JOBIMB, 2025, Vol 13, No 2, 64-69
https://doi.org/10.54987/jobimb.v13i2.1138

HIBISCUS PUBLISHER

JOURNAL OF BIOCHEMISTRY, MICROBIOLOGY AND BIOTECHNOLOGY

Website: http://journal.hibiscuspublisher.com/index.php/JOBIMB/index

JOBIMB VOL 13 NO 2 2025
AI and Biochemistry

Effect of Sacha Inchi Oil Press-Cake (*Plukenetia volubilis* L.) on Physicochemical and Sensory Properties of Reduced-Fat Chicken Patties

Aizatul Aziqah Mohd Idris[1], Nurul Shaeera Sulaiman[1], Hana Mohd Zaini[1], Anthony Chai[1], Heong Man Hin[1], Hasmadi Mamat[2], Norhidayah Abdullah[3] and Wolyna Pindi[2*]

[1]Faculty of Food Science and Nutrition, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, Malaysia.
[2]Food Security Research Laboratory, Faculty of Food Science and Nutrition, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, Malaysia.
[3]Faculty of Hotel and Tourism Management, Universiti Teknologi MARA Selangor, Puncak Alam Campus, 42300 Puncak Alam, Selangor, Malaysia.

*Corresponding author:
Wolyna Pindi,
Food Security Research Laboratory,
Faculty of Food Science and Nutrition,
Universiti Malaysia Sabah,
Jalan UMS,
88400 Kota Kinabalu,
Sabah,
Malaysia.
Email: woly@ums.edu.my

History

Received: 27th May 2025
Received in revised form: 29th July 2025
Accepted: 20th Aug 2025

Keywords

Sacha inchi oil press-cake (SIOPC)
Fat replacement
Reduced-fat chicken patties
Physicochemical properties
Sensory evaluation

SDG Keywords

SDG 2 Zero Hunger
SDG 3 Good Health and Well-being
SDG 12 Responsible Consumption and Production

Abstract

This study analyzed the proximate composition of Sacha inchi oil press-cake (SIOPC) and its effects on the physicochemical and sensory properties of chicken patties. Five formulations were prepared: a control (F0) with 0% SIOPC and 10% fat, and four variations—F1 (2.5% SIOPC + 7.5% fat), F2 (5% SIOPC + 5% fat), F3 (7.5% SIOPC + 2.5% fat), and F4 (10% SIOPC + 0% fat). Proximate analysis of SIOPC revealed a remarkable protein (54.20%) and fat (22.87%) contents. Moreover, the addition of SIOPC in chicken patties significantly increased the ash content, while reducing the fat level ($p<0.05$). Fat replacement with SIOPC reduced pH and cooking loss ($p<0.05$) while improving water holding capacity and cooking yield. Color analysis showed no effect on lightness (L*) but decreased redness (a*) and yellowness (b*) ($p<0.05$). Texture profile analysis indicated significant differences ($p<0.05$) in hardness, chewiness, and resilience, but not in cohesiveness and springiness ($p>0.05$). Sensory evaluation found no significant differences ($p>0.05$) in color, aroma, taste, or overall acceptance, though F2 received the highest score among SIOPC-enriched formulations. Overall, SIOPC shows promise as a fat replacer in reduced-fat chicken patties.

INTRODUCTION

Rapid growth of human population has caused an increase in meat consumption over the last 20 years [1]. According to the OECD-FAO Agricultural Outlook [2], poultry was the most consumed meat globally in 2019. Malaysia is projected to rank as the second highest country in poultry meat consumption by 2029, with an estimated 53.14 kg per capita. Poultry meat has a high protein content and is rich in B-complex vitamins, phosphorus, and other minerals. It also has a lower fat level than most beef and pork cuts. About half of the fat in poultry meat is monounsaturated fat, which is greater in molecular weight than trans fats and is thought to be healthful [2]. Despite the nutrition that poultry products provide, most people still purchase processed meat products such as chicken patties, nuggets and sausages, over fresh poultry meat, due to various factors such as financial resources, food environment, price and time constraint [3]. Although processed meat products are more affordable and convenient to prepare, they are often considered unhealthy due to the health risks they pose to consumers and their lower nutritional value compared to unprocessed meat, as some nutrients are lost during processing [4]. For instance, protein can be easily denatured when being cooked at a high temperature [5], thus providing consumers with less protein compared to the amount of food they have taken.

