International Journal of Nutrition and Food Sciences
2025, Vol. 14, No. 1, pp. 1–12
https://doi.org/10.11648/j.ijnfs.20251401.11

Research Article

Nutritional Value, Protein Quality and Antinutrient Factors of a New Food: *Tofu*-Type 'Vegetable Meat' Produced from Cowpeas (*Vigna Unguiculata*)

Ginette Gladys Doue*, Lessoy Thierry Zoue, Mariame Cisse, Marcelle Tano Nyameke, Aya Carole Bonny, Rose-Monde Megnanou

Laboratory of Biotechnology, Agriculture and Valorization of Biological Resources, Faculty of Biosciences, Félix Houphouët-Boigny University, Abidjan, Côte d'Ivoire

Abstract

Tofu is a 'vegetable meat' made from soybeans through coagulation of its proteins. In this study, a new food like *tofu* has been developed by processing a local legume, cowpea, into a 'vegetable meat' like *tofu*. Chemical characteristics, protein quality and antinutrient factors were studied and compared with it's traditional counterpart soy-based. Results showed that both types of 'vegetable meat' displayed an excellent production yield of over 50% with an acidic pH. As regards proximal composition, the protein (14.06±1.4 7%), lipid (05.88±1.41%), fiber (00.79±0.02%) and energy (146.44±4.65 kcal/100g) contents of the new food were lower than those of the soy-based meat counterpart, but remained within the recommended norms for each parameter. A study of the amino acid profile of their proteins revealed the presence of the nine essential amino acids, at over 50% in both types of *tofu* like 'vegetable meat'. Of these nine essential amino acids, three were found to have higher levels in cowpea-based 'vegetable meat': isoleucine (08.5±0.02%), leucine (08.6±0.0 3%) and tryptophan (08.6±0.14%). Similarly, the amino acids nutritional quality of *tofu* like cowpea 'vegetable mea was reflected by an essential amino acid index of 90.45% and biological value of 87.09% underlining the efficiency of such proteins in meeting children's amino acid needs. Furthermore, the low levels of oxalates (0.044 g/100g) and tanins (0.14 g/100g) recorded in cowpea based 'vegetable meat' compared to its traditional soy 'vegetable meat' counterpart would enhance the bioavailability of these nutrients for children's bodies. Thus, the production of *tofu*-type 'vegetable meats' from cowpea, just as nutritious as *tofu*, could make it possible to offer them as substitutes for expensive animal proteins in a context of persistent protein-energy malnutrition.

Keywords

Cowpea, 'Vegetable Meat', Malnutrition, Anti-nutritional Factors, Quality Protein

1. Introduction

The world's best indicator of a child's well-being is its growth. This indicator is very often disrupted by a combination of factors, namely infections, inadequate dietary practices and often both, which are detrimental to the child's physical growth and mental development [1]. This unfortunately leads to the cases of child malnutrition encountered in developing

*Corresponding author: gladysdoue@yahoo.com (Ginette Gladys Doue), doue.gladys@ufhb.edu.ci (Ginette Gladys Doue)

Received: 29 November 2024; **Accepted:** 10 December 2024; **Published:** 14 January 2025

countries, where one in three children under the age of 5.

Among the nutritional problems most frequently encountered in developing countries, and particularly in sub-Saharan Africa, the form of malnutrition that remains of greatest concern is protein-energy malnutrition (PEM), with high prevalence among pre-school children. Indeed, of the 190 million pre-school children suffering from PEM in developing countries, Sub-Saharan Africa alone accounts for over 50% of this prevalence [2]. This situation is unlikely to be resolved despite the many efforts being made, since the WHO Africa regional report on food and nutrition security [3] indicates that hunger has worsened since 2019 in Africa, with almost a third of children stunted in 2020. Côte d'Ivoire, a West African country, is no exception to this trend, as according to the summary study carried out by the National Multisectoral Nutrition Plan, the prevalence of child malnutrition, mainly protein-energy malnutrition, is 22.4% on average throughout the country [4]. This chronic malnutrition, linked to a situation of food insecurity, is mainly dependent on a diet of limited quality, quantity and diversity, due to the great poverty of the population, especially in rural areas [5, 6].

