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# Assessment of Yield, Flavonoid and Phytosterol Contents, and Fatty Acid Composition of Baru Almond Oil (*Dipteryx alata* Vogel) by Supercritical $CO_2$ Extraction

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**Abstract:** The objective of this study was to investigate the influence of temperature and pressure on the extraction of Baru almond oil using pressurized $CO_2$. From the obtained data, it was found that variations in pressure and temperature influenced the oil yield and total amount of phytosterols. The maximum yield of Baru oil achieved was approximately 30%, obtained at a pressure of 28 MPa and 60 °C. The phytosterols identified were campesterol, stigmasterol, and β-sitosterol, with a maximum content of 169.5 ± 4.2 mg/100 g of oil obtained at 20 MPa and 60 °C. Among these, β-sitosterol was the most abundant, accounting for 60% of the total phytosterol content under all the experimental conditions. The flavonoid content in the extracts was also quantified, with the total flavonoid levels ranging between 255 and 275 mg/100 g of oil depending on the experimental conditions. The fatty acid profile of the extracted oil predominantly consisted of oleic (51%) and linoleic (28%) acids.

**Keywords:** Baru; β-sitosterol; flavonoids; supercritical extraction

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## 1. Introduction

*Dipteryx alata* Vogel, commonly known as baruzeiro, is a tree native to the Brazilian Cerrado [1]. This species has ecological and economic significance mainly because of its almond, which is rich in oil and active compounds [2,3]. Baru oil possesses a pleasant flavor and high content of oleic acid, tocopherols, phenolic acids, and β-sitosterol, which have promising nutritional and functional properties [3,4].

Phytosterols, abundantly found in nonpolar plant fractions, are consumed in the human diet at a rate of 200–400 mg per day [5]. Some of these compounds, such as β-sitosterol, stigmasterol, and their analogs, have been shown to inhibit cholesterol absorption, cancer cell growth, angiogenesis, invasion, and metastasis [6]. Furthermore, various biological activities are observed when using these natural compounds or their extracts, including mosquito larvicidal activity and neutralizing effects against snake venom [7].

β-sitosterol, a widely recognized natural sterol, is utilized in herbal medicinal formulations for managing benign prostatic hyperplasia (BPH) and prostate cancer [8]. Moreover, research has indicated that this particular compound enhances both enzymatic and non-enzymatic antioxidant concentrations within cells, thereby demonstrating its efficacy as an antidiabetic, neuroprotective, and chemoprotective agent. The considerable therapeutic potential of β-sitosterol and its derivatives in a range of medical conditions makes it a

promising pharmaceutical agent. Clinical trials have validated its efficacy in the treatment of BPH [8,9].

The extraction and characterization of Baru oil have been studied to optimize the process and identify the components that add value to the product [10]. Supercritical carbon dioxide ($CO_2$) extraction is an alternative extraction technique owing to its efficiency, selectivity, and low environmental impact [11,12]. Previous studies have investigated the influence of parameters such as temperature and pressure on supercritical $CO_2$ extraction to maximize oil yield and evaluate the fatty acid profile of the obtained oil [13]. Fetzer et al. [11] reported the application of ethanol as a cosolvent in the extraction and evaluated the application of temperatures ranging from 40 °C to 80 °C and a pressure of up to 25 MPa. Chañi-Paucar et al. [12] and Santos et al. [13] applied pressures of up to 35 MPa and varied the temperature from 40 °C to 60 °C.

However, there are still gaps in our knowledge regarding the impact of extraction methods on the profile of minor components of Baru oil, such as phytosterols. Understanding these compounds is essential for evaluating the potential of oils in the food, pharmaceutical, and cosmetic industries, as well as for providing relevant information for developing more efficient and sustainable extraction processes. Therefore, conducting this study is justified to explore a greater operational low in the application of supercritical $CO_2$ and present additional information on the quality of the oil obtained, which could contribute to the improvement of experimental extraction techniques and add value to Baru oil, promoting its use in various industrial applications and contributing to the sustainability of the Brazilian Cerrado.

