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Pijuayo (*Bactris gasipaes*) pulp and peel flours as partial substitutes of animal fat in burgers: Physicochemical properties †

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Abstract: This study aimed to evaluate the incorporation of Peach palm (PP) pulp and peel flours as substitutes for animal fat (25 and 50% substitution) in beef-based burgers. Incorporation of PP flours reduced hardness, springiness, cohesiveness, chewiness, fat, cooking losses, and diameter reduction. Burgers with PP peel flour stood out for having low values of lipid oxidation in the two levels of fat substitution (0.14–0.23 malondialdehyde/kg) ($p < 0.05$). PP fruit has the potential to be utilized as a new ingredient in burgers, but future studies are needed regarding detailed sensory trials and consumer acceptance.

Keywords: Animal fat; Amazon fruits; Instrumental texture; TBARS

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1. Introduction

The high intake of food with a high-fat content rich in saturated fat has been recognized as a risk factor for the development of cardiovascular diseases, obesity, diabetes, and gastrointestinal cancers. This is the case with meat products, which are known to contain high amounts of animal fat (up to 31%) [1]. The search for technological alternatives to reduce the fat content in meat products is a necessity in current times given consumers' demand towards a healthier diet.

There are multiple strategies to reduce animal fat in meat products, which include the use of healthy oils entrapped in microparticles, emulsions, oleogels and hydrogels, edible mushrooms, dehydrated agro-industrial residues, and fiber-rich vegetable flours [2–4]. These technologies are differentiated by the type of processing, which may have the purpose of imitating the structure of animal fat, as is the case of oleogels and hydrogels, or have simpler processes such as cooking and dehydrating, which are typical for agro-industrial by-products and vegetable flours. The last two could be more attractive to the industry due to the lower production cost; in addition, they can improve the technological characteristics of meat products, such as binding properties, cooking yield, and textural characteristics [3], even improving oxidative stability, as observed by Selani et al. [5] in beef burgers reduced in fat and added with pineapple by-product (peel and pomace). In this context, fruit-based ingredients may be a viable option to reduce animal fat in meat products.

The Amazon is a biome rich in native fruits with prebiotic, antioxidant, anti-inflammatory, and nutritional properties [6,7]. The fruits of some Amazon palm trees are rich in fiber and lipids [8], which draws attention to being used as fat substitutes. Among the fruits of palm trees is the Peach palm (PP) (*Bactris gasipaes*) fruit, known as *pijuayo* in Peru. The fruit can contain 18% lipids, of which the fatty acid profile is highlighted by the presence of linoleic acid (ω-6) (up to 21.1%). Also, PP is rich in β-carotenes, fiber and presents the majority of essential amino acids, such as lysine, methionine, phenylalanine, threonine, tryptophan, and valine [9–11].

Some evidence shows promising results from using PP derivatives in meat and fish products. Echeverria et al. [12] used PP flour to substitute pork fat to produce lamb burgers. It was evidenced that cooking yield, moisture retention, and dietary fiber content increased. Zapata and de la Pava [13] reported that adding PP flour as an extender in red tilapia sausages improved some textural properties and increased sensory acceptance, considering less than 3% addition levels. However, more studies are necessary considering other physicochemical parameters, which must subsequently be complemented with sensory profile and consumer acceptance.

Therefore, this study aimed to evaluate the incorporation of PP flour, obtained from the pulp and peel of PP, as a substitute for animal fat in beef-based burgers, considering the instrumental texture profile, proximal analysis, cooking losses, diameter reduction, and lipid oxidation.

2. Methods

2.1. PP pulp and peel flour

The flours were obtained by cooking PP in boiling water for 30 min, separating the pulp from the peel, and drying both pulp and peel, separately, in an oven with circulating air at 55 °C until reach a moisture < 15%.

2.2. Burger treatments

Five treatments were prepared according to Rios-Mera et al. [14], with modifications by varying the substitution of pork backfat: 0% substitution (T1), 25% (T2), and 50% (T3) substitution with PP pulp flour, and 25% (T4) and 50% (T5) substitution with PP peel flour. Ingredients are detailed in Table 1.

Table 1. Burger treatments.