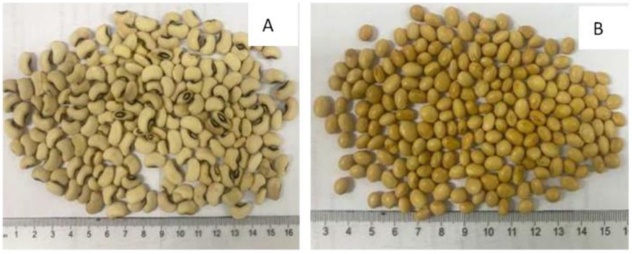
Nutritious foods such as animal protein sources (meat, eggs, milk), essential for a balanced meal, are beyond the financial reach of these populations. To find a sustainable solution to this problem of chronic malnutrition, we recommend adopting a strategy of diversifying food sources, giving priority to local foods based on their availability and accessibility to all segments of the population [7]. It is in this respect that legumes could represent an opportunity in the establishment of nutritionally, organoleptically and culturally adequate diets. Indeed, legumes, which are one of the essential components of the human diet, have a higher protein content than most plant-based foods [8]. This richness makes these plants excellent high-quality protein sources, as they contain all the essential amino acids [9]. What's more, they are grown locally, notably white beans or cowpeas (*Vigna unguiculata*), and could therefore provide a sustainable alternative to conventional animal protein sources by being transformed into "plant meat", like tofu produced from soy proteins. This type of meat, derived from plant proteins of almost identical nutritional quality to its animal counterpart, could provide populations with new sources of protein at lower cost.

Today's ready-to-use or ready-to-cook meat substitutes are mainly based on wheat and, above all, soy, due to their relatively high-quality amino acid profiles. In fact, soy-based foods are known for their high protein content, and their consumption has been shown to bring specific health benefits [10]. *Tofu* (soybean curd) is one of the main food products made from soy protein. However, like soya, many local legumes such as cowpeas and white beans are under-exploited in terms of their potential for processing into 'vegetable meat'. It therefore seems important to consider processing these local legumes into vegetable meat as an alternative to the more expensive animal meats. It is in this context that this work was initiated, with the objective of contributing to the reduction of infant malnutrition through the valorization of *tofu*-type 'vegetable meats' derived from local legumes (cowpea).

2. Materials and Methods

2.1. Plant Material

Plant material used in the present study consisted of cowpea (*Vigna Unguiculata*) and soybean (*Glycine max*) seeds purchased at the Adjamé forum market (5°29′17″ North, 4°01′56″ West) (Figure 1). These seeds were purchased at the large market in Adjamé from two wholesalers and transported to the Laboratoire of Biotechnologies of the Université Felix Houphouët-Boigny for the work. A quantity of 4 kg of seeds from each legume was used to prepare the vegetable meats.



Legend: A: cowpea (*Vigna unguiculata*), B: soybean (*Glysine max*)

Figure 1. *Photograph of seeds from the two studied legume.*

2.2. Prepartion of *Tofu*-type 'Vegetable Meat' by Coagulation

2.2.1. Preparation of Milk from the Studied Legumes (Cowpea and Soybeans)

A 250 g mass of legume seeds (Cowpea and Soybean) were cleaned (sorted by hand to remove impurities and defective seeds, washed two or three times with tap water) and soaked overnight. After soaking, the seeds were collected and left to drain for three (3) min. The drained seeds were then depelleted. The cotyledons obtained were finely ground using an electric mixer with water for three (3) min. The crushed material was filtered through a clean muslin cloth. The milk obtained was used to prepare the vegetable meat (Figure 2).

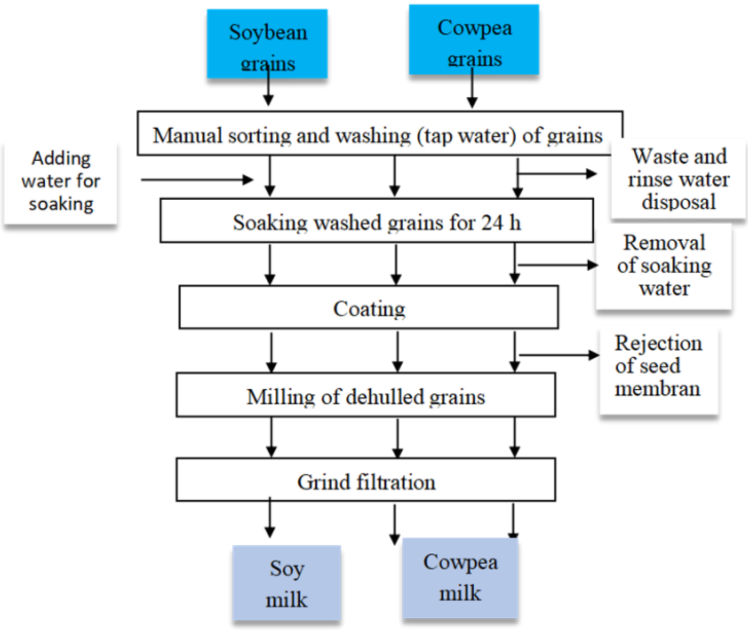
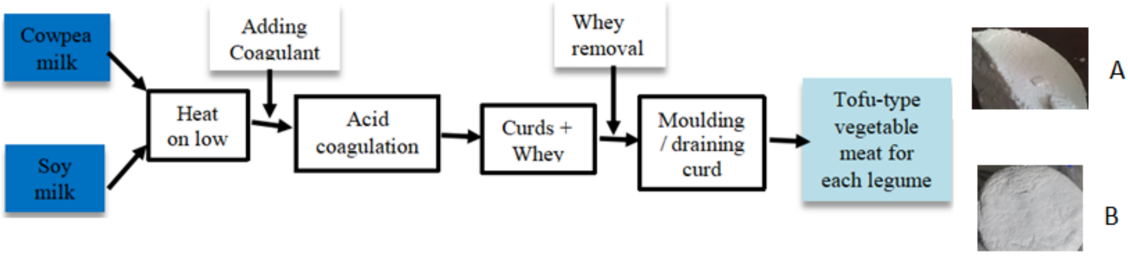


