



## Technological properties of amazonian oils and fats and their applications in the food industry



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### ABSTRACT

The application of lipids to food production is dependent on their physical, chemical, and nutritional properties. In this study, pracaxi oil, passion fruit oil, cupuassu fat, and palm stearin underwent physicochemical analyses and were combined at ratios of 40:60, 50:50, 60:40, and 70:30 to assess their potential applications in the food industry. Pracaxi oil, passion fruit oil, and cupuassu fat had interesting fatty acid profiles from a nutritional standpoint, displaying the lowest atherogenicity and thrombogenicity indices (0.02 and 0.14; 0.12 and 0.34; 0.16 and 0.65), respectively. Palm stearin had high thermal stability (7.23 h). The primary applications of the blends obtained in this study are in table and functional margarine, particularly the pracaxi-stearin and passion fruit-stearin 40:60 and 50:50, pracaxi-cupuassu 60:40 and 70:30, and passion fruit-cupuassu 40:60 blends. The results suggest new industrial applications, especially for pracaxi and passion fruit oils, which are commonly applied in the cosmetic industry.

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### 1. Introduction

Combining oils and fats is a common practice in the food industry, since many lipids may have limited applications by themselves and in their natural state due to their fatty acid and triacylglycerol composition. Pure lipids often do not have adequate physicochemical properties for direct use in the preparation of food products (e.g., a low melting point, high unsaturation level, and low oxidative stability). These properties can be changed by preparing blends (oils + fats), which allows them to be more broadly employed in foods (Chiu & Gioielli, 2008).

Although mixing is the simplest and most elementary lipid-changing procedure, it may actually cause significant changes in natural physicochemical characteristics, thus yielding more plastic products with new melting behaviors, crystallinity, and stability, which broadens their application (Dian, Sundram, & Idris, 2006).

In addition to the changes in melting point, crystallinity, and stability, it is very important that the blend also meets nutritional recommendations, with more balanced fatty acid profiles compared to the profiles of the pure samples. Higher concentrations of polyunsaturated fatty acids (PUFAs), particularly omega 3 (C18:3), balanced ratios among saturated-monounsaturated-poly

unsaturated fatty acids, omega 6 (C18:2) and 3 (C18:3), and the presence of long-chain saturated fatty acids are desirable (WHO, 2008).

The Amazon boasts many species with oleaginous potential from which oils and fats with excellent physicochemical properties can be extracted. The quality of some matrices, such as palm stearin and cupuassu fat, has already been acknowledged, and they are used in the food industry to prepare several products such as vegetable creams, margarines, chocolates, and special fats for frying, bread-making, and confectionery use (Silva et al., 2010).

However, while the interest in Amazonian matrices primarily targets the promising species that produce high edible oil yields, current changes in societal dietary intake standards and the constant use of natural oils and fats is placing other matrices under the spotlight (Almeida, Rocha Filho, & Zohbi, 2009).

The oil that is extracted from pracaxi seeds is predominated by oleic acid (C18:1) (44.32%) and is considered a natural source of behenic acid (C22:0) (19%), which has low absorption and bioavailability (Kojima et al., 2010). These properties allow its sources to be mixed with other oils and/or fats to prepare low-calorie fatty products (Bebarta, Jhansi, Kotasthane, & Sunkireddy, 2013). The fatty acid composition of passion fruit oil indicates that the oil contains two essential fatty acids, i.e., linoleic acid (C18:2) (72.69%) and linolenic acid (18:3) (0.26%), and its composition shows that it can be a potentially valuable non-conventional source of high-quality oil (Nyanzi, Carstensen, & Schwack, 2005).

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The fat that is extracted from palms has high thermal and oxidative stability, which are relevant characteristics in food production (Silva et al., 2010). Cupuassu fat stands out for its fatty acid composition, in particular the prevalence of oleic acid (18:1), which provides softness and thus enables its use in preparing chocolates, for use in place of cocoa butter (Lannes, Medeiros, & Amaral, 2002).

In the face of a greater demand for oils/fats and their derived products, aside from the scarcity of studies that have combined Amazonian raw materials to form blends, the present study aimed to determine the physicochemical characteristics of pracaxi and passion fruit oils, palm stearin, and cupuassu fat, as well as their blends, to identify their potential and their possible applications.

## 2. Materials and methods

### 2.1. Materials and blend preparation

The pracaxi and passion fruit oils, palm stearin, and cupuassu fat used in this study were provided by the Beraca and AGRO-PALMA companies. The proportions studied here were chosen based on studies by Silva, Cotting, Poltronieri, Balcão, and Gioielli (2009) and Ribeiro, Grimaldi, Gioielli, and Gonçalves (2009). Binary blends with pracaxi and passion fruit oils with palm stearin and cupuassu fat were developed at 40:60, 50:50, 60:40, and 70:30 ratios (w/w) after complete melting at 60 °C followed by filtration. All the determinations were performed in triplicate.