In this context, the present study aimed to investigate the influence of temperature and pressure on the extraction of Baru almond oil using pressurized $CO_2$ to optimize the yield. The phytosterol and flavonoid contents of the oils obtained under different extraction conditions were determined. Finally, the fatty acid profile of Baru almond oil obtained by supercritical extraction was determined and compared with that of oil obtained by Soxhlet extraction.

## 2. Materials and Methods

### *2.1. Sample Preparation*

Baru fruits, integral to this study, were harvested during the peak fall period in September and October 2021. This period is widely recognized as the prime harvest season for Baru in the Goiás region, specifically within the municipality of Rio Verde (17°47′53″ S, 51°55′53″ W).

The selection criteria for these fruits included their integrity, appearance, weight, and color, ensuring that only the healthiest specimens were selected. Selected fruits were transported to the IF Goiano Laboratory Campus in Rio Verde, Brazil. The almonds were carefully extracted from the fruits using a manual press and a table knife. The samples were then dried in an air-circulation oven at 70 °C for 24 h. The dried almonds were ground and sieved through 24–48 mesh to produce uniform particles. The triturated almonds were stored in a refrigerated environment to preserve their integrity.

### *2.2. Proximate Analysis and Micronutrient*

The proximate composition of Baru almonds was determined according to AOAC guidelines [14]. The micro-Kjeldahl method was employed to quantify the protein content [15]. As previously described, the total sugars were determined using the hot titration method with Fehling A and B solutions [16]. Additionally, mineral analysis was conducted as outlined in [17].

### *2.3. Baru Oil Extraction Process*

#### 2.3.1. Soxhlet Extraction of Baru Oil

Baru almonds (10 g) were crushed and placed into a Soxhlet extractor. Extraction was carried out using n-hexane as the solvent for 8 h. After the extraction, the solvent was removed under reduced pressure using a rotary evaporator. To ensure complete evaporation,

the samples were placed in an oven with forced air circulation at 38 °C for 12 h. After drying at ambient temperature (25 °C), the samples were stored in a desiccator containing silica gel. The extraction yield was measured gravimetrically using a digital analytical balance and reported in grams per 100 g of sample.

#### 2.3.2. Supercritical Extraction of Baru Oil

The extraction of Baru almonds using a supercritical fluid involved a setup that included a $CO_2$ cylinder, two temperature-controlled baths, a syringe pump (ISCO 500 D), a jacketed extraction vessel (1.91 cm in diameter and 16.8 cm in height), and an absolute pressure transducer (Smar LD301, Sertãozinho, SP, Brazil). The apparatus and methodologies employed were thoroughly described in previous studies [18].

For the extraction process, 10 g of dried Baru almonds was placed in the extractor, and the remaining volume was filled with glass beads to form an inert bed. $CO_2$ passes through this inert bed before reaching the almonds. Upon reaching the desired extraction temperature, both the pump and extractor were simultaneously pressurized. Once the operating pressure was reached, the system was cooled for 30 min to establish equilibrium and ensure solvent saturation. A $2^2$ factorial design was used to examine the effects of pressure (20, 24, and 28 MPa) and temperature (40, 50, and 60 °C) on the extraction yield. $CO_2$ with a purity of 99.5% (Linde Gas) was compressed using a syringe pump to 293.15 K. The solvent flow rate was kept constant at 2 g/min for 100 min, and the solvent was preheated to 80 °C. Extracts were collected in pre-weighed glass flasks at 10 min intervals, and the yield was determined gravimetrically. The final yield was calculated by dividing the total mass extracted by the initial dry mass of almonds in the extractor.

### *2.4. Flavonoids Content*

The flavonoids in the Baru almond oil samples were quantified using a precise and reliable spectrophotometric method. Initially, a standard curve for the pyrocatechin concentrations ranging from 10 mg/L to 50 mg/L was established. This curve was vital for quantifying flavonoid concentrations and was created by measuring the absorbance at 510 nm using a UV-Vis spectrophotometer.

For flavonoid extraction, 10 g of sample from each treatment group was mixed with 100 mL of a 50% hydroethanolic solution. These mixtures were then sonicated for 2 h to ensure the thorough extraction of the flavonoids. Following sonication, the suspensions were filtered and transferred into 100 mL flasks, which were then filled to the brim with the same hydroethanolic solvent to maintain a consistent volume across samples.

