Research, Society and Development, v. 11, n. 11, e145111133307, 2022
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v11i11.33307

Development of a prototype of a food supplement enriched with selenium based on fibers from the peel and pulp of *Dipteryx alata* Vogel (Baru)

Desenvolvimento de um protótipo de suplemento alimentar enriquecido com selênio a base de Fibras da casca e polpa de *Dipteryx alata* Vogel (Baru)

Desarrollo de un prototipo de complemento alimenticio enriquecido con selenio a base de fibras de la cáscara y pulpa de Dipteryx alata Vogel (Baru)

Received: 07/23/2022 | Reviewed: 08/08/2022 | Accept: 08/09/2022 | Published: 08/18/2022

Cláudia Maria Barbosa Santos
ORCID: https://orcid.org/0000-0003-0986-3235
Federal University of Goiás, Brazil
E-mail: claudiamariabs@gmail.com
Meriane Lourdes Paiva de Brandão
ORCID: https://orcid.org/0000-0003-3308-8208
Federal University of Goiás, Brazil
E-mail: merianebbrandao@gmail.com
Andressa Tuane Santana Paz
ORCID: https://orcid.org/0000-0002-2754-7474
Federal University of Goiás, Brazil
E-mail: andressa.santanapaz@gmail.com
Camila Aline Romano
ORCID: https://orcid.org/0000-0002-3564-6368
Federal University of Goiás, Brazil
E-mail: camilaalineromano@gmail.com
Talita Gonçalves Silva
ORCID: https://orcid.org/0000-0003-1891-8912
Federal University of Goiás, Brazil
E-mail: biomedtalitagon@gmail.com
Raquel de Andrade Cardoso Santiago
ORCID: https://orcid.org/0000-0002-6894-2008
Federal University of Goiás, Brazil
E-mail: racsantiago@gmail.com
Tatiana de Sousa Fiuza
ORCID: https://orcid.org/0000-0003-0135-177X
Federal University of Goiás, Brazil
E-mail: tatianaanatomia@gmail.com
Edemilson Cardoso da Conceição
ORCID: https://orcid.org/0000-0003-4113-2686
Federal University of Goiás, Brazil
E-mail: edemilson_conceicao@ufg.br

Abstract

Dipteryx alata, popularly known as “baruzeiro” is a typical plant from the Cerrado Biome, with nutritional potential of the peel and pulp little explored. The *D. alata* fruit, named “baru”, has a fibrous pulp, which can provide a reduction in food consumption by increasing the power of satiety and consequent reduction in the waist-hip ratio, controlling arterial hypertension and improving intestinal functioning.It is known that baru has a fibrous pulp, and despite the benefits that it can provide such as, reduced food consumption by increasing satiety power and consequent reduction in waist-hip ratio, control of arterial hypertension and improvement of intestinal functioning. A large part of the population has a fiber intake lower than recommended. In addition to fiber, another important nutrient for health is selenium, given its association with changes or malfunction of the digestive tract. The aim of this study was to develop a prototype of a food supplement in sachets, made from the bark and pulp of *D. alata*, which meets the daily nutritional needs of fiber and selenium. The microbiological quality, centesimal composition, evaluation of the accelerated stability study of baru peel and pulp powder and the supplement prototype were evaluated. The raw material was adequate to the quality parameters. The prototype of the supplement remained stable, in relation to the microbiological profile, humidity, fibers, selenium and other parameters. Two sachets with 30 g of supplement provide an energy value of 67.40 kcal, 1.56 g of protein, 0.82 g of lipids, 13.44 g of carbohydrates, 9.42 g of fiber, 200.22 µg of selenium, and other micronutrients. The formulation elaborated was able to meet the recommendations

for dietary supplements in relation to dietary fiber and selenium, and can be used for other food purposes, and also promote the use of products or by-products of Cerrado fruits.
Keywords: Food reuse; Fruits of the Cerrado; Immune system.

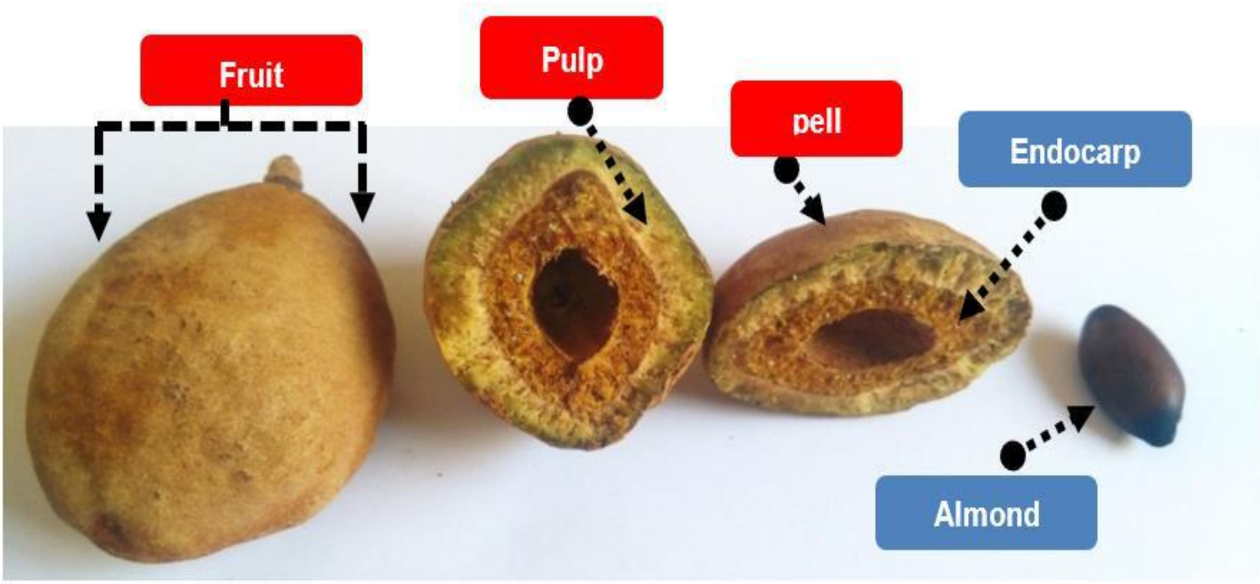
Resumo
Dipteryx alata, popularmente conhecido como “baruzeiro” é uma planta típica do Bioma Cerrado, com potencial nutricional da casca e polpa pouco explorado. O fruto *D. alata*, denominado “baru”, possui polpa fibrosa, que pode proporcionar redução no consumo alimentar aumentando o poder de saciedade e consequente redução da relação cintura-quadril, controlando a hipertensão arterial e melhorando o funcionamento intestinal. Sabe-se que o baru possui polpa fibrosa, e apesar dos benefícios que pode proporcionar como, redução do consumo alimentar pelo aumento do poder de saciedade e consequente redução da relação cintura-quadril, controle da hipertensão arterial e melhora do funcionamento intestinal. Grande parte da população tem ingestão de fibras abaixo do recomendado. Além da fibra, outro nutriente importante para a saúde é o selênio, dada a sua associação com alterações ou mau funcionamento do trato digestivo. O objetivo deste estudo foi desenvolver um protótipo de suplemento alimentar em sachês, elaborado a partir da casca e polpa de *D. alata*, que atenda às necessidades nutricionais diárias de fibra e selênio. Foram avaliados a qualidade microbiológica, composição centesimal, avaliação do estudo de estabilidade acelerada da casca e polpa de baru e o protótipo do suplemento. A matéria-prima estava adequada aos parâmetros de qualidade. O protótipo do suplemento se manteve estável, em relação ao perfil microbiológico, umidade, fibras, selênio e outros parâmetros. Dois sachês com 30 g de suplemento fornecem valor energético de 67,40 kcal, 1,56 g de proteína, 0,82 g de lipídios, 13,44 g de carboidratos, 9,42 g de fibra, 200,22 µg de selênio e outros micronutrientes. A formulação elaborada foi capaz de atender as recomendações para suplementos alimentares em relação à fibra alimentar e ao selênio, podendo ser utilizada para outros fins alimentícios, e ainda promover o aproveitamento de produtos ou subprodutos de frutos do Cerrado.
Palavras-chave: Reaproveitamento de alimentos; Frutos do Cerrado; Sistema imunológico.