### 2.2. Acidity and peroxide

Acidity was determined according to AOCS method Cd 3d-63 (2004), and peroxide was determined according to AOCS method Cd 8-53 (2004).

### 2.3. Iodine value

The iodine value was calculated from the fatty acid composition, according to the procedure described in AOCS method Cd 1c-85 (2004).

### 2.4. Melting point determination

The melting points of the blends were determined by open capillary tube method. The tube was immersed in water under stirring and heating, according to AOCS method Cc 1-25 (2004).

### 2.5. Oxidative Stability Index (OSI)

The oxidative stability index was evaluated by an OSI instrument (Metrohm Rancimat model 873, USA) following AOCS method Cd 12b-92 (2004). The instrument was run at 130 °C, and air at a flow rate of 20 L/h was bubbled through the oil (3 g). The volatile degradation products were trapped in distilled water, increasing the water conductivity. The oxidative stability index was equivalent to the time needed to reach the conductivity curve's inflection point.

### 2.6. Fatty acid composition determination

The fatty acid composition was determined by conversion to FAMES (fatty acid in methyl esters) based on the method by Rodrigues, Darnet, and Silva (2010) and detected using a gas chromatograph (Varian model CP 3380, USA) equipped with a flame ionization detector (FID) and with a CP-Sil 88 capillary column (length 60 m, internal diameter 0.25 mm, film thickness 0.25 µm;

Varian Inc., USA). The operating conditions were as follows: helium was the carrier gas at a flow rate of 0.9 mL/min, FID detector at 280 °C, injector (split ratio 1:100) at 250 °C, and injection volume of 1 µL. The column's programmed temperature began at 175 °C for 8 min, followed by 2.0 °C/min up to 180 °C for 28 min, and then 2.0 °C/min up to 250 °C for 10 min. The individual fatty acid peaks were identified by comparing the retention times with those of the known blends of standard fatty acids (74 X Nu-Chek-Prep, Inc., USA) that were run under the same operating conditions. The retention time and area of each peak were computed using Varian Star 3.4.1 software. The results were expressed as relative percentages of total fatty acids.

### 2.7. Atherogenicity and thrombogenicity indexes

The sample nutritional quality was determined using the AI (atherogenicity index) (Eq. (1)) and TI (thrombogenicity index) (Eq. (2)) as described by Ulbricht and Southgate (2001).

$$AI = \frac{C12:0 + 4 \times C14:0 + C16:0}{\sum MUFA + \sum FA\omega6 + \sum FA\omega3} \quad (1)$$

$$TI = \frac{C14:0 + C16:0 + C18:0}{(0.5 \times \sum MUFA) + (0.5 \times \sum FA\omega6) + (3 \times FA\omega3)} \quad (2)$$

### 2.8. Solid fat content determination

The solid fat content was determined by nuclear magnetic resonance (NMR) according to AOCS method Cd 16b-93 (2004). The direct method was used and the readings were determined in series at 10 °C, 20 °C, 25 °C, 30 °C, 35 °C, and 40 °C.

### 2.9. Consistency measurement

The consistency was determined via penetration test using a 45° acrylic cone fitted to a constant-speed QTS-25 texture analyzer (Brookfield, USA), according to the procedure described by D'agostini, Ferraz, and Gioielli (2000). The samples were heated to 70 °C for the complete melting of the crystals and then conditioned in 50 mL glass beakers (Pyrex, USA). The samples were tempered for 24 h in a common refrigerator (5–8 °C) and then for 24 h in a temperature-controlled oven (5–10 °C). The tests were conducted under the following conditions: determination of compression force, distance of 10.0 mm, speed of 120 mm/min, and time of 5 s. Measurements were performed in duplicate, and the reported value is the simple average of the two runs. The consistency was calculated as a "yield value" (gf/cm<sup>2</sup>) according to Eq. (3), as proposed by Haighton (1959):

$$C = K \times W/p^{1.6} \quad (3)$$

where "C" is the yield value (gf/cm<sup>2</sup>), "K" is a constant depending on the cone angle (4700, non-dimensional), "W" is the compression force (gf), and "p" is the penetration depth (0.1 mm).

### 2.10. Crystallization kinetics determination

The crystallization kinetics were analyzed by determining the solid fat content using NMR with a 20 MHz Maran Ultra Bench Top NMR device according to AOCS method Cd 16b-93 (2004). The blends in the NMR tubes were melted and kept at 60 °C for 30 min and then placed in a water bath at the crystallization temperatures of 3 °C, 10 °C, and 20 °C. The solid fat content was measured as a function of time up to 90 min. The original Avrami equation (Wright, Hartel, Narine, & Marangoni, 2000) was linearized (Eq. (4)) and applied to the results.

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