Due to the increasing awareness on meat and meat products, there is an increasing demand for low-fat or reduced-fat meat products over these few decades. Meat and meat products contain high saturated fat which can increase the risk of diseases,

https://doi.org/10.54987/jobimb.v13i2.1138

therefore low-fat and reduced-fat meat products may fulfill consumer health demand. Three methods have been used to reduce fat, including replacing fat with one or more useful substances, diluting fat with water, and extracting the high-calorie components following traditional manufacturing [6]. Moreover, plant-based derivatives like fruits, nuts, vegetables, herbs, and spices are mainly used nowadays to replace animal fat in meat products. Some of the most common ingredients used to replace animal fat are canola oil, rapeseed oil, soybean oil, palm oil, coconut oil and sunflower oil [7-8]. Recently, Sacha inchi (*Plukenetia volubilis* L.), a plant native to the Amazon rainforest and traditionally a staple food among tribal communities in Peru, is gaining commercial interest in Malaysia. Sancha inchi kernels are high in minerals, vitamin E, vital amino acids, oils (35–60%), proteins (25–30%), and other nutrients [9-11]. It has been used in many different fields such as food ingredients, medicine and in cosmetics due to its anti-inflammatory and antibacterial properties [9,12-13].

Sacha inchi are typically used for its oil, which are usually extracted through hydraulic press or screw press extraction method. These methods often produce by-products once the extraction method has been completed, which is called an oil press-cake. Sacha inchi oil press-cake (SIOPC) contains abundant amounts of bioactive compounds such as free fatty acids, glycerides, phosphatides, sterols, tocopherols and protein fragments [9]. Moreover, SIOPC has a low fat and high dietary fiber content which makes it an ideal fat replacer for meat and meat products [9]. In addition, the high percentage of protein content, especially essential amino acids such as lysine, leucine and histidine in SIOPC may improve the nutritional value of processed meat products [13-14]. Therefore, this study aims to determine the effects of incorporating SIOPC with chicken patties on physicochemical properties, sensory attributes of the reduced-fat chicken patties.

MATERIALS AND METHODS

Materials

The boneless chicken breast and chicken fat (CF) were obtained from Desa Hatchery Sdn. Bhd., Lok Kawi, Sabah, Malaysia. Sacha inchi seed was purchased from Koperasi Agro Borneo Bayu, Kota Kinabalu, Sabah, Malaysia. Meanwhile, dry ingredients were obtained from the local market around Kota Kinabalu, Sabah, Malaysia. All chemicals and solvents used were of analytical grade and obtained from Rinitek Sdn. Bhd.

Preparation of Sacha inchi oil press cake

The seed were first dried in a drying cabinet at 60 °C overnight, then it was blended using a blender before extracting the oil through cold press extraction under 50 MPa at 25 °C with a hydraulic press machine (Manual Hydraulic Press 20-Tonne, Malaysia). The press cake was ground using a dry grinder machine (Orimas, FFC23, Malaysia) and sieved before kept in freezer at -4 °C [15].

Development of chicken patties formulation

The formulation of chicken patties, as presented in **Table 1**, was adapted from Pindi et al. [16] and Guedes-Oliveira et al. [17]. A meat mincer was used to mince 65 g of chicken breast, after which 1.0 g of salt was added, and the mixture was processed for 90 s. Ice water was then incorporated, and the mixture was further processed for 2 min to maintain a consistent temperature. Varying amounts of chicken fat were added and mixed for 4 min (F0: 10.0 g; F1: 7.5 g; F2: 5.0 g; F3: 2.5 g). Subsequently, dry ingredients (5.0 g potato starch, 0.5 g black pepper, 0.5 g white pepper, and powdered onion) along with SIOPC (F0: 0 g; F1: 2.5 g; F2: 5.0 g; F3: 7.5 g) were incorporated and mixed for an additional 2 min. A motorized burger mold (Sirman, Italy) was used to portion and shape approximately 80 g of the meat batter into patties. The patties were stored at 4 °C until further analysis.

Table 1. Formulation of control chicken patties and chicken patties incorporated with SIOPC as fat replacer.