Resumen
Dipteryx alata, conocida popularmente como “baruzeiro”, es una planta típica del Bioma Cerrado, con potencial nutricional de la cáscara y pulpa poco explorado. El fruto de *D. alata*, denominado “baru”, tiene una pulpa fibrosa, que puede proporcionar una reducción en el consumo de alimentos aumentando el poder de saciedad y consecuente reducción de la relación cintura-cadera, controlando la hipertensión arterial y mejorando el funcionamiento intestinal. Se sabe que el baru tiene una pulpa fibrosa, y a pesar de los beneficios que puede proporcionar, como la reducción del consumo de alimentos al aumentar el poder de saciedad y la consiguiente reducción de la relación cintura-cadera, el control de la hipertensión arterial y la mejora del funcionamiento intestinal. Gran parte de la población tiene un consumo de fibra inferior al recomendado. Además de la fibra, otro nutriente importante para la salud es el selenio, dada su asociación con alteraciones o mal funcionamiento del aparato digestivo. El objetivo de este estudio fue desarrollar un prototipo de complemento alimenticio en sobres, elaborado a partir de la corteza y pulpa de *D. alata*, que cubra las necesidades nutricionales diarias de fibra y selenio. Se evaluó la calidad microbiológica, composición centesimal, evaluación del estudio de estabilidad acelerada del polvo de cáscara y pulpa de barú y el suplemento prototipo. La materia prima fue adecuada a los parámetros de calidad. El prototipo del suplemento se mantuvo estable, en relación al perfil microbiológico, humedad, fibras, selenio y otros parámetros. Dos sobres con 30 g de suplemento aportan un valor energético de 67,40 kcal, 1,56 g de proteínas, 0,82 g de lípidos, 13,44 g de hidratos de carbono, 9,42 g de fibra, 200,22 µg de selenio y otros micronutrientes. La formulación elaborada pudo cumplir con las recomendaciones para suplementos dietéticos en relación con la fibra dietética y el selenio, y puede ser utilizada para otros fines alimentarios, y también promover el uso de productos o subproductos de frutas del Cerrado.
Palabras clave: Reutilización de alimentos; Frutos del Cerrado; Sistema inmunológico.

1. Introduction

Dipteryx alata Vogel (Papilionoideae), popularly known as “baruzeiro” (Figure 1) (*Dipteryx alata* Vogel), is a tree species typical of the Cerrado Biome, which occurs in fertile soils of the forest, cerradão and cerrado (Rocha *et al*., 2021; Vera *et al*., 2009). The *D. alata* fruit, named “baru”, has a fibrous pulp (Figure 1). Baru peel and pulp flour can replace part of the calories provided by conventional flours. The nutritional quality and health benefits of baru peel and pulp are poorly explored. Baru peel and pulp can be used in bread making and improve nutritional and sensory characteristics, with a low total fat content (Rocha & Santiago, 2009). Biscuits containing baru pulp flour in their formulation had a high content of total fiber (26.4%), high content of sugar (30.3% sucrose, 22.8% fructose and 6.7% glucose) (Freitas *et al.*, 2014). The preparation of cupcakes with flour prepared with peel and pulp resulted in greater acceptability and higher levels of moisture, minerals, fiber and reduced carbohydrates and calories (Marcelino *et al.*, 2018).

Figure 1. *Dipteryx alata* fuits obtained in Jussara-GO. Whole fruit and cuts showing bark, pulp, endocarp and almond.



Source: Authors.

The baru has fibrous pulp is edible to the natural (Vera *et al.*, 2009) and used in food preparation. The recommendation of daily dietary fiber intake in the diet are around 14 g of fibers per 1000 kcal ingested (IOM, 2005) or 25 g/day for women and 38 g/day for men, aged 19 to 50 years (WHO/FAO, 2003). According IBGE (2011), the percentage of the population with fiber intake less than or equal to 12.5 g per 1000 kcal was 68%. Food fibers decreases the time of the intestinal transit and increases the fecal cake, are fermented by bacterial microbiota, lowers LDL-cholesterol levels; reduces plasma glucose and insulin levels (CODEX, 2010). The increase in total fiber or insoluble fiber intake of 5 g/day contributes to a decrease in overweight, high waist-hip ratio and hypertension (Lairon *et al.*, 2005).