To each of these solutions, a series of reagents were added in precise quantities: 0.3 mL of 5% $NaNO_2$ (aqueous), 0.3 mL of 10% $AlCl_3$ (dissolved in methanol), and 2 mL of 1 mol/L NaOH (aqueous). This step is important for initiating the reactions necessary for flavonoid detection. After a concise agitation period to ensure adequate blending, the solution was left undisturbed for 10 min. The final step involved measuring the absorbance of these solutions at 510 nm using a UV-Vis spectrophotometer. This method was based on the protocol established by Barbosa et al. [19].

### *2.5. Fatty Acid Profile and Phytosterol Content*

The fatty acid profile and phytosterol content of the Baru almond oil were determined using a gas chromatographer coupled to a mass spectrometer (GCMS-QP2010 SE, Shimadzu, Kyoto, Japan) following the analytical conditions reported by Iwassa et al. [20] for the heating ramp, chromatographic columns, split ratio, injector temperature, and ion source. Helium (99%, White Martins, São Paulo, SP, Brazil), which was chosen for its inert properties and efficiency as a carrier gas, was used at a linear velocity of 35.6 cm/s throughout the analysis. Mass spectra were recorded at 70 eV, covering a mass range of 55–550 $m/z$.

Compound identification was performed according to a previously established methodology [21]. Following methylation, the fatty acid composition was determined using area normalization, calculated as the ratio of the individual peak area to the total area of all peaks

in the chromatogram. Phytosterol quantification involved sample derivatization with N,O-bis(trimethylsilyl)trifluoroacetamide containing 1% trimethylchlorosilane (Sigma-Aldrich). The results are reported as milligrams of phytosterol per 100 g of oil.

### 2.6. Statistical Analysis

The influence of temperature and pressure on the extraction yield was assessed using analysis of variance (ANOVA) with a 95% confidence level ($p < 0.05$), assuming a full factorial randomized design. Design-Expert software (version 12) [22] was used to determine the main effects, interactions, and contributions of the independent variables to the response. Data were subjected to Tukey's test for mean comparisons ($p < 0.05$).

## 3. Results

### 3.1. Proximate Composition of Baru Almond

The proximate composition of the Baru almond was used to assess the moisture, protein, and ash content (Table 1).

**Table 1.** Proximal composition of the Baru almonds.

| Component | This Work | Literature | | | |
|---|---|---|---|---|---|
| | | Chani-Paucar et al. [12] | Vallilo et al. [23] | Campidelli et al. [24] | Takemoto et al. [3] |
| Moisture | 5.05 ± 0.32% | 3.5% | 5.8% | 6.6% | 6.1% |
| Ash | 3.10 ± 0.01% | 3.2% | 2.8% | 1.55% | 2.7% |
| Lipids | 37.1 ± 0.45% | 41.9% | 41.6% | 31.7% | 38.2% |
| Proteins | 22.01 ± 0.34% | 29.9% | 23.4% | 22.9% | 23.9% |
| Carbohydrates | 32.60 ± 0.91% | 12.25% | 23.0% | 37.13% | 15.8% |

Baru almond is recognized as a nutritionally dense food source rich in proteins and carbohydrates. The protein content was 22%. Once dried, the Baru almonds exhibited a low moisture content of 5%, which is indicative of their shelf stability and quality. The ash content was measured to be 3%, reflecting the inorganic mineral composition of the nuts. The lipid content (37%) obtained in this study was consistent with the values reported in the literature. The carbohydrate content was 32.6%, highlighting the nutritional profile of the Baru almonds.

### 3.2. Nutrients

The nutrient profile obtained from the analyses revealed nitrogen (N) at 53.4 g/kg, phosphorus (P) at 5.2 g/kg, potassium (K) at 14.3 g/kg, calcium (Ca) at 1.2 g/kg, magnesium (Mg) at 1.5 g/kg, and sulfur (S) at 1.8 g/kg. Iron (Fe) was found at 66.5 mg/kg, manganese (Mn) at 21.8 mg/kg, copper (Cu) at 21.5 mg/kg, zinc (Zn) at 31.1 mg/kg, and boron (B) at 9.3 mg/kg. All analyses were performed in triplicate with a standard deviation of 0.001 for all measurements.