Figure 2. *Flow chart of the legume milk preparation process.*

2.2.2. Milk Cooking and Coagulation of Legume Protein Extracts

The milk obtained was poured into a stainless steel saucepan and heated over low heat for around 30 à45 minutes until the mixture simmered. Acid coagulant was then added to the mixture and the whole was homogenized. Once the protein clots had formed, they were filtered after cooling and shaped in a press mold to remove the water (Figure 3).



Legend: A: tofu-type vegetable meat from cowpea; B: tofu-type vegetable meat from soybeans

Figure 3. *Flowchart of the process for preparing tofu-type vegetable meat from legume milk.*

2.3. Yield Determination of *Tofu*-type 'Vegetable Meats' Production

The *tofu* yield was calculated on the basis of the mass of vegetable meat obtained from 250 g of the seeds of different types of legumes and expressed in weight of tofu or vegetable meat (g/100 g raw legumes) [11]. Yield is calculated according to the following formula (1):

$$R\ (\%) = \frac{M1}{M0} \text{ X } 100 \qquad (1)$$

R%: Extract yield expressed in g/100g of dry matter.

M1 (g): Quantity of *Tofu*-type 'vegetable meat' recovered

M0 (g): Quantity of biological material used for extraction

2.4. pH Determination of *Tofu*-type 'Vegetable Meats'

The pH was determined according to the [12] method. One (1) g of sample was diluted in ten (10) mL of distilled water. The resulting solution was filtered through Whatman filter paper. The pH was measured directly by dipping the electrode of a calibrated pH meter (HANNA) into the filtrate obtained.

2.5. Moisture Content of *Tofu*-type 'Vegetable Meats'

Moisture content was determined according to the [12] method by drying at 105 ℃ to constant mass. Crucibles were pre-dried, then cooled in a desiccator. A 5 g sample was placed in an oven at 105 ℃, cooled in a desiccator for 30 minutes and the mass of the crucible containing the dried sample determined. Moisture (% H) and dry matter (% DM) were calculated according to the following equation (2):

$$\text{H (\%)} = \frac{(M_1 - M_2)}{M_e} \times 100 \qquad (2)$$

With:

Me: mass (g) of fresh sample.

M_1: mass (g) of (crucible + fresh sample) before steaming.

M_2: mass (g) of crucible + dried sample after steaming.

2.6. Proximate Composition Determination of *Tofu*-type 'Vegetable Meats'

The proximate composition of the *tofu* like 'vegetable meat' was evaluated by the analysis of ash content in the dry method by incinerating in a furnace at 550 ℃, crude fat content by continuous extraction in a Soxhlet apparatus for 8 h using hexane as solvent, crude protein (N×6.25) content by Kjeldahl method and Total fiber content in triplicate according to the Standard method described by the Association of Official Analytical Chemists procedures [12]. Total carbohydrate content of foods was calculated by difference according to the method recommended by [6].

The energy value of these vegetables meat samples was calculated on the basis of the energy coefficients defined by [6] according to the following formula (3):

$$\text{EV (kcal/100 g)} = 4{*}\text{C (\%)} + 9{*}\text{L (\%)} + 4{*}\text{P (\%)} \qquad (3)$$

With EV, C, L and P refer to the energy value, carbohydrate, lipid and protein contents respectively.

2.7 Amino Acid Determination of *Tofu*-type 'Vegetable Meats'

2.7.1. Amino Acid Profil Determination

Amino acid levels in 'vegetable meat' samples were determined according to the method described by [13]. For amino acid extraction, 4 g of vegetable meat was dissolved in 20 mL sodium citrate (0.2 N, pH 2.3) and diluted in 10 mL hydrochloric acid (6 N) after 25 min stirring at room temperature. The mixture was heated to 110 ℃ for 24 h, then the acid evaporated. The sample was dissolved in 10 mL ethanol (70%) and filtered to 0.45 µm. An aliquot of 20 µL was injected into an HPLC (Waters Alliance e2695). Separation was performed with two Lichrospher 100 RP18 columns, and detection carried out by spectrofluorimetry (Excitation 340 nm; Emission 450 nm). Elution was carried out with two eluents, A (sodium acetate, distilled water, triethylamine, tetrahydrofuran) and B (sodium acetate, distilled water, acetonitrile, methanol). Concentrations were determined by chromatogram and expressed in mg/100 g.

