plays significant roles in blood clothing and muscle contraction in humans [61]. It assists in bone formation [62]. Results showed that its contribution to RDA ranged from 17.5-22.5% in both adult males and females, respectively if 250g flour is eaten daily [60]. The calcium content of wheat flour in this study was 30.81±0.01 mg/100g while those of composite flours from wheat/ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm flours ranged from 27.59±0.07 to 38.67±0.05 mg/1001g. In regard to calcium, the values reported in this study are in agreement with those reported by [63]. Calcium contents obtained from this study were considerably higher than reported in others studies that obtained between 10 to 21 mg/100g [64,58]. Results showed that calcium contribution to RDA ranged from 17.5-22.5% in both adult males and females, respectively if 250g flour is eaten daily [60]. When wheat flour substitution was achieved by taro flour, the Ca/P ratio of the composite flour from wheat/ivorian taro (*Colocasia esculenta* cv *yatan*) corm did not change while that of wheat/ivorian taro (*Colocasia esculenta* cv *fouê*) decreased. In all cases, the Ca/P ratios were below 0.3. However, according to [65], a good menu should have a Ca/P ratio over 1. Phosphorus works closely with calcium to build strong bones and teeth. It is stored in the bone as calcium phosphate [66]. Foods high in phosphorus and low in calcium tend to make the body over acid deplete it of calcium and other minerals and increase the tendency towards inflammations [57]. In order to avoid these problems, these flours need to supplementation with calcium to prevent mineral and osmotic imbalance.

Table 2. Effect of Ivorian Taro (*Colocasia esculenta* cv *yatan*) Corm Flour Addition on the Macro Mineral Bioavailability of Wheat Flour

Macro mineral (mg/100g)	WF	WF-TCF$_{y1}$	WF-TCF$_{y3}$	WF-TCF$_{y6}$	WF-TCF$_{y9}$	WF-TCF$_{y12}$
Mg	26.33±0.58a	26.83±0.23a	30.89±0.75b	36±0.18c	41.83±0.34d	44.83±0.32c
Na	5.18±0.02a	5,86±0.12a	6.11±0.04b	6.40±0.11b	6.61±0.16b	7.52±0.23c
K	173.16±0.11a	173.95±0.14a	177.16±0.11b	186.11±0.11c	190.66±0.04d	206.69±0.43e
Ca	30.81±0.01a	30.91±0.05a	38.01±0.07b	38.34±0.02^{b}	38.62±0.05^{b}	38.67±0.05^{b}
P	147.37±0.05a	147.64±0.25a	169.56±0.04b	171.41±0.07c	171.64±0.03c	181.13±0.02d
K/Na	33.42	29.68	28.99	29.07	28.84	27.48
Ca/P	0.20	0.20	0.22	0.22	0.22	0.21

The obtained values are averages ± standard deviation of triplicate determinations. On the lines of each parameter, the averages affected of no common letter (a or b) are significantly different between them on the threshold of 5% according to the test of Duncan.
WF: wheat flour
WF-TCF$_{y1}$: composite flour from wheat flour (99%) and taro (*Colocasia esculenta* cv *yatan*) corm flour (1%)
WF-TCF$_{y3}$: composite flour from wheat flour (97%) and taro (*Colocasia esculenta* cv *yatan*) corm flour (3%)
WF-TCF$_{y6}$: composite flour from wheat flour (94%) and taro (*Colocasia esculenta* cv *yatan*) corm flour (6%)
WF-TCF$_{y9}$: composite flour from wheat flour (91%) and taro (*Colocasia esculenta* cv *yatan*) corm flour (9%)
WF-TCF$_{y12}$: composite flour from wheat flour (88%) and taro (*Colocasia esculenta* cv *yatan*) corm flour (12%)

Table 3. Effect of Ivorian Taro (*Colocasia esculenta* cv *fouê*) Corm Flour Addition on the Micro Mineral Contents of Wheat Flour