### 3.3. Oil Extraction Yield

The experimental conditions and overall yields of the Baru almond oil extraction using supercritical $CO_2$ are presented in Table 2. This table also includes the values obtained through Soxhlet extraction and a comparison with data reported in the literature. A maximum extraction yield of 30.3 wt% was achieved at 60 °C and 28 MPa.

The yield of 22.8% found in a study by Santos et al. [13], which used $CO_2$ at 35 MPa and 50 °C, was lower than that of this work. A study by Fetzer et al. [11] reported yields of 32.6% when using $CO_2$ with ethanol as the co-solvent at 25 MPa and 80 °C. Extraction with propane provided a greater yield under milder conditions (10 MPa and 60 °C) [11] because the solvation power of triglycerides in this solvent is greater than that in $CO_2$.

**Table 2.** Experimental conditions and extraction results for Baru oil extraction using supercritical $CO_2$.

| This Work | | | | Yield (%) (Literature) | | | |
|---|---|---|---|---|---|---|---|
| | | | | Santos et al. [13] | Chani-Pauçar et al. [12] | Fetzer et al. [11] | Fetzer et al. [11] |
| Test | Pressure (MPa) | Temperature (°C) | Yield (%) | $CO_2$ 35 MPa/50 °C | $CO_2$ 35 MPa/45 °C | $CO_2$ + Ethanol 25 MPa/80 °C | Propane 10 MPa/60 °C |
| 1 | 20 | 40 | 16.4 | | | | |
| 2 | 20 | 60 | 25.3 | | | | |
| 3 | 28 | 40 | 27.7 | | | | |
| 4 | 28 | 60 | 30.3 | 22.8% | 29% | 32.6 | 36.8 |
| 5 | 24 | 50 | 26.6 | | | | |
| 6 | 24 | 50 | 25.5 | | | | |
| 7 | 24 | 50 | 27.3. | | | | |
| Soxhlet | Atmospheric | 40 | 38.3 ± 0.4 [a] (hexane) | 24.1 | | 39.70 ± 0.32 | 39.70 ± 0.32 |

Note: extraction carried out in triplicate [a].

Figure 1 shows the extraction kinetic curves. The changes in the slope can be attributed to variations in the convective mass transfer mechanism. The convective mechanism in the fluid phase significantly influences the mass transfer rate and is less affected by the diffusion mechanism. Discontinuity in the surface layer occurred as the lipid materials were gradually removed. At the beginning of this phase, the extraction rate, governed by the diffusion mechanism, decreased. This suggests that the duration of the experimental extraction was adequate to reach the region of extractive equilibrium.