Ingredients (%)	Formulation				
	F0	F1	F2	F3	F4
Chicken meat	65.0	65.0	65.0	65.0	65.0
Chicken fats	10.0	7.5	5.0	2.5	0
SIOPC	0	2.5	5.0	7.5	10
Iced water	17.0	17.0	17.0	17.0	17.0
Potato starch	5.0	5.0	5.0	5.0	5.0
Salt	1.0	1.0	1.0	1.0	1.0
Sugar	0.5	0.5	0.5	0.5	0.5
Black pepper	0.5	0.5	0.5	0.5	0.5
White pepper	0.5	0.5	0.5	0.5	0.5
Powdered onion	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100

Proximate composition of Sacha inchi oil press cake and chicken patties

A Kjedhal assembly (Kjeltech 2300 Analyzer Unit, Foss Analytical, Denmark), a Soxhlet extraction apparatus (Soxtech Avanti 2050 Auto System, Foss Analytical, Denmark), a hot air oven, and a muffle furnace, were used to determine the protein, lipid, moisture, ash, and moisture contents of the SIOPC and chicken patties. All analyses were conducted following the AOAC methods.

Physicochemical properties and sensory evaluations on chicken patties

Expressible water

Expressible water, which indicates the water holding capacity (WHC), was characterized by centrifugal loss using the centrifugation method [18]. The sample was divided into 1 cm long, weighed, and covered with filter paper. After that, the sample was centrifuged (Kubota 5220, Japan) for 20 min at 10 °C at 5,000 x g. The sample was weighed again after the filter paper was taken out. The expressible water (%) was calculated based on the formula, $[(W_1 – W_2)/W_1) \times 100]$. W_1 is the initial weight of sample, whereas W_2 is the weight of sample after centrifugation.

Cooking yield and cooking loss

The cooking yield and cooking loss was determined based on Chiong et al. [3] and Pindi et al. [19]. Initially, the sample was pan-fried for 6 min on each side using 10 mL of cooking oil. After the patties are cooled, samples were weighed again. Cooking loss (%) was calculated using the formula, $[(W_2/W_1) \times 100)]$, whereas cooking loss (%) was calculated by $[(W_1 – W_2)/W_1 \times 100]$. W_1 is the initial weight of sample and W_2 is the weight of cooked sample.

Texture profile analysis

The texture profile of the sample was determined using TA. XT Plus Texture Analyzer (Stable Micro System, UK) with P/50 cylindrical probe (50 mm diameter) at room temperature. The method was based on Feng et al. [20], where the samples were cut into 25 mm x 25 mm x 10 mm pieces. After that, the patties were subjected to a two-cycle compression using a 25 kg load cell and compressed to 30% of their original height. The test condition was set at a pre-test speed of 2.0 mm/s, test speed of 1.0 mm/s, and post-test speed of 5.0 mm/s. Parameters that were assessed are cohesiveness (dimensionless), springiness (mm), hardness (g), chewiness (g) and resilience (dimensionless).

Color
The color of the samples was measured using a colorimeter (Hunter Lab Colorflex 45/0, USA), following the method described by Pindi et al. [16]. Color measurements were recorded using the CIE color scale, which includes three parameters: L*, a*, and b*. The L* value represents lightness, ranging from 0 (black) to 100 (white). The a* value indicates redness (+a) to greenness (–a), while the b* value reflects yellowness (+b) to blueness (–b). All measurements were recorded accordingly for the chicken patties.

pH determination
About 10 g of chicken patty sample was homogenized with 100 mL of deionized water [21]. The pH of the resulting homogenate was measured at 25 °C using a pH meter (PH2700, Eutech Instruments Pte Ltd., United Kingdom).

Sensory evaluation
The sensory evaluation was performed using the 7-point hedonic scale (1-dislike very much, 2-dislike moderately, 3-dislike slightly, 4- neither like nor dislike, 5-like slightly, 6-like moderately, 7-like very much) by 40 randomly picked untrained panellists. The panellists were students aged 20 – 26 years (20 males and 20 females) from the Faculty of Food Science and Nutrition, Universiti Malaysia Sabah. The patty samples were labelled with three-digit numbers and randomly given to the panellists. The panelists were also given a glass of water to cleanse their palate. Color, aroma, texture, taste and overall acceptance were evaluated.

Statistical Analysis
All analyses were performed in triplicates. Data analysis was conducted using SPSS 25.0 software (IBM Corporation, New York, United States) with one-way Analysis of Variance (ANOVA), accompanied by Tukey's HSD test for multiple comparisons at $p<0.05$.