Macro mineral (mg/100g)	WF	WF-TCF$_{f1}$	WF-TCF$_{f3}$	WF-TCF$_{f6}$	WF-TCF$_{f9}$	WF-TCF$_{f12}$
Mg	26.33±0.58a	26.01±0.07a	25.83±0.22b	25.50±0.70b	24.50±0.35c	24.33±0.47c
Na	5.18±0.02a	5.02±0.07a	4.85±0.15b	4.50±0.35c	3.75±0.28d	3.49±0.14e
K	173.16±0.11a	173.5±0.35a	175.66±0.66b	175.83±0.02b	180.83±0.73c	181.5±0.03c
Ca	30.81±0.01a	30.24±0.03a	29.08±0.06b	28.92±0.72c	28.81±0.22c	27.59±0.07d
P	147.37±0.05a	147.5±0.14a	155.12±0.01b	167.37±0.05c	170.36±0.04d	173.47±0.01e
K/Na	33.42	34.70	36.21	39.07	48.22	52
Ca/P	0.20	0.20	0.18	0.17	0.16	0.15

The obtained values are averages ± standard deviation of triplicate determinations. On the lines of each parameter, the averages affected of no common letter (a or b) are significantly different between them on the threshold of 5% according to the test of Duncan.
WF: wheat flour
WF-TCF$_{f1}$: composite flour from wheat flour (99%) and taro (*Colocasia esculenta* cv *fouê*) corm flour (1%)
WF-TCF$_{f3}$: composite flour from wheat flour (97%) and taro (*Colocasia esculenta* cv *fouê*) corm flour (3%)
WF-TCF$_{f6}$: composite flour from wheat flour (94%) and taro (*Colocasia esculenta* cv *fouê*) corm flour (6%)
WF-TCF$_{f9}$: composite flour from wheat flour (91%) and taro (*Colocasia esculenta* cv *fouê*) corm flour (9%)
WF-TCFf12: composite flour from wheat flour (88%) and taro (*Colocasia esculenta* cv *fouê*) corm flour (12%).

Magnesium is essential to good health because it helps to maintain normal muscle and nerve function, keeps heart rhythm steady, supports a healthy immune system, keeps bones strong [66] and also plays a role in regulating the acid alkaline balance of the body [62]. By comparing the contents of magnesium in the composite flours (107.99 to 205.93mg/100g) from wheat/ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm with the others composite flours from sorghum-african yam bean [51] and wheat/sweet potato [64] of this mineral, it was observed that wheat/ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm composite flours are rich in magnesium.

3.2. Micro Minerals

Selected micro minerals (Cu, Zn, Fe and Mn) were analyzed and the results are shown in Table 4 and Table 5. In general, the highest micro mineral found in the wheat flour and composite flours consisting wheat and ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm is iron which range between 1.00±0.02 to 1.23±0.07 mg/100g, followed by zinc from 0.73±0.03 to 0.94±0.23 mg/100g, Mn from 0.71±0.10 to 0.86±0.46 mg/100g and finally copper between 0.12±0.02 to 0.18±0.04 mg/100g. Substitution of wheat flour with ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm flours caused gradual increased in Cu, Zn, Fe and Mn contents of wheat/ivorian taro corm composite flours. In this regard, the possible increment of micro mineral contents with increasing taro corm flour could be due to the fact that taro corm flour is rich source of micro minerals and it is imperative to blend wheat flour with it to enhance the micro mineral contents. Analyzis on the data showed that significant differences ($p<0.05$) existed in the micro mineral contents of the wheat/ivorian taro (*Colocasia esculenta* cv *yatan*) corm composite flour and wheat/ivorian taro (*Colocasia esculenta* cv *fouê*) corm composite flour studied. Composite flour from wheat/ivorian taro (*Colocasia esculenta* cv *yatan)* corm flour showed superior performance in terms of micro mineral constituents except for Mn and iron where composite flour from wheat/ivorian taro (*Colocasia esculenta* cv *fouê)* corm had the highest content.