2.7.2. Essential Amino Acid Index Evaluation

The EAAI was calculated using formula (4) described by [14].

$$\text{EAAI (\%)}=100{*}\ \sqrt[n]{(100a * 100b.....100h)/\ (av * bv.....100h)} \qquad (4)$$

Where n is the number of essential amino acids: a, b,....., h are the concentrations of the essential amino acids (his, iso, leu, lys, met, phe, threo, val) in the the vegetable meat sample, and av, bv, cv,...hv are the concentrations of the essential amino acids (%) in standard protein (casein).

Biological value evaluation

The biological value was calculated using formula (5) described by [14]

$$\text{BV (\%)} = 1{,}09 * \text{EAAI} - 11{,}7 \qquad (5)$$

2.8. Antinutrient Factors Determination in *Tofu*-type 'Vegetable Meats'

2.8.1. Oxalate Determination

Oxalates content was determined by the methods descibed by [15]. Two (2) g of vegetable meat sample (MS) were weighed and placed in a beaker containing 25 mL sulfuric acid (3M). The mixture was stirred for one hour, then filtered through Whatman paper. The filtrate obtained was titrated under heat with a solution of potassium permanganate (0.05M) until it turned pink (Latta and Eskin, 1980). The amount of oxalates in 100 g of 'vegetable meat' was determined by the following formula (6):

$$\text{Oxalates (mg/100g)} \ = \frac{2{,}2 \times Veq \times 100}{me} \qquad (6)$$

Veq: volume (mL) of $KMnO_4$ poured at equivalence

me: mass (mg) of sample

2.8.2. Tanins Determination

Tanin determination was carried out using the method of [16], in which tannins react with vanillin in a sulfuric medium to form a yellow complex, the intensity of which is proportional to the quantity of tannins. For methanolic extraction, 1 g of 'vegetable meat' was homogenized in 10 mL of 70%

methanol, then centrifuged at 5000 rpm for 10 min. The supernatants were combined and made up to 50 mL with distilled water. Next, 0.5 mL extract was mixed with 2.5 mL vanillin, allowed to stand for 30 min in the dark, and OD measured at 500 nm. Tanin content was determined using a tanic acid standard (2 mg/mL).

2.9. Statistical Analysis

All data were analyzed using one way Analysis of variance (ANOVA). Results were presented as mean ± SD and software Statistica version 7.1 used to assess differences between plant meat variables. In the event of significant differences, Duncan's test was used to rank the means. A significance level (α) of 0.05 was applied: values below 0.05 are significant, while those above are not.

3. Results and Discussion

The development of a new food requires an assessment of its production yield and the nutrients it contains, in order to evaluate its profitability and nutritional quality.

3.1. Production Yield and Physico-chemical Characteristics of *Tofu*-type 'Vegetable Meats'

The results relating to production yield, pH, water content and ash content of samples of vegetable meat produced from cowpea and soybean control are shown in Table 1. These results revealed significant differences (P < 0.05) between the plant meats studied with regard to yield, pH value and water content, in contrast to ash content, for which no significant difference was found.

As far as yield is concerned, both types of 'vegetable meat' showed values above 50% with traditional counterpart V1 (69.54±2.35) made from soybean recording the highest yield (table 1). This production yield of over 50% underlines the performance of the process employed and the advantages of producing this type of 'vegetable meat' from cowpeas.

Table 1. *Production yield, moiture and ash content and pH value of tofu-type 'vegetable meats' from the various legumes studied.*

	Yield (%)	Moisture (%)	Ash (g/100g)	pH
VM_1	57.53±1.57^b	68.77±1.13^a	01.18±0.10^a	04.81±0.01^b
VM_2	69.54 ±2.35^a	55.34±0.55^b	01.00±0.00^a	05.07±0.02^a

High values are in bold and low values are underlined. Values on the same line assigned different alphabetical letters are significantly different according to Duncan's test at the 5% threshold; those assigned the same letter are not. VM_1: 'vegetable meat' from cowpea; VM_2: 'vegetable meat' from soybeans.

In the case of pH, the values of 4.81±0.01 for cowpea vegetable meat and 5.07±0.02 for its usual soybean counterpart reflect the acidic character of these preparations. This is due to the use of vinegar to coagulate protein extracts during the vegetable meat preparation process [17].