According Anderson (2008) the supplementation of 7.5 g/day of insoluble fiber showed a reduction in body weight of 1.7 kg (placebo group) and 3.0 kg (intervention group), at 8 weeks the reduction was 2.4 kg (group placebo) and 4.9 kg (intervention group). In addition to fiber, another important nutrient for health is selenium, whose biological functions are achieved by 25 selenoproteins (selenium compounds) that have selenocysteine in its active center. Among the functions of selenium are the antioxidant and anti-inflammatory action (Rayman, 2012) and the capacity of modulation and its importance for the digestive tract can be highlighted. Selenium levels affect immune responses in the intestine (Zhai *et al.*, 2018) and their deficiency may be related to alterations or malfunctioning of the digestive tract and may lead to selenium deficiency (Navarro-Alarcón & López-Martínez, 2000). The intestinal microbiota is also linked to the health of humans and animals by affecting many metabolic processes of the host, including mineral metabolism (Skrypnik & Suliburska, 2017). Changes in the contribution of this oligoelement can modulate the composition of the intestinal microbiota (Stolz *et al*., 2006).

However, the recommended dietary allowance (RDA) of selenium for individuals between the ages of 19 and 70 is 55 µg/day (IOM, 2000). Selenium supplementation at daily doses of 100-200 micrograms above RDA is necessary to prevent genetic damage and cancer development, so the use of a mixture composed of selenium, vitamins and minerals is a promising approach (El-Bayoumy, 2001). Supplementation even in individuals with recommended levels of selenium has pronounced immunostimulatory effects including increased T cell proliferation and natural killer cell activity (Wu *et al*., 2021; Rayman, 2000) and may provide a significant contribution to potential neuroprotective effects in stroke AVC; increases the activity of antioxidant enzymes, reducing the production of reactive oxygen species (ROS) and oxidative damage to macromolecules (Skalny *et al*., 2018).

The possibility of conservation of natural resources associated with the use of products or by-products of the Cerrado biome and the search for new sources and utilities of nutrients justify research using fruits in the formulation of supplements. Baru is used in many food products, but the bark and pulp are usually discarded. The use of the bark and pulp of baru, parts of the fruit that are normally considered non-consumable, makes it possible to use the fruit in the preparation of foodstuffs for food supplementation, which can contribute to cost reduction and waste generated for the environment. The aim of this study was to develop a prototype of a food supplement in sachets, made from the bark and pulp of *D. alata*, which meets the daily nutritional needs of fiber and selenium.

2. Methodology

2.1 Plant material

The fruits of *Dipteryx alata* Vogel, named baru, were supplied by Flora do Cerrado, Jussara, Goiás. They were sanitized with sodium hypochlorite solution (2.5%, 200ppm) for 15 minutes. To facilitate removal of the peel and pulp the fruits were immersed in water for 24 hours. The despolpa was done manually, with the aid of knives and vegetable cutters. After this step, the sample was taken to oven drying with forced air circulation at 60 °C and crushed in an industrial blender (Skymsen LS-10MB-N®) to the powder form.

2.2 Centesimal composition of the powder from baru peel and pulp

The determination of the iron, copper, calcium, magnesium, zinc, manganese, phosphorus, sodium, selenium and potassium minerals was performed by the flame atomic absorption spectrometry (FAAS) method in a representative sample of the food (AOAC, 1984). The determination of the water content (moisture) was performed by drying the sample in an oven at 105 ° C until constant weight, as described by the Instituto Adolfo Lutz (IAL, 2008). The ash content determination was performed according to the Brazilian Pharmacopoeia 5th edition (Brazil, 2010). Total lipids were determined by the technique described by Bligh & Dyer (1959). The protein content was determined by the Kjeldahl method for total nitrogen, using the factor of 6.25 to transform the number of g of nitrogen found in number of g of proteins according to AOAC (1984). The total dietary fiber content was determined by the gravimetric enzymatic method in a dry sample, following the techniques proposed by the Association of Official Analytical Chemists (AOAC, 2005). The carbohydrate fraction was obtained by the difference between 100 and the sum of the percentages obtained with the analyses of moisture, ash, proteins, lipids and total dietary fiber (IAL, 2008). In order to determine the total energy value (VET), the calculations were performed according to the amount of macronutrients obtained in the analyses, considering Atwater conversion factors of 4, 4 and 9 kcal/g for protein, carbohydrate and lipid respectively (Greefield; Southgate, 2003).

2.3 Evaluation of the accelerated stability of the powder from peel, pulp and of the sachet supplement prototype (Step 3 and 5)

Stability evaluation was performed in two types of dry samples in 15g sachets (Tepron) used for supplements: one containing baru peel and pulp (140 sachets with 10 g each) and one containing the preformulation of the prototype of the supplement (140 sachets with the prototype of 12.50 g each, 10 g of peel and pulp powder plus 2.50 g of the excipients). The samples were stored in a climatic chamber (Solab®, Series 206) under a temperature of 40ºC at 75% relative humidity for 45 days. Analyses were performed on the 1st day (T0), 15 days (T1), 30 days (T2) and 45 days (T3).

The evaluation of microbiological stability was performed according to a technique described by the American Public Health Association (APHA, 2015) and the microbiological standards recommended by Resolution RDC No. 12/ANVISA/MS, of January 2, 2001 (Brazil, 2001). Antimicrobial analyses of coliforms at 45 ° C and *Salmonella* sp/25 g were performed for peel and pulp powder, and of coliforms at 45 °C, *Salmonella* sp/25 g, Coagulase positive Staphylococci/g and *Bacillus cereus*/g were performed for the supplement prototype. The contents of proteins, lipids, selenium, moisture contents and ash were determined in each sachet according to the methodologies described above. Furthermore, the determinations of dietary fiber (FA), insoluble dietary fiber (FAI) and soluble dietary fiber (FAS) were used as recommended by the Association of Official Analytical Chemistis (AOAC, 2005) for peel and pulp powder and to the prototype of the supplement.

2.4 Formulation of the prototype of the fiber-based supplement from peel and pulp baru enriched with selenium in sachets

The peel and pulp baru powder and the prototype formulation of the supplement were produced in Pharmaceutical Art Pharmacy Manipulation, in Inhumas, Goiás, by the researchers themselves with technical assistance from the responsible pharmacistfollowed the protocol established by RDC N°. 239 of July 26, 2018.