Ingredient (%)	T1	T2	T3	T4	T5
Beef	70	70	70	70	70
Pork backfat	20	15	10	15	10
Peach palm pulp flour	0	5	10	0	0
Peach palm peel flour	0	0	0	5	10
Cold water	7.5	7.5	7.5	7.5	7.5
Salt	1.5	1.5	1.5	1.5	1.5
Monosodium glutamate	0.28	0.28	0.28	0.28	0.28
Garlic powder	0.28	0.28	0.28	0.28	0.28
Onion powder	0.28	0.28	0.28	0.28	0.28
White pepper powder	0.15	0.15	0.15	0.15	0.15
Sodium erythorbate	0.01	0.01	0.01	0.01	0.01

2.3. Proximal analysis

Moisture, ash, protein (Kjeldahl method), lipid (Soxhlet method), and carbohydrate (percentage difference) were performed on the burger samples according to the methodologies described by the AOAC [15].

2.4. Instrumental texture profile analysis

The texture profile parameters (hardness, springiness, cohesiveness, and chewiness) were determined in the cooked burgers, according to Rios-Mera et al. [16]. A texturometer

TVT 6700 (Perkin Elmer, Australia) was used with a 50 kg load cell, coupled to a cylindrical probe for texture determination. The burger samples (2.5 cm diameter, 1 cm height) were compressed up to 75% of their original height at a constant speed of 20 cm/min (pretest and posttest speed: 40 cm/min).

2.5. Cooking losses and diameter reduction

Cooking losses were calculated with the weight values before and after cooking, using Equation 1:

$$Cooking\ losses\ (\%) = \frac{Raw\ burger\ weight - Cooked\ burger\ weight}{Raw\ burger\ weight}\ x\ 100 \qquad (1)$$

Diameter reduction was calculated with the diameter values before and after cooking, using Equation 2:

$$Diameter\ reduction\ (\%) = \frac{Raw\ burger\ diameter - Cooked\ burger\ diameter}{Raw\ burger\ diameter}\ x\ 100 \qquad (2)$$

2.6. Lipid oxidation

Lipid oxidation of raw burger samples was performed by quantification of thiobarbituric acid reactive substances (TBARS), according to the Cd 19–90 method described by AOCS [17], with modifications described by Patinho et al. [18]. The analyzes were carried out after 14 days of storage at 4 °C. A solution containing 0.015 g of ethylenediamine tetraacetic acid (EDTA), 0.015 g of propyl gallate, and 15 mL of an aqueous solution of trichloroacetic acid (7.5 g/100 mL) was prepared, and mixed with 7 g of burgers using a vortex (1800 rpm, 1 min). The mixture was filtered (qualitative #4, 125 mm filter paper). Then, an aliquot of 2.5 mL from the filtrate was added to 2.5 mL of an aqueous thiobarbituric acid (TBA) solution (46 mM). The samples were kept in a water bath with boiling water (95 ± 5 °C) for 35 min and then cooled in an ice bath. The absorbance (532 nm) was read using a spectrophotometer (Thermo Scientific, UV–Visible Spectrophotometer, Genesys 150, Madison, USA). TBARS values were calculated from a standard curve (0.6, 1.0, 2.5, 5.0, 10.0 µM) of 1,1,3,3 tetraethoxypropane and expressed in mg of malonaldehyde (MDA)/kg of burger sample.

2.7. Data analysis

Data was analyzed using ANOVA and Tukey post hoc test at 5% of significance, in a randomized complete block design, considering treatments and block as sources of variation (the block was the repetition of the burger processing in three independent days).

3. Results and Discussion

The results of proximal composition, instrumental texture, cooking losses, diameter reduction, and lipid oxidation are shown in Table 2. Regarding the proximal composition, moisture levels ranged from 60.3–63.6%, protein from 14.3–15.9%, fat from 9.4 to 16.5%, carbohydrate from 4.8–8.9%, and ash from 2.4–3.0%. Significant differences were observed for moisture and ash but without a clear trend in applying PP flours. On the other hand, a significant reduction in fat content was expected, mainly in the treatments with the highest reduction in animal fat (T3 and T5).