The ash content of a food is a valuable indicator of its mineral potential. Thus, the almost similar ash contents of 1.18±0.10 (V1) and 1.00±0.00 (V2) obtained for these two types of vegetable meat reflect their good mineral potential. Ash, mineral constituent of meat, is very important for human health. In fact, these elements are generally involved in the constitution of the body, where they are stored in various parts such as teeth and bones (calcium, phosphate, magnesium) [18]. It would therefore be advisable to draw them from food sources that have them, such as vegetable meats and particularly cowpea meats, in order to avoid mineral deficiencies that can lead to health problems [19, 20].

As concern moisture content, the analysis revealed the existence of a significant difference (p≤ 0.05) between the two vegetable meats with cowpea-derived vegetable meat displaying the highest moisture content compared to its usual soybean-derived counterpart (55.34±0.55). However, it is important to emphasize that these values were found to be lower than the previous study which mentioned that moisture content of regular *tofu* was ranging from 81, 82±0.51 to 82.20±0.09% [21]. Under these conditions, vegetable meats, especially those prepared from niebe, could have a longer shelf life than conventional *tofu*.

3.2. Proximate Composition of *Tofu*-type 'Vegetable Meats'

The proximate composition of the two 'vegetable meat' is shown in the table 2. The results highlight the existence of significant differences (P < 0.05) within these two studied vegetable meats in terms of crude protein, crude lipid, total carbohydrate, crude fiber and energy content (table 2).

Table 2. *Macronutrient and energy content of tofu-type 'vegetable meats' from the studied legumes in 100 g (wet basis).*

	Proteins (g)	Lipids (g)	carbohydrates (g)	Fiber (g)	Energie kcal/100g
VM_1	14.06 ± 1.47^b	05.88 ± 1.41^b	09.32 ± 0.34^a	00.79 ± 0.02^b	146.44 ± 4.65^b
VM_2	20.31 ± 2.55^a	16.26 ± 2.25^a	04.98 ± 0.66^b	01.66 ± 0.00^a	251.55 ± 3.54^a

High values are in bold and low values are underlined. Values on the same line assigned different alphabetical letters are significantly different according to Duncan's test at the 5% threshold; those assigned the same letter are not. VM_1: 'vegetable meat' from cowpea; VM_2: 'vegetable meat' from soybeans.

Protein content is one of the most important nutrients required during children's growth period. Of the two types of vegetable meat studied, the highest protein content (20.31±2.55% on a fresh basis) was observed in traditional soybean vegetable meat, while cowpea vegetable meat showed the lowest value (14.06±1.47%). In any case, these values were well above the range of values (12.08 to 14.00% wet basis) obtained by various researchers for tofu-type vegetable meats based on fermented soybeans [22] and unfermented soybeans [17]. What's more, this protein content was well above the minimum value of 14% specified in the Codex Alimentarius standards for maximum amino acid intake in growth-promoting foods [23]. Thus, these two form of *tofu* like 'vegetable meat' formulation satisfy the protein demands like usual meat. The adequate intake of protein is essential for meeting the growing demand of children especially during this critical stage of growth. It would therefore be wise to recommend the consumption of vegetable meats produced from niebe in view of its protein potential and its availability at lower cost compared with more expensive animal meats [24]. Promoting these plant proteins, especially those derived from cowpea, could help maintain children's well-being insofar as they have the ability, like soy, to lower serum concentrations of total cholesterol and triglycerides, unlike animal proteins [25].

The results about the crude fat content of the differents vegetable meat are shown on table 2. Their analysis revealed that, as previously, vegetable meat from cowpea had the lowest content (5.88 g/100g), in contrast to its traditional counterpart (16.26 g/100g) from the soybean. These values are within the range (10-25%) of value of the dietary requirements for and young children foods, recommended by [26]. Fat is essential for supplying energy in the body, facilitate absorption fat soluble vitamins and provide essential fatty acids indispensable for normal brain development [27].

The results for total dietary fibre are shown in table 2. Also in this respect, vegetable meat from cowpea has the lowest content (0.79±0.02%), in contrast to its traditional counterpart. Furthermore, the contents of both types of vegetable meat are in the range (0.36-1.03%) reported for raw *tofu* [27, 28]. Dietary fiber is considered one of the most important ingredients in the human diet [28] and helps make us full and keeps things moving in the digestive tract [29].

Energy value and carbohydrate content are depicted on table 1. As observed in this table, both types of the studied vegetable meat displayed inverse levels of these parameters. Indeed, 'vegetable meat' from niebe has the highest carbohydrate content (09.32±0.34%) and the lowest energy value (146.44±4.65%), compared with its traditional soy-based counterpart. Energy from diet is recommended to be adequate to meet the physiological requirement of the body. Unfortunately, the values displayed by these vegetable meats are below the recommended values (400-450 Kcal) for children's diets [26]. However, meeting the recommended daily energy requirements depends on the frequency of meals, the quantity of food consumed and the energy density of the food.