The components used to elaborate the prototype of the formulation were peel and pulp baru powder r, benzoic acid (Neon®), vitamin E (Purifarma®), disodium EDTA (Fagron®), chelated selenium (Pharma Nostra®) and xylitol (Infinity Pharma®). In order to improve dissolution, effervescent base (Infinity Pharma) was added. The formulation was weighed in analytical balance and reached the total weight 12.5 g, distributed in sachets with a capacity of 15 g and sealed by a sealer.

2.5 Statistical analysis

For analysis of the data obtained with the stability evaluation of the peel and pulp and the prototype of the supplement, analysis of variance (ANOVA) and Tukey's test for comparison of averages at a significance level of 5% were used the Past software version 2.17c.

3. Results and Discussion

3.1 Determination of minerals from the peel anp pulp baru powder

The results obtained from minerals in 100 g (Table 1) of the powder containing peel and pulp of baru qualify it as suitable to supplement a diet, if it is used in food or in the preparation of these, as for example in the manufacture of baked goods (breads, cakes, etc.). It is recommended to include more than 100 g of peel and pulp powder. However, in lower amounts to supplement the diet or nutritional deficiencies most of the elements would not reach the recommended minimum values as for sachets with approximately 15g, for example.

(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v11i11.33307

Table 1. Mineral composition of peel and pulp baru in 15 and 100 g and comparison with minimum and maximum limits of nutrients that should be provided by dietary supplements in the daily recommendation of consumption for population groups ≥ 19 years of age.

Mineral	Value determined in 15g	Value determined in 100g	* Normative Instruction n° 28, 26/06/2018 Minimum - Maximum Limits (19-50 years old)
Calcium (mg)	12.102	80.68	30 – 2.516.59
Copper (µg)	72.45	483	135 – 8.975.52
Iron (mg)	0.4902	3.268	0.04 – 39.73
Phosphormg)	0.009	0.06	69 – 3.123.51
Magnesium (mg)	4.9335	32.89	12 – 350
Manganese (mg)	0.14265	0.951	0.35 – 1.66
Potassium (mg)	105.73395	704.893	**NC
Selenium (µg)	0.000165	0.0011	2.25-320.20
Sodium (mg)	3.2955	21.97	**NC
Zinc (mg)	0.11205	0.747	0.33 – 29.59

* Source: Brasil. National Health Surveillance Agency. Normative Instruction No 28, of July 26, 2018. It establishes lists of constituents, limits of use, claims and supplementary labeling of food supplements. ** NC = There is no reference of the element in Normative Instruction No. 28/2018.

The data on the mineral composition in peel and pulp baru are scarce in the scientific literature. Almeida et al. (1987) verified the presence of potassium (572 mg), copper (3.54 mg) and iron (5.35 mg/100 mg), different values from those found for these elements in this research. The availability of nutrients in the soil can influence the chemical composition of the fruit. The differential nutrient accumulation varies according to the stage of maturity, level and availability of nutrients in soil, climate, cultivar and cropping system (Oliveira *et al*., 2012), which may explain the differences between the results found.

The selenium value found, 0.000165 µg (corresponding to a sachet of 15 g), did not present significant results to contemplate the daily recommendation for food supplements (2.25-320.20 µg) from the baru powder. However, because it is an important antioxidant and has important properties, such as reducing the risk of non-transmissible chronic diseases and increasing the resistance of the immune system (Cominetti & Cozzolino, 2009), among other activities; this was added in the formulation.

3.2 Accelerated stability evaluation of packaged powder and baru supplement prototype

By means of the microbiological analyzes of the packaged powder and the prototype of the baru supplement, <10 CFU (colony forming unit) was detected for Coliforms at 45 ° C/g and absence of *Salmonella* sp. In the prototype of the supplement, Staphylococcus coagulus positive/g and Bacillus cereus / g were also analyzed and detected <100 CFU, which is in accordance with the standards established by Resolution RDC no. 12 of the National Health Surveillance Agency (ANVISA) of the Ministry of Health of January 2, 2001. This result confirms that the sanitation procedures and manipulation of the raw material and equipment used were adequate to guarantee the microbiological quality of the sample and formulation of the supplement under a temperature of 40 ° C and 75% humidity in the 0 to 45 days' time (Table 2).

In food preparation and processing, bacteria are the most important and problematic of all microorganisms (USDA, 2012) and are associated with foodborne illness. Data from the epidemiological profile in Brazil from 2000 to 2017 show that these microorganisms constituted the etiological agent responsible for 97.6% of outbreaks of foodborne diseases (DTA). *Salmonella* sp. (35%), *Escherichia coli* (28.2%), *Staphylococcus aureus* (18.2%), Coliforms (6.8%), *Bacillus cereus* (6.0%), *Shigella* sp. are among the main ones. A total of 12,660 outbreaks were reported involving 239,164 patients resulting in 186 deaths.

In 2017 alone, 598 outbreaks were reported, with 9,320 patients and 12 deaths (Brasil, 2018), and for all the risk that the microorganism represents to human health, it is important to control the quality of these microorganisms in the various stages of the production of food supplements.

3.3 Centesimal and nutritional composition of bark and pulp powder (raw material), accelerated stability evaluation of packaged powder and the prototype of the supplement (Table 2).

Table 2. Results found in baru pulp and pulp powder, in the evaluation of accelerated stability of peel and pulp baru and prototype of the sachet supplement.