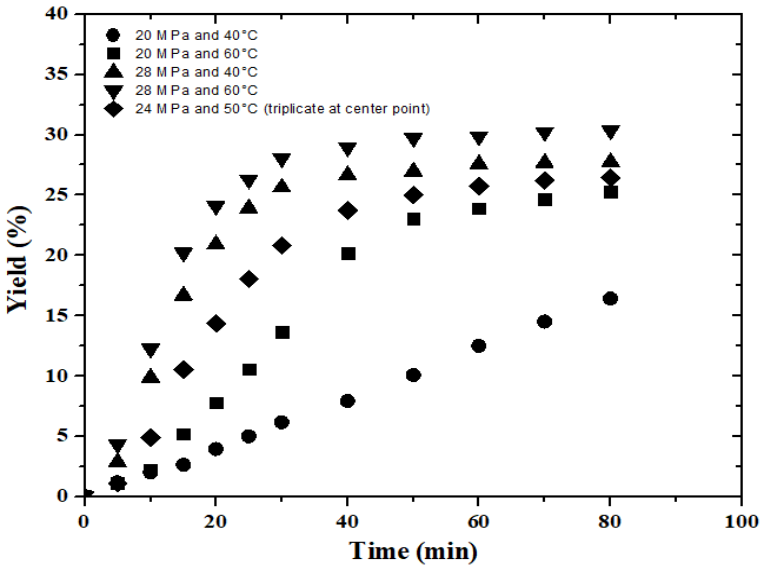



**Figure 1.** Experimental kinetic curves for Baru almond oil extraction with supercritical $CO_2$.

This study indicated that elevated pressures are crucial for achieving high oil yields. The effect of temperature on yield was observed in the experiments. Increasing the temperature from 40 °C to 60 °C at a steady constant pressure reduced the $CO_2$ density and increased the extraction yield. The positive effect of pressure was evident in Experiments (1 and 3) and (2 and 4), where increasing the pressure from 20 to 28 MPa at a constant temperature increased the extraction yield. A higher pressure reduces the molecular distance and enhances interactions between $CO_2$ and the sample, potentially increasing mass transfer via convection. The influence of pressure and temperature on the extraction yield can be visualized using response surface and contour plots, as shown in Figures 2 and 3.

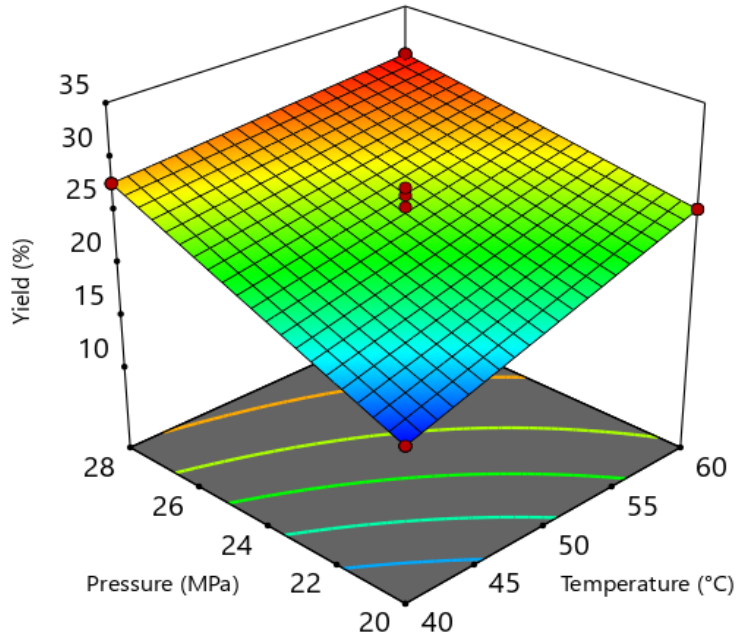



**Figure 2.** The response surface refers to the extraction yield of the Baru almonds.

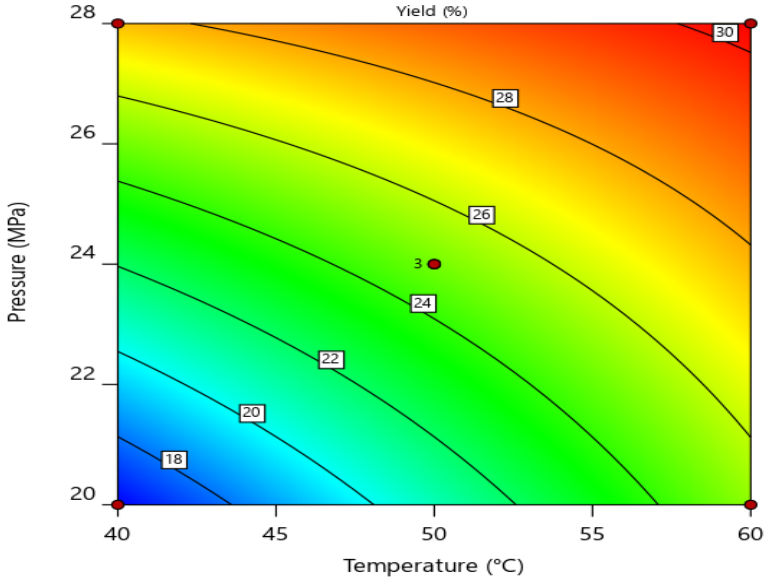



**Figure 3.** The response contour refers to the oil extraction yield of Baru almonds as a function of the temperature and pressure.