3.3. Nutritional Quality of Vegetable Meat Proteins

The development and use of a new nutritious food from available and affordable food products is an approach that is being encouraged as part of efforts to reduce infant morbidity and mortality [30]. The analysis of vegetable meat produced from cowpea allowed to determine, in qualitative and quantitative terms, the adequacy of this vegetable meat with the recommended nutritional requirements of essential amino acids in children.

3.3.1. Amino Acid Profile of Vegetable Meat Proteins

The amino acid profile is essential for assessing the quality of the dietary protein source and also makes it possible to determine the proportion of available amino acids, in particular the essential amino acid content of a protein source, which largely influences the quality of that protein [31].

Table 3 presents the amino acid composition of the studied tofu-type vegetable meat made from sorbeans end cowpae.

Table 3. Amino acid content of tofu-type 'vegetable meats' from the studied legumes (g/100g).

	Amino acids	VM_1	VM_2	RDA%*
EAA	Histidine	03.3 ±0.03^b	05.0 ±0,03^a	01.00
	Isoleucine	08.5 ±0.02^a	08.5 ±0,02^a	02.00
	leucine	08.6 ±0.03^a	08.1 ±0,01^a	03.90
	lysine	08.4 ±0.00^b	10.6 ±0,04^a	03.00
	Methionine	02.0 ±0.04^b	02.6 ±0,03^a	01.50
	Phenylalanine	04.9 ±0.02^b	05.2 ±0,04^a	02.50
	Threonine	03.0 ±0.01^b	08.9 ±0,02^a	01.50
	Tryptophane	08.6 ±0.14^a	07.3 ±0,01^b	-
	Valine	05.5 ±0.00^b	06.8 ±0,01^a	02.60
NEAA	Glutamic acid	04.2 ±0.02^b	07.7 ±0,05^a	
	Arginine	04.4 ±0.02^b	06.2 ±0,02^a	
	Proline	03.3 ±0.01^b	03.0 ±0,01^a	
	Alanine	03.1 ±0.02^b	03.3 ±0,01^a	
	Serine	03.6 ±0.03^b	04.8 ±0,02^a	
	Tyrosine	03.0 ±0.04^b	04.4 ±0,02^a	
	Cysteine	03.1 ±0.01^b	03.5 ±0,02^a	
Total AA (%)		79.90	89.6	-
Total EAA (%)		52.80	63.00	-
Total NEAA (%)		27.10	26.60	

High values are in bold and low values are underlined. Values on the same line assigned different alphabetical letters are significantly different according to Duncan's test at the 5% threshold; those assigned the same letter are not.
VM_1: 'vegetable meat' from cowpea; VM_2: 'vegetable meat' from soybean. *RDA%=recommended dietary allowanced [32].

As concern EAA, the total percentage obtained for the vegetable meat made from cowpea is 52.80% while that of the traditional soy-based meat counterpart is 63.00%. These two legume vegetable meats diplayed higher TEAA than 36% considered for an ideal protein [32]. Among these essential amino acids, leucine and lysine content were higher in both type legume 'vegetable meats' than the recommended dietary requirements [32] while the methionine content was the lowest amino acid in these legume vegetable meats (table 3). This difference in content could be attributed to the initial composition of these essential amino acids in the native legumes used to produce these vegetable meats [31].

Both studied vegetable meats were found to be rich in the other EAA such as valine, phenylalanine, histidine etc. These amino acids has multiples roles including that in protein interactions, repair and tissue growth, cell growth and differenciation [33] and antioxidant defense [34].

Recent evidence has highlighted the dietary essentiality of amino acids traditionally considered non-essential (dispensable). Indeed, there is a lack of in-depth research into the hypothesis that nutritionally non-essential amino acids are adequately synthesized in human beings to meet their basic needs [35].

These amino acids, known as functional amino acids, include aspartic acid, serine, glutamic acid, alanine, proline and glycine, and also play an important role in intestinal integrity [36], immune responses [37] and others.

Among the AANEs, glutamic acid and arginine have the highest content in both types of meat studied (table 3), followed by serine and tyrosine. It should be pointed out that, the difference in amino acid content of the proteins observed in the different vegetable meats could be attribue to the difference in the kind of seed.

3.3.2. Nutritional Quality of 'Vegetable Meat' Proteins

The values for the nutritional quality of the proteins in both vegetable meats derived from legumes are shown in table 4.