Parameters analyzed [2] (g/100g)	Peel and pulp powder	Peel and pulp powder stability evaluation			
		$T_{0\ days}$	$T_{15\ days}$	$T_{30\ days}$	$T_{45\ days}$
Moisture	4,67 ±0,30^{a}	4,69±0,14^{b}	4,52±0,10^{c}	4,44±0,02^{d}	4,91±0,05^{e,c,d}
Ashes	2,42±0,05^{a}	2,77±0,08^{b,a}	2,70±0,04^{c,a}	2,86±0,08^{d,a}	2,82±0,05^{e,a}
Proteins	5,23±0,28^{a}	5,81±0,15^{b,a}	4,92±0,04^{c,a}	5,19±0,03^{d,a}	5,38±0,07^{e}
Lipids	2,73±0,08^{a}	2,54±0,06^{b}	2,81±0,07^{c}	2,50±0,11^{d,c}	2,63±0,04^{e}
Total fibers	31,4±0,04^{a}	33,7±0,40^{b,a}	34,5±0,01^{c,a}	34,8±0,45^{d,a,b}	33,6±0,53^{e,a,d}
Carbohydrates	44,8±0,22^{a}	50,4±0,22^{b,a}	50,5±0,14^{c,a}	50,1±0,30^{d,a}	50,6±0,48^{e,a}
VET (kcal/100g)	224,9±0,97^{a}	247,8±0,95^{b,a}	247±0,19^{c,a}	243,8±1,88^{d,a}	247±2,50^{e,a}
Selenium (µg/10 g)	0,11^{a}	0,06^{a}	0,12^{a}	0,04^{a}	0,14^{a}
Parameters analyzed [2]	Prototype stability assessment				
	$T_{0\ day}$	$T_{15\ days}$	$T_{30\ days}$	$T_{45\ days}$	
Moisture	4.45±0.20^{a}	4.23±0.02^{a}	4.16±0.08^{a}	4.16±0.08^{a}	
Ashes	2.91±0.01^{a}	2.82±0.03$^{b.a}$	2.92±0.01$^{c.b}$	2.92±0.09$^{d.b}$	
Proteins	4.55±0.12^{a}	4.70±0.11^{b}	4.15±0.04$^{c.a.b}$	4.15±0.04$^{d.a,b}$	
lipids	2.56±0.09^{a}	2.53±0.03^{a}	2.60±0.03^{a}	2.43±0.04^{a}	
Total fibers	27.9±0.15^{a}	28.3±0.07^{a}	28.8±0.29^{a}	28.8±0.29^{a}	
Insoluble fibers	27.9±0.15^{a}	28.1±0.01^{a}	28.2±0.44^{a}	28.2±0.44^{a}	
Soluble fibers	0.03±0.04^{a}	0.20±0.07^{b}	0.65±0.10$^{c.a,b}$	0.65±0.10^{d,a,b}	
Carbohydrates	57.2±0.22^{a}	57.2±0.08^{a}	57.2±0.28^{a}	57.4±0.30^{a}	
VET (kcal/100g)	271.3±0.55^{a}	271.0±0.14^{b}	269.2±0.83^{c}	268.4±0.79$^{d.a,b}$	
Selenium (µg/12,5g)	100.06	100.06^{a}	100.04^{a}	100.04^{a}	

* Climatic Conditions for the stability study: Temperature T = 40 ° C, Relative Humidity: 75%. 1Values are means ± standard deviations of 3 replicates. Means with equal letters, in the same row, do not differ statistically from each other (Tukey test at 5% probability). 2 (VET) Total energy value. Source: Authors.

3.3.1 Water content (humidity)

The moisture content found in the peel and pulp powder was 4.67% and the contents of the powders packed in sachets ranged from 4.44 to 4.91% and the supplement prototype from 4.16 to 4.45%, in the stability assessment for 45 days The values are within the maximum moisture limit of 8 to 14% for peels and 8 to 15% for fruits (Simões *et al*., 2016) and within the maximum limit of 12% humidity allowed by the legislation for dried vegetables or dehydrated (Brazil, 2005). One of the factors that may have contributed to the permanence of humidity below the maximum recommended limit may be due to the packaging of the powder in sachets. This type of packaging can guarantee greater protection and stability to bark pulp and pulp powder, which in the analysed samples is an important parameter from the industrial point of view for the formulation of the prototype.

The results obtained in the evaluation of pulp and bark powder stability showed a slight increase in moisture content from 45 days, which may be indicative of safe powder consumption occurring up to 30 days. However, in the stability evaluation of the prototype the moisture contents tended to be stable (4.16 and 4.16%) in 30 and 45 days, possibly due to the excipients added to the prototype formulation, which guaranteed this stability.

3.3.2 Total Ashes

The ash content found for peel and powder was 2.42%. The contents of the peel and pulp powder in the stability evaluation were between 2.70 and 2.86% and the prototype of 2.82 to 2.92%. The results had few variations, and in the stability evaluation the prototype remained at 2.92% in times of 30 and 45 days. Lima *et al.*, (2010) evaluated the sample consisting of pulp and peel baru found 2.00% of ash, an approximate value for this study.

3.3.3 Total Proteins

The protein content of peeland pulp powder was 5.23 g/100g. The sachets with the peel and pulp presented between 4.92 and 5.81 g/100 g and the samples of the powder in the prototype from 4.15 to 4.70 g/100g. Some authors, when evaluating the pulp andpeel sample, found 4.25 g/100 g (Rocha & Santiago, 2009) and 5.88 g/100 g (Lima *et al*., 2010), respectively, values close to those found in this study.

Although it is an arboreal leguminous, baru has, in its composition centesimal, protein content equivalent or superior to the legumes of popular consumption such as beans (4.8g/100g), peas (4.6g/100g) and string beans 3.17g/100g). Nutritionally, protein behaves like bean protein, characterized by low PER (protein efficacy coefficient), biological value and average values for apparent digestibility, etc. (Togashi, 1993; TACO, 2011).

3.3.4 Lipids

The lipid content of the peel and pulp powder was 2.73%. Samples of peel and pulp powder of baru presented values of 2.50 to 2.81 g / 100g, and the supplement prototype values were 2.43 to 2.60 g / 100g of lipids, close to found by Alves *et al*., (2010) of 2.27%, Santiago *et al*., (2018) of 2.7 g / 100g for peel and 3.7 for barium pulp. The lipid content present in the peel and pulp was not expressive, which may help to reduce the caloric value in the final product. Lipids should contribute 20 to 35% of the total energy of the diet (IOM, 2005).

3.3.5 Food fiber, insoluble food fiber and soluble food fiber

The initial analyses carried out only with samples containing peel and pulp presented around 31.4 g/100 g of total fibers. In the evaluation of stability of the shell and pulp in sachets were found from 33.6 to 34.8 g/100g and from 27.9 to 28.8 g/100g of total fibers in the prototype, with stabilization of 28.8 in 30 to 45 days.

Regarding the insoluble fibers, the analysis showed a predominant concentration of this type of fiber for all the samples. According to Togashi and Sgarbieri (1994) the pulp of baru has high content of insoluble fibers (29,5 g/100g). In the study by Lima et al. (2010) verified 41.6 g/100 g of total fibers, a value slightly above that found. The centesimal composition may suffer variations due to the way of cultivation, the region of cultivation, genetic and environmental variations (Rocha et al., 2009; Vera et al., 2009).The amount of fibers increased from 31.4 g/100 g of total fibers in the sample of peel and pulp powder to approximately 34 g/100 g (in the evaluation of powder stability in sachets). The time elapsed between these analyses was approximately 3 months. In addition, the starch present in the pulp of baru becomes less available to the enzymatic action, increasing the starch content, which influences the composition of the total fibers (Bazzo, 2010; Alves *et al*., 2010). This behavior was also observed in the study by Alves *et al*., (2010), whose initial value was 19.1g/100g and after 136 days of storage the result was 27 g/100g.