Variations in the yield were evaluated through statistical analyses, as presented in Table 3, resulting in a significant linear model for the temperature ($T$) and pressure ($P$) factors (Equation (1)). These variables demonstrate an important relationship between the extraction conditions and yield.

$$Yield\ (\%) = -61.15 + 1.23\ T + 2.98P + -0.039\ T{\cdot}P \quad (1)$$

The model F-value of 44.29 indicates statistical significance, with only a 2.22% probability of obtaining such a value due to chance. Both temperature and pressure demonstrated a synergistic influence on the oil yield, with increasing values of both parameters leading to higher yields (Figure 1). This is corroborated by the Pareto chart (Figure 4), in which the Bonferroni limit delineates the threshold for significant effects. Effects exceeding this limit were considered significant, whereas those falling below the t-limit threshold were deemed

insignificant. The effects surpassing the t-limit, but remaining below the Bonferroni limit, may be moderately important.

**Table 3.** Variance analysis data for the extracts were obtained using $2^2$ factorial designs to extract Baru almonds with carbon dioxide.

| Terms | Sum of Squares | Degrees of Freedom | Mean Squares | F-Value | *p*-Value | $R^2$ |
|---|---|---|---|---|---|---|
| Model | 109.41 | 3 | 36.47 | 44.29 | 0.0222 | |
| T | 33.06 | 1 | 33.06 | 40.16 | 0.0240 | |
| P | 66.42 | 1 | 66.42 | 80.68 | 0.0122 | |
| T.P | 9.92 | 1 | 9.92 | 12.05 | 0.0739 | 0.9852 |
| Curvature | 4.07 | 1 | 4.07 | 4.95 | 0.1561 | |
| Pure Error | 1.65 | 2 | 0.8233 | | | |
| Cor Total | 115.13 | 6 | | | | |

T = Temperature; P = Pressure.

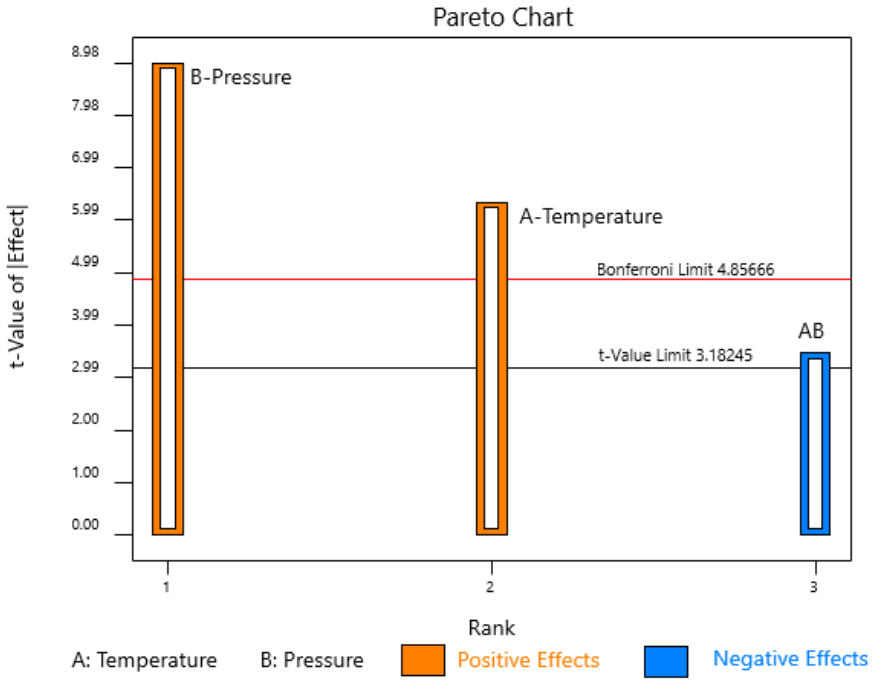



**Figure 4.** Pareto chart representing the effect of each factor on Baru almond extraction.

### *3.4. Phytosterol Compounds*

Phytosterol analysis was conducted on Baru almond oil samples extracted using the supercritical and Soxhlet methods, and the results are presented in Table 4.