RESULTS AND DISCUSSION

Proximate composition of Sacha inchi oil press cake
The proximate composition of SIOPC is presented in **Table 2**. The ash content was 1.83%, which is relatively low compared to values reported in previous studies [9]. The moisture content was recorded at 4.99%, slightly below the range reported in earlier research (5.1–12.4%) [9,13]. The protein content was notably high at 54.20%, surpassing that of pumpkin seed and sunflower seed oil press cakes [22-23], highlighting its potential as a protein enhancer in food products. The fat content was 7.45%, which is consistent with the findings of Torres Sánchez et al. [24]. Lipids are the most abundant component of Sacha inchi kernels, however, only 5-25% lipids may remain in Sacha inchi oil press cake, depending on the efficiency of the extraction technique [24].

Table 2. Proximate composition result on Sacha inchi oil press cake (n=3).

Composition	Percentage (%)
Ash	1.83 ± 0.09
Moisture	4.99 ± 0.04
Protein	54.20 ± 0.13
Fat	7.45 ± 0.69

Proximate composition of chicken patties
The proximate composition of the samples is presented in **Table 3**. The control sample (F0) exhibited the lowest ash content (1.26%), while F4, which contained 10% SIOPC, had the highest ash content (1.63%). This increasing trend is likely attributed to the high mineral content of SIOPC, which is known to be rich in phosphorus, calcium, and magnesium [9]. Moisture plays a critical role in food preservation, quality, and shelf life, and accurate moisture determination is essential for calculating the concentration of other components in food products [25]. The results show a decreasing trend in moisture content with increasing levels of SIOPC. The highest moisture content was recorded in F0 (71.02%), while F4 showed the lowest (64.59%). This reduction in moisture may be attributed to the inherently low moisture content of SIOPC. Similar trends have been reported in other studies [26].

Table 3. Proximate composition on chicken patty formulations.

Form-ulation	Ash	Moisture	Protein	Fat
F0	1.26 ± 0.40[a]	71.02 ± 3.16[a]	26.55 ± 0.86[c]	6.03 ± 0.42[a]
F1	1.33 ± 0.04[a]	71.98 ± 0.08[a]	29.33 ± 1.02[b]	5.21 ± 0.39[ab]
F2	1.32 ± 0.14[a]	69.56 ± 0.43[a]	30.68 ± 0.97[b]	4.58 ± 0.44[b]
F3	1.51 ± 0.21[a]	64.88 ± 5.53[a]	32.03 ± 1.05[a]	3.96 ± 0.59[bc]
F4	1.63 ± 0.52[a]	64.59 ± 4.90[a]	33.38 ± 1.14[a]	3.34 ± 0.61[c]

Note: The treatments were formulated by: F0 (0% SIOPC + 10% fat), F1 (2.5% SIOPC + 7.5% fat), F2 (5% SIOPC + 5% fat), F3 (7.5% SIOPC + 2.5% fat), and F4 (10% SIOPC + 0% fat).
[a-c] Equal letters in the same column are not statistically different ($p>0.05$).

Sample F0 recorded the lowest protein content (26.55%) and the highest fat content (6.03%), while F4 showed the highest protein (33.38%) and lowest fat (3.34%) levels. This trend reflects the varying amounts of animal fat used in the formulations, with F0 containing the most and F4 the least. Overall, increasing the concentration of SIOPC led to higher protein levels and reduced fat content, likely due to the naturally high protein content of SIOPC. Similar results were observed by Kerner et al. [27], where the inclusion of 2% mechanically pressed hempseed cake elevated protein content in pork patties.

Water holding capacity, pH, cooking yield and cooking loss
Table 4 presents the results for water holding capacity (WHC), pH value, cooking yield, and cooking loss for each sample analyzed. WHC is a critical quality attribute in meat and meat products, as it influences product yield, visual appeal, weight loss during storage and cooking, as well as sensory characteristics upon consumption [28]. WHC was assessed based on expressible water, where a higher amount of expressible water indicates lower water-holding capacity. As shown in **Table 4**, WHC increased with the addition of SIOPC in the chicken patty formulations. This finding aligns with expectations, as SIOPC is rich in dietary fiber, which contributes to enhanced water retention in meat products.