In relation to the fibers found in the supplement, the values were around 28 g/100 g, about 6 g/100 below the results observed in the sachets with the peeland pulp baru. This is because in the preparation of the sachet’s formulation excipients and/or additives were added as preservative, sweetener, effervescent base among others, adding the largest proportion of material to be analysed, being this free of fibers (decreasing the ratio of fiber to material analysed). The weight of 10 g of powder for the peel and pulp sample was established in the elaboration of the supplement, but with the excipients added in the formulation, the latter had a final weight of 12.5 g. Therefore, in 100 g of sample of the prototype of the supplement it was possible to find a lower dietary fiber content than the one found in the powder sample containing only bark and pulp. This conclusion is important for the elaboration and planning of the final dosage of the product to meet the needs of the main constituents in the elaboration of supplements, being the determination of total dietary fiber and its soluble and insoluble fractions relevant for the research of food analysis and nutritional labeling (Garcia-Amezquita *et al*., 2018).

3.3.6 Carbohydrates

The carbohydrate content of the peel and pulp was 44.8 g/100 g, while the samples present in the shell and pulp sachets ranged from 50.1 to 50.6 g/100 g and the samples of the shell and pulp of the prototype presented values between 57.2 to 57.4 g/100g. Santiago *et al*., (2018) found 51.5 g/100 g for shell and 57 g/100 g for pulp, and Alves *et al*., (2010) found 54.9 g/100g of total carbohydrates in their study.

3.3.7 Total energy value

The total energetic value (TEV) of peeland pulp sample, considering proteins, lipids and carbohydrates, was 224.9 kcal/100 g, the values of the samples in sachets of pulp and peel were between 243.8 to 247,8 kcal/100g and the prototype of the supplement was 268.4 at 271.30 kcal/100g. Santiago *et al*., (2018) found 240 and 276 kcal/100g (peel and pulp separately). The energy value is calculated based on the values found for proteins, lipids and carbohydrates, and its value is subject to variations of these parameters.

The parameters analysed for the sample of peel and pulp powder, in comparison with the evaluation of the stability of the sachets containing the bark and pulp, differed statistically from each other, except for the results for selenium. Such behavior may be associated with the loss or transformation of the constituents of the fruit during the stability evaluation. In the stability evaluation for bark and bark pulp powder differed statistically from each other, but with small variations. Regarding the prototype of the supplement, parameters such as moisture, lipids, total fibers, insoluble fibers, carbohydrates and selenium did not differ statistically. The remainder also presented small variations, which were not significant. It is observed that there was a trend towards stability of the final values of the analysed parameters. With the exception of lipids, total energy value and carbohydrates (with slight increase), all other parameters stabilized. Selenium remained stable and very close to the established amount of 100μg (proposed value for composing sachets) in the evaluation of accelerated stability (45 days), which shows that it is possible the enrichment of selenium in the prototype of the supplement.

3.4 Elaboration of the prototype formulation of the fiber-based supplement from peel and pulp and addition of selenium

The elaboration of the prototype of the supplement followed that established by RDC No. 239/2018, according to the provisions of Annex 1 of this resolution (Table 3).

Table 3. Formulation of the fiber-based supplement from peel and pulp and selenium pulp.

Component	Weight/sachet	Concentration *
Powder with peel and pulp	15 g	85.682%
Benzoic acid	0.002 g	0.011%
Vitamin E	0.003 g	0.017%
Disodium EDTA	0.0015 g	0.009%
Selenium (chelated)	100 µg	0.001%
Xylitoll	2.0 g	11.424%
Effervescent base	0.5 g	2.856%
Final prototype weight	17.5066 g	100.000%

Source: Brasil (2018). National Health Surveillance Agency. Normative Instruction No 28, of July 26, 2018. It establishes lists of constituents, limits of use, claims and supplementary labelling of food supplements. * Concentration in relation to the total of the formula.

The suggested dosage for the prototype to be considered a fiber and selenium-based supplement would be from 2 sachets/day, which would provide 9.42 g of fiber/day (considering that the peel and pulp powder provides in around 4.71 g of fiber in 15 g). With regard to selenium, 2 sachets / day would provide around 200 µg of selenium. Studies suggest that the best selenium / day intake would be from 100 to 200 µg for better health effects (El-Bayayum, 2001).

The minimum and maximum value to be provided by dietary supplements in the daily recommendation of consumption of individuals aged 19 years and over, for selenium is from 8.25 to 319.75 µg, and of fibers is 5.70 g (no value maximum established) (Brazil, 2018), for this reason, the elaborated formulation supplies the requirement for fibers and selenium constituting a prototype of food supplement.

3.5 Labeling: nutrients that make up the prototype of the food supplement (Table 4)

It was verified that Two sachets with 30 g of supplement provides an energy value of 67.40 kcal, 1.56 g of protein, 0.82 g of lipids, 13.44 g of carbohydrates, 9.42 g of fibers, 200.22 g of selenium, 24.20 mg of calcium, 144.90 µg of copper, 0.98 mg of iron, 0.018 mg of phosphorus, 9.86 mg of magnesium, 0.283 mg of manganese, 211.468 mg of potassium, 6.591 mg of sodium and 0.225 mg of zinc.

(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v11i11.33307

Table 4. Shows the other nutrients that are part of the nutritional composition of the food supplement prototype.