The identified phytosterols were campesterol, stigmasterol, and β-sitosterol. Of these, β-sitosterol had the highest occurrence in quantity per mg/100 g of oil, accounting for 60% of the total phytosterols under all experimental conditions studied. Variations in pressure and temperature influenced the oil extraction yield and quantity of phytosterols, with higher levels obtained up to 20 MPa and 60 °C. This experimental condition was also used by Santos et al. [27] and Vasquez et al. [28] to extract β-sitosterol from *Morus alba* leaves and cake byproducts from Brazil nuts, respectively.

The quantity of sitosterol plays a crucial role in the bioactivity of this oil compared to that of olive oil, given that the intake of squalene and sitosterol contributes to the mitigation of several illnesses. The therapeutic attributes of these substances are significant, serving various functions within the body, including reducing low-density lipoprotein (LDL) absorption and alleviating cardiovascular issues [29].

**Table 4.** Phytosterol content of Baru almond oil obtained using supercritical $CO_2$.

| Phytosterols (mg/100 g) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Test** [1] | **Campesterol** | | **Stigmasterol** | | **β-Sitosterol** | | **Total (This Work)** |
| | **This Work** | **Literature** | **This Work** | **Literature** | **This Work** | **Literature** | |
| 1 | 11.3 ± 1.5 $^{b,c}$ | 5.5 [25] | 31.5 ± 0.7 $^{b}$ | 14.21 [25] 12.3 [26] | 83.8 ± 2.0 $^{b}$ | 63.9 [25] 145 [26] | 126.6 ± 2.7 $^{b}$ |
| 2 | 16.3 ± 0.7 $^{a}$ | | 46.9 ± 0.6 $^{a}$ | | 106.2 ± 2.9 $^{a}$ | | 169.5 ± 4.2 $^{a}$ |
| 3 | 7.7 ± 0.3 $^{d}$ | | 25.9 ± 1.2 $^{c}$ | | 61.4 ± 0.0 $^{d}$ | | 95.0 ± 1.5 $^{c}$ |
| 4 | 13.5 ± 0.6 $^{a,b}$ | | 31.1 ± 1.3 $^{b}$ | | 72.0 ± 3.6 $^{c}$ | | 116.6 ± 5.5 $^{b,c}$ |
| 5–7 | 9.8 ± 0.3 $^{c,d}$ | | 30.3 ± 1.2 $^{b}$ | | 67.6 ± 0.5 $^{c,d}$ | | 107.7 ± 0.3 $^{c,d}$ |
| Soxhlet | 7.8 ± 0.2 $^{d}$ | | 24.2 ± 0.5 $^{c}$ | | 65.4 ± 0.6 $^{c,d}$ | | 97.4 ± 0.8 $^{d,e}$ |

[1] See Table 2. Different letters in the same column indicate statistically significant differences between mean values according to Tukey's test ($p < 0.05$).

### 3.5. Flavonoids

Table 5 presents the results of the phytochemical analyses of the flavonoids in Baru nut almond oil extracted using supercritical $CO_2$.

**Table 5.** Flavonoid content of Baru almond oil obtained using supercritical $CO_2$.

| | **Flavonoids (mg/100 g)** | |
|---|---|---|
| **Test** [1] | **This Work** | **Literature** |
| 1 | 254.94 ± 1.05 $^{b}$ | |
| 2 | 276.46 ± 2.63 $^{a}$ | |
| 3 | 264.66 ± 2.29 $^{b}$ | 29 ± 1.7 [30] |
| 4 | 277.12 ± 2.07 $^{a}$ | |
| 5–7 | 274.83 ± 6.95 $^{a}$ | |

[1] See Table 2. Different letters indicate statistically significant differences between mean values by Tukey's test ($p < 0.05$).

The total flavonoid content varied between 255 and 275 mg/100 g of oil, depending on the experimental conditions, and a tendency to obtain oil with higher levels of these compounds at 60 °C was observed. Atwi-Ghaddar et al. [31] reported that increasing the extraction temperature resulted in samples with a higher flavonoid content. These compounds have significant antioxidant properties that contribute to protection against oxidative damage.