Zinc is an essential metal and a component of a wide variety of different enzymes in which it is involved in catalytic, structural and regulatory roles [67]. This micro mineral acts as an activator of many enzyme systems in humans [68]. Zinc constitutes about 33 ppm of adult body weight and is essential of many enzymes involved in a number of physiological functions, such as protein synthezis and energy metabolism [67]. WHO has recommended permissible limit of Zn in foods such as 60 mg/kg [69]. The contents of this micro mineral in composite flours from wheat/ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê)*corm were below the limit. The zinc contents were within the range of 0.42 to % 1.72 mg/100g reported by [70] for composite flour from breadfruit, breadnut and wheat, but higher than 0.52-0.68 mg/100g as found by [63]. However, these values were below the range of 2.85 to 2.95 mg/100g reported by [57].

Iron (Fe) deficiency anemia for instance affect one third of the worlds population. On the other hand, excessive intake of iron is associated with an increase risk of colorectal cancer [71]. Iron levels reported in this study were however far lower than those reported by other authors. [58] reported values such as 3.77-4.14 mg/100g, [57] had values such as 3.92-4.06 mg/100g and 4.08-5.63 mg/100g was reported by [72]. The maximum and minimum iron values determined in the wheat flour and wheat/ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm composite flours are below the limit of 15 mg/kg set by [69].

Table 4. Effect of Ivorian Taro (*Colocasia esculenta* cv *yatan*) Corm Flour Addition on the Micro Mineral Contents of Wheat Flour

Micro Mineral (mg/100g)	WF	WF-TCF$_{y1}$	WF-TCF$_{y3}$	WF-TCF$_{y6}$	WF-TCF$_{y9}$	WF-TCF$_{y12}$
Cu	0.12±0.02^{a}	0.13±0.01^{b}	0.13±0.07^{b}	0.15±0.04^{c}	0.16±0.04^{d}	0.18±0.04^{e}
Zn	0.73±0.03^{a}	0.74±0.09^{b}	0.83±0.11^{c}	0.87±0.11^{d}	0.89±0.23^{e}	0.94±0.23^{f}
Fe	1.00±0.02^{a}	1.05±0.04^{b}	1.10±0.02^{c}	1.13±0.03^{d}	1.14±0.04^{e}	1.16±0.03^{f}
Mn	0.71±0.10^{a}	0.71±0.04^{a}	0.73±0.16^{b}	0.74±0.01^{c}	0.80±0.01^{d}	0.84±0.11^{e}

The obtained values are averages ± standard deviation of triplicate determinations. On the lines of each parameter, the averages affected of no common letter (a or b) are significantly different between them on the threshold of 5% according to the test of Duncan.
WF: wheat flour
WF-TCF$_{y1}$: composite flour from wheat flour (99%) and taro (*Colocasia esculenta* cv *yatan*) corm flour (1%)
WF-TCF$_{y3}$: composite flour from wheat flour (97%) and taro (*Colocasia esculenta* cv *yatan*) corm flour (3%)
WF-TCF$_{y6}$: composite flour from wheat flour (94%) and taro (*Colocasia esculenta* cv *yatan*) corm flour (6%)
WF-TCF$_{y9}$: composite flour from wheat flour (91%) and taro (*Colocasia esculenta* cv *yatan*) corm flour (9%)
WF-TCF$_{y12}$: composite flour from wheat flour (88%) and taro (*Colocasia esculenta* cv *yatan*) corm flour (12%)

Table 5. Effect of Ivorian Taro (*Colocasia esculenta* cv *fouê*) Corm Flour Addition on the Micro Mineral Contents of Wheat Flour

Micro Mineral Contents (mg/100g)	WF	WF-TCF$_{f1}$	WF-TCF$_{f3}$	WF-TCF$_{f6}$	WF-TCF$_{f9}$	WF-TCF$_{f12}$
Cu	0.12±0.02^{a}	0.12±0.01^{a}	0.13±0.05^{a}	0,14±0,02^{a}	0,15±0,01^{b}	0,16±0,04^{b}
Zn	0.73±0.03^{a}	0.73±0.02^{a}	0.75±0.01^{b}	0.83±0.06^{c}	0.85±0.05^{d}	0.90±0.09^{e}
Fe	1.00±0.02^{a}	1.11±0.03^{b}	1.16±0.04^{c}	1.18±0.03^{d}	1.21±0.17^{e}	1.23±0.07^{f}
Mn	0.71±0.10^{a}	0.72±0.01^{b}	0.73±0.16^{c}	0.75±0.01^{d}	0.81±0.02^{e}	0.86±0.46^{f}