Nutrients	Value found in 100 g of powder	Value found 15 g powder (1 sachet)	Value found 30 g powder (2 sachets)	* Normative Instruction No. 28, 06/26/2018 Minimum – Maximum Limits (population groups ≥ 19 years old)
Proteins (g)	5.23	0.78	1.56	8.40 – NE
Lipids (g)	2.73	0.41	0.82	5.0 – NE
Carbohydrates (g)	44.80	6.72	13.44	19.5 – NE
Total fibers (g)	31.40	4.71	9.42	5.7 – NE
VET (kcal)	224.90	33.70	67.40	40 kcal**
Calcium (mg)	80.68	12.10	24.20	180 – 1.534.67
Copper (µg)	483.00	72.45	144.90	135 – 8.975.52
Iron (mg)	3.27	0.49	0.98	2.7 – 34.31
Phosphor (mg)	0.06	0.009	0.018	105 – 2.083.89
Magnesium (mg)	32.89	4.9335	9.867	63 – 350
Manganese (mg)	0.95	0.14265	0.2853	0.35 – 1.66
Potassium (mg)	704.89	105.734	211.468	NC**
Sample selenium (µg) + Added selenium	0.11 +100	100.11	200.22	8.25 – 319.75
Sodium (mg)	21.97	3.2955	6.591	-----
Zinc (mg)	0.75	0.1125	0.225	1.65 – 29.59

* Source: Brasil (2018). National Health Surveillance Agency. Normative Instruction No 28, of July 26, 2018. It establishes lists of constituents, limits of use, claims and supplementary labelling of food supplements. NE = Not established. NA = not authorized. ** NC = There is no reference of the element in Normative Instruction No. 20/2018.

4. Conclusion

It was possible to prove by means of the study of the centesimal composition the high dietary fiber content in the peel and pulp powder ofbaru. By the accelerated stability evaluation, it was possible to prove that the nutrients remained stable for the determined period of 45 days and that the raw material and the prototype remained stable regarding the microbiological parameters. The formulation elaborated from peel and pulp baru was able to meet the recommendations of food supplement in relation to dietary fiber, and also in relation to selenium and copper. The powder obtained from the peel and pulp baru can be used for other food purposes, in addition, the use of products or byproducts of fruits of the cerrado can contribute and supplement the daily necessities nutrients.

Conflict of interest

The author would like to declare no conflict of interest.

References

Almeida, S.P; Silva, J.A; Ribeiro, J.F. (1987). *Aproveitamento alimentar de espécies nativas dos cerrados:* araticum, baru, cagaita e jatobá. EMBRAPA-CPAC, Documentos, 26, p. 83, Planaltina.

Alves, A.M.; Mendonça, A.L. de.; Caliari M.; Cardoso-Santiago, R.A. (2010). Avaliação química e física de componentes do baru (*Dipteryx alata* Vog.) para estudo da vida de prateleira. *Pesquisa Agropecuária Tropical,* vol. 40, n. 3, p. 266–273.

Anderson, J.W. (2008). Dietary fiber and associated phytochemicals in prevention and reversal of diabetes. In: Pasupuleti VK, Anderson JW, eds. *Nutraceuticals, glycemic health and type 2 diabetes*. Ames, Iowa: Blackwell Publishing Professional; 2008. p. 111-42.

AOAC. Association of Official Analytical Chemists. (2005). *Official Methods of Analysis of AOAC International.* 18a. ed. Gaitherburg, Maryland: AOAC International.

AOAC. Association of Official Analytical Chemists. (1984). *Official Methods of Analysis of AOAC International.* Washington D. C., p. 1141, 1984.

APHA. American Public Health Association. (2015). *Compendium of Methods for the Microbiological Examination of Foods.* 5 ed. 995p. American Public Health Association, Washington, DC.

Basso, C. (2010). *Amido resistente:* Efeito de processamento, aceitabilidade e resposta glicémica. Dissertação de Mestrado, Centro de Ciências Rurais - Universidade Federal de Santa Maria, Brasil.

Bligh, E. G.; Dyer, W. J. A. (1959). Rapid method of total lipid extraction and purification. *Canadian Journal Biochemistry Physiology*, v.37, n. 8, p.911-917.

Brasil. (2010). Agência Nacional de Vigilância Sanitária. *Farmacopeia Brasileira*. 5. ed. Brasília: Anvisa, 2010. 2v.

Brasil. (2018). Agência Nacional de Vigilância Sanitária. *Instrução Normativa In n° 28*, de 26 de julho de 2018. Estabelece as listas de constituintes, de limites de uso, de alegações e de rotulagem complementar dos suplementos alimentares.

Brasil. (2001). Agência Nacional de Vigilância Sanitária. *Resolução RDC nº 12 de janeiro de 2001.* Aprova o regulamento técnico sobre padrões microbiológicos para alimentos.

Brasil. (2018). Agência Nacional de Vigilância Sanitária. *Resolução RDC nº 243 de 26 julho de 2018.* Estabelece os aditivos alimentares e coadjuvantes de tecnologia autorizados para uso em suplementos alimentares.

Brasil. (2018). Agência Nacional de Vigilância Sanitária. *Resolução RDC nº 239 de 26 julho de 2018*. Dispõe sobre os requisitos sanitários dos suplementos alimentares.

Brasil (2005). Agência Nacional de Vigilância Sanitária; *Resolução RE no. 1, de 29 de julho de 2005*. Guia para a realização de estudos de estabilidade, Diário Oficial da União, de 01/08/2005.

Brasil. (2018). Ministério da Secretaria de Vigilância em Saúde. Departamento de Vigilância das Doenças Transmissíveis. Coordenação Geral de Doenças Transmissíveis. Unidade de Vigilância das Doenças de Transmissão Hídrica e Alimentar. Sistema de Informação de Agravos de Notificação – SINAN. *Surtos de doenças transmitidas por alimentos no Brasil*, 2000-2017. Brasília.

CODEX. (2010). Codex Alimentarium. *Guidelines on nutrition labelling CAC/GL 2-1985 as last amended 2010*. Joint FAO/WHO Food Standards Programme, Secretariat of the Codex Alimentarius Commission, FAO, Rome, 2010.

Cominetti, C.; Cozzolino, S. M. F. (2009). Funções plenamente reconhecidas de nutrientes: Selênio. *Série de publicações ILSI Brasil,* v. 8, p. 1-20.

El-Bayoumy K. (2001). The protective role of selenium on genetic damage and on cancer. *Mutation Research*, 475:123–139.

Freitas, D. G. C.; Takeiti, C. Y.; Godoy, R. L. O.; Ascheri, J. L. R., Carvalho, C. W. P.; Souza, P. L. M.; Ribeiro, A. E. C.; Ascheri, D. P. R. (2014). Extruded baru flour addition (Dipteryx alata Vog.) in cookie formulations: effect on consumer's acceptability. *Acta Horticulturae*, 1040, 89-96.