Table 4. Protein quality of tofu-type vegetable meats from the studied legumes.

parameters	cowpea-based vegetable meat	soybeans-based vegetable meat
Total amino acids	79.90	89.6
Total EAA	52.80	63.00
Total NEAA	27.1	26.6
Total EAA/Total AA (%)	66.08	70.31
Total NEAA/Total AA	33.92	29.69
EAAI (%)	90.45	95.34
Biological Value (%)	87.09	97.66

Total EAA: total essential amino acids; Total NEAA: total non essential amino acids; Total EAA/Total AA: ratio total essential amino acid on total amino acid; Total NEAA/Total AA: ratio total non essential amino acid on total amino acid; EAAI: essential amino acid index

As shown in Table 4, vegetable meat from cowpea (66.08%) and its counterpart from traditional soybean (70.31%) both showed a high ratio of essential amino acids to total amino acids of over 50%, indicating the dominance of these essential amino acids. In addition, the essential Amino acid values found in the two types of vegetable meats, and in particular in the one from cowpea, were above the reference value of 26% for ideal protein food for children and 11% for adult [38].

The chemical index (EAAI) evaluates the proportion and digestibility of essential amino acids contained in a protein compared to a reference protein. Both types of vegetable meat, especially cowpea with EAAI between 80 and 90%, are considered to be of good nutritional quality [39].

As for the Biological Value, this index expresses the quantity of amino acids in dietary protein (after ingestion) that will be used for protein synthesis in the body. In this respect, the values obtained of 87.09% (vegetable meat from cowpea) and 97.66% (vegetable meat from soybeans) underline once again that these protein-based foods are of good nutritional quality as the obtained values were as high as 70 and up to 100%. Moreover, these high values are indicative of good digestibility and effective utilization of these proteins in the body [39].

3.4. Antinutrient Factors

Legumes, the main ingredients in cowpea and soy-based 'vegetable meat' formulations, naturally contain anti-nutritional factors, notably tanins and oxalates, which limit the bioavailability of minerals [40]. This is of particular concern in young and older children, where the irreversible consequences can lead to deficiencies during their development [41].

Figure 4 depicted the content in these anti-nutrients factors in the different studied 'vegetable meat'.

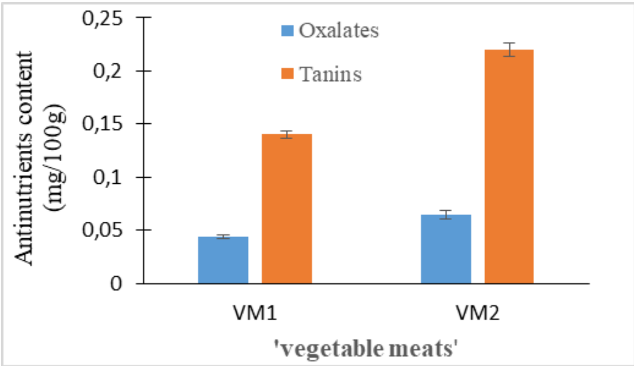


Figure 4. Oxalate and tanin content of tofu-type vegetable meats from studied legumes.

Legend: VM_1: 'vegetable meat' from cowpea; VM_2: 'vegetable meat' from soybeans.

As observed in figure 4, oxalates (0.044±0.00 g/100 g) and tanins (0.14±0.00g/100g) contents registered by the vegetable meat from cowpea are significantly ($p<0.05$) lower than those of traditional counterpart vegetable meats. The low values recorded in the vegetable meat from cowpea are an undeniable advantage, since low contents of these factors improve the digestibility of the feed. In fact, low oxalate levels are a major advantage, as non-complexed bivalent elements will be bioavailable to these children. Similarly, low tanin levels limit the complexation of proteins, carbohydrates and other minerals, making them bioavailable [42]. Thus, the low content of anti-nutritional factors recorded for these vegetable meats, mainly that from cowpea, points to the nutritional quality of the vegetable meats studied [28].

4. Conclusion

This study has highlighted that it is possible to prepare *to-*

fu-type 'vegetable meat' from other types of legumes such as cowpeas with good production yields. This 'vegetable meat', which is of good nutritional quality in terms of protein, lipids, ash and fibre, meets the essential amino acid requirements of the diet. In addition, the low tanin and oxalate content will undoubtedly improve nutritional status and thus help reduce malnutrition. It would therefore be advisable to introduce this 'vegetable meat' into the diet of populations, particularly children.

Abbreviations

VM1	Vegetable Meat from Cowpea
VM2	Vegetable Meat from Soybeans
EAA	Essential Amino Acids
NEAA	Non Essential Amino Acids
RDA	Recommended Dietary Allowanced
EAAI	Essential Amino Acids Index

Acknowledgments

The authors warmly thank the women of the agricultural groups involved in the project (BINKADI and SI-NAINIEKAN) in the Bouna department, for the legumes they provided.

Author Contributions

Ginette Gladys Doue: Conceptualization, Data curation, Funding acquisition, Visualization, Writing – original draft

Lessoy Thierry Zoue: Funding acquisition, Methodology, Validation

Mariame Cisse: Conceptualization, Formal Analysis

Marcelle Tano Nyameke: Resources, Software

Aya Carole Bonny: Conceptualization, Investigation, Validation

Rose-Monde Megnanou: Project administration, Supervision

Funding

This work is supported by FONSTI (Science, Technology and Innovation Fund) for funding this research project. (FONSTI Project N °31).