The obtained values are averages ± standard deviation of triplicate determinations. On the lines of each parameter, the averages affected of no common letter (a or b) are significantly different between them on the threshold of 5% according to the test of Duncan.
WF: wheat flour
WF-TCF$_{f1}$: composite flour from wheat flour (99%) and taro (*Colocasia esculenta* cv *fouê*) corm flour (1%)
WF-TCF$_{f3}$: composite flour from wheat flour (97%) and taro (*Colocasia esculenta* cv *fouê*) corm flour (3%)
WF-TCF$_{f6}$: composite flour from wheat flour (94%) and taro (*Colocasia esculenta* cv *fouê*) corm flour (6%)
WF-TCF$_{f9}$: composite flour from wheat flour (91%) and taro (*Colocasia esculenta* cv *fouê*) corm flour (9%)
WF-TCFf12: composite flour from wheat flour (88%) and taro (*Colocasia esculenta* cv *fouê*) corm flour (12%).

Copper is an essential constituent of some metalloenzymes and is required in haemoglobin synthezis and in the catalyzis of metabolic growth [73]. Copper concentrations determined in this study are below the safe limit set by World Health Organization (WHO) (40 mg/kg) as copper in foods [69]. The samples may also be capable of contributing to the absorption of copper in view of concerns that suboptimal copper status maybe involved in developing many inflammatory and degenerative conditions such as osteoporosis and heart disease [64].

According to [75], manganese is an essential metal and it plays an important role in biological systems such as its presence in metalloproteins. The highest and lowest manganese concentrations determined in this work are far below the toxicity limit between 400-1000 mg/kg of manganese in plant. Manganese content obtained from this study were considerably lower than reported in other study [57,76,51].

3.3. Anti-nutritional Factors

The effect of ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm flours addition on anti-nutritional factors of wheat flour is indicated in Table 6 and Table 7. The anti-nutritional factors (tannins, phytates, phenolic compounds, flavonoids and oxalates) contents of wheat flour were 195.49±0.24, 16.45± 0.04, 202.38± 0.04, 5.09±0.01 and while those of wheat/ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm composite flours with different levels of taro corm flour substitution ranged from 195.49±0.24 to 62.70±0.24, 16.45± 0.04 to 12.45±0.04, 202.38± 0.04 to 426.58±1.40, 5.09±0.01 to 22.68±0.06 and 22.41±0.84 to 80.4±0.84 mg/100g. The levels of the toxic substances were not high enough to cause concern as about 80 mg/g diet is detrimental to health. It is, however noteworthy that some of these toxicants, namely phytate, oxalate and tannin, can reduce nutrient bioavailability [77,78,79,70,80]. On the whole, it appears that wheat flour and wheat/ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm composite flours could serve as a good source of some nutrients and hence maybe used to substitute wheat flour in baking and confectionery foods [70].

There was a significant difference (p <0.05) amongst the samples. This pattern is in accordance with that reported by [81]. The results revealed that substitution of wheat flour with ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm flours significantly ($p < 0.05$) increased the phenolic compound, oxalate and flavonoid contents of the mixture increased as the percentage of substitution of taro flour increased. This may be attributed to high phenolic compound, oxalate and flavonoid contents of taro flour than wheat flour. These results are in accordance with those reported by [82,81,33,83]. Inversely to phenolic compounds, oxalates and flavonoids, wheat flour had higher phytates and tannins than wheat/ivorian taro composite flours. This means that, substitution of wheat flour with taro corm flour decreased phytate and tannin contents in the composite flours consisting wheat and ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm. This finding agrees with the report of [81,33,63].