Table 1. Mean values and standard deviation of proximal composition, texture profile analysis, cooking losses, diameter reduction, and lipid oxidation of beef-based burgers[1] added with Peach palm pulp and peel flours as animal fat substitutes.

Ingredient (%)	T1	T2	T3	T4	T5
Proximal composition					
Moisture	60.3±1.2^{b}	63.6±0.6^{a}	63.3±0.3^{a}	62.1±1.5^{ab}	63.2±0.2^{a}
Protein	15.4±0.2	14.4±0.5	15.7±0.2	15.7±2.5	15.9±0.5

Fat	16.5±1.2^{a}	13.0±0.9^{b}	9.4±0.5^{c}	13.1±0.4^{b}	9.6±0.3^{c}
Carbohydrates	4.8±0.9	5.2±0.4	8.7±0.4	8.1±2.9	8.9±0.8
Ash	3.0±0.0^{a}	2.6±0.1^{ab}	2.7±0.0^{ab}	2.4±0.3^{b}	2.6±0.3^{ab}
Texture profile analysis					
Hardness (N)	65.7±2.1^{a}	42.1±1.7^{c}	53.3±6.9^{b}	45.0±2.2^{bc}	48.3±0.8^{bc}
Springiness	0.89±0.0^{a}	0.69±0.1^{bc}	0.57±0.1^{c}	0.79±0.1^{ab}	0.59±0.1^{c}
Cohesiveness	0.68±0.0^{a}	0.48±0.0^{bc}	0.38±0.0^{d}	0.55±0.0^{b}	0.43±0.0^{cd}
Chewiness (N)	39.7±1.9^{a}	13.9±1.3^{bc}	11.5±0.9^{c}	19.7±5.5^{b}	12.2±2.2^{bc}
Cooking losses	30.3±1.5^{a}	22.3±0.6^{b}	10.3±0.6^{d}	17.2±0.3^{c}	11.7±0.3^{d}
Diameter reduction	22.6±1.3^{a}	18.2±0.6^{b}	15.2±0.2^{c}	18.0±0.9^{b}	16.0±0.8^{bc}
Lipid oxidation (TBARS)[2]	1.09±0.1^{a}	0.41±0.0^{b}	0.22±0.0^{c}	0.23±0.0^{c}	0.14±0.0^{c}

[1] T1: 0% fat substitution; T2: 25% fat substitution with PP pulp flour; T3: 50% fat substitution with PP pulp flour; T4: 25% fat substitution with PP peel flour; T5: 50% fat substitution with PP peel flour.
[2] Evaluated after 14 days of storage at 4 °C.
Different letters on the same line represent a significant difference ($p < 0.05$) between treatments, according to Tukey's test.

Adding the PP flours produced less hard, springy, cohesive, and chewy burgers than the control sample (T1). These results are contrary to that reported by Echevarria et al. [12] and Zapata and de la Pava [13] in the application of PP flour in lamb burgers and red tilapia sausages, respectively. Differences in preparation, raw materials, and ingredients may explain those differences; for example, in this study, the levels of animal fat and PP flours were higher than those reported by these authors, which could have caused interference in the formation of protein gel that has an impact on the final texture of meat products [19].

Cooking losses and diameter reduction also decreased significantly with the addition of PP flours, presumably due to the presence of fiber, which is usually high in PP fruit [9] and is associated with water retention in meat products. The carbohydrate levels in the samples with PP flours were higher than in the control sample, but the ANOVA did not identify the differences between treatments. Nevertheless, it can indicate higher fiber content in burgers with PP flours.

Finally, lipid oxidation was lower in samples with PP flours compared to the control ($p < 0.05$), especially with PP peel flour. It has been reported that PP peel contains high amounts of carotenoids [20], of which β-carotene has antioxidant activity [7]. Therefore, PP peel flour may have a slight advantage compared to PP pulp flour as a partial substitute for animal fat in burgers and possibly in other meat products.

4. Conclusions

PP fruit has the potential to be utilized as a new ingredient in burgers. Still, future studies are needed regarding detailed sensory profile, consumer acceptance, and a pilot scale study to evaluate their potential industrialization.

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