Garcia-Amezquita, L.E., Tejada-Ortigoza V., Heredia-Olea, E. Serna-Saldívar S.O., Welti- Chanes, J. (2018). *Differences in the dietary fiber content of fruits and their by-products quantified by conventional and integrated AOAC official methodologies. J. Food Compos. Anal*., 67, pp. 77-85.

Greenfield H., Southgate, DAT: (2003). *Food Composition Data* – Production, Management and Use. Rome, FAO.

IAL. Instituto Adolfo Lutz. (2008). *Métodos físico-químicos para análise de alimentos*. São Paulo: Instituto Adolfo Lutz, 1020 p.

IBGE. Instituto brasileiro de geografia e estatística. *Pesquisa de Orçamentos Familiares 2008- 2009: análise do consumo alimentar no Brasil.* Rio de Janeiro: IBGE; 2011.

IOM. (2005). Institute of Medicine. National academies press. Dietary Reference Intakes: Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. Washington, D.C., *The National Academies Press*.

IOM. (2000). Institute of Medicine. National academies press. Dietary reference intakes for vitamin C, vitamin E, selenium, and carotenoids. Washington, D.C., *The National Academies Press*.

Lairon, D.; Arnault, N.; Bertrais, S.; Planells, R.; Clero, E.; Hercberg, S.; Boutron-Ruault, M-C. (2005). Dietary fiber intake and risk factors for cardiovascular disease in French adults. *American Journal of Clinical Nutrition*.

Lima, J. C. R.; Freitas, J.B.; Czeder, L.P.; Fernandes, D.C.; Naves, M.M.V. (2010). Qualidade microbiológica, aceitabilidade e valor nutricional de barras de cereais formuladas com polpa e amêndoa de baru. *Boletim CEPPA*, v. 28, n. 2.

Marcelino, G., Coleta, I. T., Candido, C. J., Santos, E. F. (2018). Caracterização e análise sensorial de cupcakes elaborados com diferentes concentrações de farinha de casca e polpa de baru (*Dipteryx alata* Vog.). *Multitemas,* p. 265-281.

Navarro-Alarcon, M., López-Martínez, M.C. (2000). Essentiality of selenium in the human body: relationship with diferente diseases. *Sci Total Environ*. 249:347-71.

Oliveira, M.I.B.; Sigrist, M. R. (2008). Fenologia reprodutiva, polinização e reprodução de *Dipteryx alata* Vogel (Leguminosae-Papilionoideae) em Mato Grosso do Sul, Brasil. *Revista Brasileira Botânica*, v.31, n.2, p.195-207.

Rayman, M.P. (2000). The importance of selenium to human health. *Lancet*, 356: 233–41.

Rayman, M.P. (2012). Selenium and human health. *Lancet*; 379:1256-1268.

Rocha, EFL; Cabral, IB; Sampaio LHF; Bento, LBP; Ayres, FM. (2021). Aplicabilidades do baru (*Dipteryx alata* Vogel) na saúde humana: revisão de literatura. *Estudos, Vida e Saúde*, 48(1), 1-6.

Rocha, L.S.; Santiago, R.A.C. (2009). Use of peel and pulp of baru in the development of bread. *Ciência e Tecnologia dos Alimentos*, 29(4):820-825.

Santiago, G.L.; Oliveira, I.G.; Horst, M.A.; Naves, M.M.V.; Silva, M.R. (2018). Peel and pulp of baru (*Dipteryx Alata* Vog.) provide high fiber, phenolic content and antioxidant capacity. *Journal of Food Science and Technology*, v.38, n.2, Campinas.

Simões, C.M.O.; Schenkel, E.P.; J.C.P.; Mentz, L.A.; Petrovick, P.R. (2016). Farmacognosia: do produto natural ao medicamento. Artmed Editora.

Skalny, A. V.; Skalnaya, M. G.; Klimenko, L. L.; Mazilina, A. N.; & Tinkov, A. A. (2018). Selenium in Ischemic Stroke. Selenium. *Springer*, Cham. 211–230.

Skrypnik, K.; Suliburska, J. (2017). Association between the gut microbiota and mineral metabolism. *J Sci Food Agric*, 98: 2449-2460.

Stolsz, J. F.; Basu, P.; Santini, J. M.; Oremland, R. S. (2006). Arsenic and selenium in microbial metabolism. *Annu Rev Microbiol* 60, 107–130.

TACO. (2011). *Tabela Brasileira de Composição de Alimentos*. 4ed. Revisada e ampliada. Campinas, SP: UNICAMP.

Togashi, M. (1993). *Composição e caracterização química e nutricional do fruto do baru (Dipteryx alata Vog.)*. Dissertação (Mestrado em Engenharia de Alimentos) – Faculdade de Engenharia de Alimentos, Universidade Estadual de Campinas, Campinas, 108 f.

Togashi, M.; Sgarbieri, V. C. (1994). Caracterização química parcial do fruto do baru. *Ciência e Tecnologia de Alimentos*, v. 14, n. 1, p. 85-95.

USDA. (2012). United States Departament of Agriclture. *Introduction to the microbiology of food processing*. Small Plant. Food Safety and Inspection Service, 63 p.

Vera, R.; Junior, M.S.S.; Naves, R.V.; Souza, E.R.B.; Fernandes, E.P.; Caliari, M.; Leandro, W.M. (2009). Características químicas de amêndoas de barueiros (*Dipteryx alata* vog.) de ocorrência natural no cerrado do estado de Goiás, Brasil. *Revista Brasileira de Fruticultura*, v. 31, n. 1, p. 112-118.

WHO/FAO. (2003). World Health Organization / Food and Agriculture Organization. *Diet, Nutrition and the Prevention of Chronic Diseases*. WHO Technical Report Series, 916, Geneva.

Wu, B-K; Chen, Q-H; Pan, D; Chang, B; Sang, L-X. (2021). A novel therapeutic strategy for hepatocellular carcinoma: Immunomodulatory mechanisms of selenium and/or selenoproteins on a shift towards anti-cancer. *International Immunopharmacology*, 96, 107790.

Zhai, Q.; Cen, S.; Li, P.; Tian, F.; Zhao, J.; Zhang, H.; Chen, W. (2018). Effects of dietary selenium supplementation on intestinal barrier and immune responses associated with its modulation of gut microbiota. *Environ. Sci. Technol. Lett*. 5, 724–730.