Table 6. Effect of Ivorian Taro (*Colocasia esculenta* cv *yatan*) Corm Flour Addition on the Anti-nutritional Factors Contents of Wheat Flour

Anti-nutritional factors contents (mg/100g)	WF	WF-TCF$_{y1}$	WF-TCF$_{y3}$	WF-TCF$_{y6}$	WF-TCF$_{y9}$	WF-TCF$_{y12}$
Tannins	195.49±0.24^{f}	169.13±0.45^{e}	137.94±0.24^{d}	126.68±0.24^{c}	95.33±0.68^{b}	72.50±0.22^{a}
Flavonoids	5.09±0.01^{a}	7.85±0.03^{b}	9.46±0.27^{c}	11.18±0.03^{d}	14.94±0.05^{e}	22.68±0.06^{f}
Phenolic compounds	202.38± 0.04^{a}	240.07±1.40^{b}	283.23±0.70^{c}	323.90±0.70^{d}	372.02±1.40^{e}	426.58±1.40^{f}
Phytates	16.45± 0.04^{d}	14.51±0.04^{c}	13.78±0.04^{b}	13.81±0.04^{b}	12.72±0.04^{a}	12.45±0.04^{a}
Oxalates	22.41±0.84^{a}	27.45±2.05^{b}	37.30±0.70^{c}	52.40±0.84^{d}	66.25±1.06^{e}	80.4±0.84^{f}

The obtained values are averages ± standard deviation of triplicate determinations. On the lines of each parameter, the averages affected of no common letter (a or b) are significantly different between them on the threshold of 5% according to the test of Duncan.
WF: wheat flour
WF-TCF$_{y1}$: composite flour from wheat flour (99%) and taro (*Colocasia esculenta* cv *yatan*) corm flour (1%)
WF-TCF$_{y3}$: composite flour from wheat flour (97%) and taro (*Colocasia esculenta* cv *yatan*) corm flour (3%)
WF-TCF$_{y6}$: composite flour from wheat flour (94%) and taro (*Colocasia esculenta* cv *yatan*) corm flour (6%)
WF-TCF$_{y9}$: composite flour from wheat flour (91%) and taro (*Colocasia esculenta* cv *yatan*) corm flour (9%)
WF-TCF$_{y12}$: composite flour from wheat flour (88%) and taro (*Colocasia esculenta* cv *yatan*) corm flour (12%)

Table 7. Effect of Ivorian Taro (*Colocasia esculenta* cv *fouê*) Corm Flour Addition on the Anti-nutritional Factors Contents of Wheat Flour

Anti-nutritional factor contents (mg/100g)	WF	WF-TCF$_{f1}$	WF-TCF$_{f3}$	WF-TCF$_{f6}$	WF-TCF$_{f9}$	WF-TCF$_{f12}$
Tannins	195.49±0.24^{f}	179.42±0.24^{e}	134.72±0.24^{d}	112.70±0.22^{c}	86.01±0.22^{b}	62.70±0.24^{a}
Flavonoids	5.09±0.01^{a}	6.53±0.02^{b}	8.07±0.03^{c}	12.61±0.04^{d}	15.27±0.21^{e}	25.12±0.25^{f}
Phenolic compounds	202.38± 0.04^{a}	253.96±2.10^{b}	292.16±2.10^{c}	355.65±0.70^{d}	392.85±1.40^{e}	409.22±2.10^{f}
Phytates	16.45± 0.04^{d}	16.24±0.04^{d}	14.15±0.04^{c}	12.94±0.04^{b}	12.51±0.04^{b}	11.24±0.02^{a}
Oxalates	22.41±0.84^{a}	23.12±1.14^{a}	26.15±3.18^{b}	30.62±0.42^{c}	44.84±1.55^{d}	50.82±0.14^{e}

The obtained values are averages ± standard deviation of triplicate determinations. On the lines of each parameter, the averages affected of no common letter (a or b) are significantly different between them on the threshold of 5% according to the test of Duncan.
WF: wheat flour
WF-TCF$_{f1}$: composite flour from wheat flour (99%) and taro (*Colocasia esculenta* cv *fouê*) corm flour (1%)
WF-TCF$_{f3}$: composite flour from wheat flour (97%) and taro (*Colocasia esculenta* cv *fouê*) corm flour (3%)
WF-TCF$_{f6}$: composite flour from wheat flour (94%) and taro (*Colocasia esculenta* cv *fouê*) corm flour (6%)
WF-TCF$_{f9}$: composite flour from wheat flour (91%) and taro (*Colocasia esculenta* cv *fouê*) corm flour (9%)
WF-TCFf12: composite flour from wheat flour (88%) and taro (*Colocasia esculenta* cv *fouê*) corm flour (12%).