Data Availability Statement

The data is available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

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Biography

Ginette Gladys Doue was born on May 23, 1970, in Abidjan (Côte d'Ivoire). She is senior lecturer CAMES universities and teacher researcher at Félix Houphouet-Boigny University Côte d'Ivoire since 2015. She has got Ph.D. in Biotechnology with a specialization in Biochemistry and Food Science, obtained with honours since 2014. She has to her credit some twenty publications in peer-reviewed and indexed journals and several communications on various biological materials (cassava, cocoa, shea, plant leaves, etc.), and has also supervised some ten master's theses. She advocates for the valorization of local plant resources in order to promote the food security and health of the population. Dr. Doué is also assistant manager of the UPR of Biotechnology in the Biotechnology, Agriculture, and valorization of Biological Resources laboratory. She is also a member of the Nutrition and Dietetics team.

Rose-Monde Megnanou, a Biochemist, Lecturer at University Félix Houphouët-Boigny, where I got with Honor my phD of Biochemistry/Food Sciences, twelve (12) years ago. I have about forty (40) scientific publications and several communications on various biological material (shea butter, cassava, vegetable-leaves, yellowish sweet patato, etc.), but my main interest concerns shea butter and shea sub-ptoducts. I supported my pHD, on "Shea traditional processes optimisation" and now, I am supervising two pHD, also on Shea butter since 2018. I have also supervised about Twenty Master under various themes. Concerning my skills I can quote for example, my ease about statistical analyses (descriptive statistic, ANOVA, ACP, etc.), microbiology tests (germs numeration and identification), molecular biology techniques (DNA extraction, enzymatic digestion, western blot, etc.) and biophysico-chemical analyses (ordinar analyses, chromatography, spectrometry, etc). I currently use these techniques but I also teach them to students.

Aya Carole Bonny is a researcher in the BIOSCIENCES department at Félix HOUPHOUËT-BOIGNY University in Côte d'Ivoire. She obtained her PhD in Biochemistry-Microbiology in 2016 from the same university, and a master's degree in Food Microbiology from the Unit of Training in Food Science and Technology at Nangui Agrogoua University (formerly Abobo-Adjamé University) in Côte d'Ivoire. Recognized for her contributions within her institution, she has participated in the development of research projects and scientific events of national and international scope. She serves as a member of the technical committee, session chair at national and international conferences.

Mariame Cisse is a Research Lecturer in the Biosciences Training and Research Unit, and more specifically in the Biotechnology, Agriculture and Valorization of Biological Resources Laboratory.She is a specialist in Nutrition and Food Science from the Université Félix Houphouët-Boigny. She develops formulations for children's foods, studies wild fruits and vegetables, has conducted research on non-conventional proteins, and has also studied corn.

Lessoy Thierry Zoue is born 02 on July 1975, Abidjan. Lecturer, Senior Lecturer (CAMES) in Agri-food Biotechnology and Nutrition, Administrative Secretary of the Biology-Environment-Health Doctoral School, Université Félix Houphouët-Boigny, Representative of CAPEC (Cellule d'Analyse des Politiques Economiques du CIRES) on the National Council for Nutrition, Food and Early Childhood (CONNAPE). I've been a lecturer and researcher in Agri-Food Biotechnology at the Université Félix Houphouët-Boigny (UFR Biosciences) since December 2012. I'm currently Maître de Conférences in this specialty, for which I give lectures to students at Master's level.

Marcelle Tano Nyameke was born on 28-02-1998 in Côte d'Ivoire. She is a Ph.D. student at Biosciences Faculty of University Félix Houphouët-Boigny. She has a Master of Biotechnology-Biosafety-Bioresources at the same University precisely in the Laboratory of Biotechnology, Agriculture and Biological Resources. She is in the 1st year of her thesis and works in the team of Dr DOUE Ginette Gladys. Her research work focused on the valorization of legume are centered on the valorization of protein legume of local agroresources. She has participated in Scientific Days, especially at the first scientific days organized at the University of Daloa on the valorization of natural substances of interest.

Research Fields

Ginette Gladys Doue: Food security, Biochemistry, Food Nutrition, Nutrition dietetic, Public health
Lessoy Thierry Zoue: Food security, Biotechnology, Nutrition dietetic
Mariame Cisse: Food process, Nutrition dietetic, Biochemistry
Marcelle Tano Nyameke: Setting local toffu prosses, food safety, Biochemistry, food process
Aya Carole Bony: Biochemistry, Microbiology, Molecular Biology, Food Safety, Microbiological Risk Assessment, OneHealth approach
Rose-Monde Megnanou: Food safety, Oilseeds processing technology, Public health, Diabetes, Preventive medecine