### 3.6. Fatty Acid Profile

The fatty acid profiles of the oil obtained under the highest extraction yield conditions (T = 60 °C and P = 28 MPa) and using Soxhlet extraction are shown in Table 6. Seven distinct fatty acids with carbon chain lengths varying from 16 to 22 were observed. The observed profile aligns with that of previous studies, as shown in Table 6. Fatty acids are categorized into three primary types: saturated, monounsaturated fatty acids (MUFAs), and polyunsaturated fatty acids (PUFAs). The predominant saturated fatty acids in Baru oil are palmitic acid (7.11%) and stearic acid (6.92%).

Analysis of the unsaturated fatty acid content, which constitutes the major component of the oil, showed significant amounts of linoleic acid (28.56%) and oleic acid (51.1%). The high concentration of oleic acid, with no substantial variation across different extraction methods, suggests that the supercritical $CO_2$ extraction process does not adversely affect the primary fatty acids in the oil.

**Table 6.** Fatty acid profile of Baru almond oil obtained using supercritical $CO_2$.

| Fatty Acid | | This Work | | Literature | | |
|---|---|---|---|---|---|---|
| | | 28 MPa/60 °C | Soxhlet | Santos et al. [13] | Chani-Paucar et al. [12] | Fetzer et al. [11] |
| Palmitic acid | C16:0 | 7.1 ± 0.11 [b] | 7.9 ± 0.01 [a] | 7.8 ± 0.08 | 7.6 ± 0.1 | 5.56 |
| Stearic acid | C18:0 | 6.9 ± 0.06 [b] | 8.1 ± 0.19 [a] | 4.8 ± 0.06 | 5.7 ± 0.1 | 5.16 |
| Oleic acid | C18:1 | 51.1 ± 0.46 [b] | 54.3 ± 0.33 [a] | 48.8 ± 0.04 | 50 ± 1 | 52.4 |
| Linoleic acid | C18:2 | 28.5 ± 0.2 [a] | 21.7 ± 0.03 [b] | 26.0 ± 0.17 | 27 ± 1 | 23.9 |
| Arachidic acid | C20:0 | 1.4 ± 0.05 [b] | 1.7 ± 0.03 [a] | 1.2 ± 0.02 | 1.4 ± 0.1 | 1.3 |
| Gadoleic acid | C20:1 | 1.9 ± 0.01 [b] | 2.4 ± 0.04 [a] | 2.3 ± 0.03 | 2.9 ± 0.1 | |
| Behenic acid | C22:00 | 3.0 ± 0.02 [b] | 3.9 ± 0.1 [a] | 4.1 ± 0.06 | 3.0± 0.1 | |

Note: Different letters indicate statistically significant differences between mean values by Tukey's test ($p < 0.05$).

## 4. Conclusions

With a proximate composition of 22% protein and 32.6% carbohydrates, Baru almonds stand out as a high-quality nutritional source. A detailed analysis confirmed the nutritional value of Baru almonds, highlighting their importance in a dietary context. Oil extraction using supercritical $CO_2$ was highly efficient, especially under high-pressure and high-temperature conditions, achieving a maximum yield of 30.3% at 60 °C and 28 MPa. The phytosterol analysis revealed significant concentrations of campesterol, stigmasterol, and β-sitosterol, with β-sitosterol being the most abundant, representing approximately 60% of total phytosterols. Depending on the extraction conditions, the flavonoid content ranged from 255 to 275 mg/100 g of oil. The fatty acid composition of the extracted oil showed a predominance of unsaturated fatty acids such as oleic acid (51.1%) and linoleic acid (28.56%). The nutritional and active profile of Baru oil demonstrates its potential as a substitute for conventional oils, such as olive oil. The high content of unsaturated fatty acids, phytosterols, and flavonoids underscores the nutritional and therapeutic value of Baru oil, positioning it as a viable and sustainable alternative in the food and health markets. These results encourage further research to deepen our understanding of the benefits and applications of Baru oil. Future studies should explore its economic viability, sustainability, and therapeutic potential in order to confirm its role as a valuable component of human nutrition.

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