Among the two cultivars (cv *yatan* and *fouê*) of ivorian taro (*Colocasia esculenta*), the corms of *Colocasia esculenta* (cv *fouê)* contained more phenolic compounds. This value is found to be higher than that of the earlier studies in the composite flours from white skinned sweet potato-unripe plantain [83]. This pattern indicates that taro (*Colocasia esculenta*, cv *fouê*) corm could exhibit a wide range of health promoting function such as anti-bacterial, anti-inflammatory, anti-allergic, hepato-protective, anti-thrombotic, anti-viral, anti-diabetic and anti-hypertensive activities [84]. It contains strong antioxidants which prevent oxidative damage to biomolecules such as DNA, lipids and proteins which play a role in chronic diseases such as cancer and cardiovascular diseases [85].

Flavonoids are known to possess anti-bacterial, anti-inflammatory, anti-allergic, anti-viral and anti-neoplastic activity [86]. The levels of this substance in composite flours from wheat/ivorian taro (*Colocasia esculenta* cv *yatan*) corm flours were found to be lower when compared with the composite flours from wheat/ivorian taro (*Colocasia esculenta* cv *fouê*) corm flours. This is in indication that the taro *Colocasia esculenta* (cv *fouê)* corms contained more flavonoids than ivorian taro *Colocasia esculenta* (cv *yatan)* corm.

The tannin and oxalate levels in composite flours from wheat/ivorian taro (*Colocasia esculenta* cv *yatan*) corm flour were significantly higher ($p < 0.05$) than those in the composite flours from wheat/ivorian taro (*Colocasia esculenta* cv *fouê*) corm. This could be due to the high levels of tannin and oxalate in ivorian taro (*Colocasia esculenta* cv *yatan*) corm flour than ivorian taro (*Colocasia esculenta* cv *fouê*) corm flour. The oxalate contents of composite flours consisting wheat and ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm in this study were within the range of oxalate content (0.07 to 430 mg/100g) of composite flours from wheat/non-wheat reported by various authors [33,81]. The highest value of phytate was observed in composite flour containing 70% whole wheat and 30% whole sorghum flours whereas, the lowest value of phytate was observed in composite flour containing 70% pearled wheat and 30% sorghum flours [50]. The results obtained for phytate contents in this study are similar to the reports of [87,88] who observed that pearling reduced the phytic acid to a considerable extent. Tannins are also well known for their antioxidant and antimicrobial properties as well as for soothing relief, skin regeneration, as anti-inflammatory and diuresis [89]. The tannin contents of the wheat flour and composite flours from wheat/ivorian taro corm obtained in this study are lower than the tannin contents of sorghum-soy-plantain flours (23.8-27.4%) reported by [90,91] reported higher tannin contents for malted sorghum-soy composite flour (18.9-27.6%).

4. Conclusion

The composite flour consisting wheat and ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm flours possessed good potassium, phosphorous, magnesium, sodium, copper, zinc, iron, manganese contents and K/Na ratio. The K/Na ratios were greater than 27. Ivorian taro (*Colocasia esculenta* cv *yatan*) had positive effect on potassium, phosphorous, magnesium, sodium, calcium, copper, zinc, iron, manganese contents and K/Na ratio while ivorian taro (*Colocasia esculenta* cv *fouê*) exerted positive effect on potassium, phosphorous, copper, zinc, iron, manganese contents and K/Na ratio. The composite flours from wheat/ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm flours contained phenolic compounds, flavonoids, oxalates, phytates and tannins. But, the levels of these toxic substances were not high enough to cause concern as about 80 mg /g diet is detrimental to health. These results could encourage the use of ivorian taro (*Colocasia esculenta* cv *yatan* and *fouê*) corm flours for the development of food products and help reduce dependence on importation of wheat. Meanwhile, consumption of these products should be accompanied with calcium rich diets such in order to eat a nutritionally balanced diet.

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