Previous studies have also reported that fat replacers can improve the water-binding capacity of reduced-fat meat products [29]. The observed decrease in pH of the chicken patties with increasing levels SIOPC may be attributed to the intrinsic acidity of Sacha inchi. Notably, the pH trend is non-linear, with a gradual decline from formulations F0 to F3, followed by an unexpected increase in F4, despite its highest SIOPC content. This deviation may be due to changes in the matrix composition, particularly the absence of animal fat and the elevated protein content in F4, which could enhance the buffering capacity of the formulation and counteract the acidifying effect of SIOPC. These findings suggest that pH modulation in the patties is influenced not only by the acidity of individual ingredients but also by the interactions between fat and protein components. Supporting this, Kirkyol and Akköse [30] reported that reducing animal fat content in beef patties led to increased pH values, as animal fat is a source of free fatty acids. Therefore, lower animal fat levels may contribute to a rise in pH.

https://doi.org/10.54987/jobimb.v13i2.1138

Table 4. Expressible water, pH value, cooking yield and cooking loss result for chicken patty formulations.

Formulation	Expressible water (%)	pH	Cooking yield (%)	Cooking loss (%)
F0	29.02 ± 1.05^{a}	6.40 ± 0.14^{a}	83.96 ± 0.74^{c}	16.04 ± 0.73^{a}
F1	15.63 ± 4.14^{b}	5.68 ± 0.01^{c}	91.86 ± 4.31^{bc}	8.14 ± 4.30^{ab}
F2	13.00 ± 0.88^{bc}	5.77 ± 0.02^{c}	91.08 ± 0.95^{bc}	8.91 ± 0.95^{ab}
F3	11.35 ± 0.86^{c}	5.76 ± 0.01^{c}	95.48 ± 2.94^{a}	4.52 ± 2.94^{b}
F4	7.29 ± 3.33^{d}	6.07 ± 0.07^{b}	94.94 ± 2.14^{a}	5.06 ± 2.14^{b}

Note: The treatments were formulated by: F0 (0% SIOPC + 10% fat), F1 (2.5% SIOPC + 7.5% fat), F2 (5% SIOPC + 5% fat), F3 (7.5% SIOPC + 2.5% fat), and F4 (10% SIOPC + 0% fat).
$^{a-c}$Equal letters in the same column are not statistically different (p>0.05).
*Expressible water is inversely related to water holding capacity (WHC); lower values indicate higher WHC.

Cooking yield and cooking loss are closely associated with WHC, as an increase in WHC typically leads to higher cooking yield and reduced cooking loss. A similar trend was reported by Bin Mohd Zaini et al. [31] in their study on the effects of banana peel powder in fish patties. The control sample (F0) exhibited greater cooking loss due to the lack of components capable of binding water and fat, other than the fat itself. This lack of binding leads to excessive water and fat separation during processing and cooking [32].

Color

The results of the color analysis are presented in **Table 5**. No significant differences (p>0.05) were observed in L* values among the formulations, although F4 recorded the highest L* value (29.18) and F2 the lowest (27.76). In contrast, significant differences (p<0.05) were observed in both a* and b* values between the control and the other formulations. The control sample (F0) exhibited the highest a* and b* values, while F4 showed the lowest. A visual comparison of the color differences among the chicken patty formulations is provided in **Fig. 1**.

Table 5. Color result for chicken patty formulation.

Formulation	L* (lightness)	a* (redness)	b* (yellowness)
F0	28.01 ± 0.76^{a}	5.04 ± 0.64^{a}	13.33 ± 0.69^{a}
F1	27.93 ± 0.46^{a}	3.87 ± 0.17^{b}	11.80 ± 0.71^{b}
F2	27.76 ± 1.17^{a}	3.60 ± 0.14^{bc}	10.74 ± 0.31^{bc}
F3	29.00 ± 2.20^{a}	3.14 ± 0.10^{bc}	10.53 ± 0.53^{bc}
F4	29.18 ± 1.63^{a}	2.86 ± 0.25^{d}	10.46 ± 0.57^{c}

Note: The treatments were formulated by: F0 (0% SIOPC + 10% fat), F1 (2.5% SIOPC + 7.5% fat), F2 (5% SIOPC + 5% fat), F3 (7.5% SIOPC + 2.5% fat), and F4 (10% SIOPC + 0% fat).
$^{a-c}$Equal letters in the same column are not statistically different (p>0.05).

Replacing animal fat with vegetable-based ingredients such as SIOPC can influence the color characteristics of meat products, although the extent and nature of these changes depend on both the type and amount of fat substitute used [33]. In this study, F3 (7.5% SIOPC) and F4 (10% SIOPC) showed gradual increase in L* values. This trend may reflect the dilution or dispersion of color pigments due to the fibrous nature of the press cake, which can scatter light and lead to a lighter appearance. The higher a* value (redness) in F0 likely results from the presence of animal fat, which helps preserve the natural red pigments, mainly myoglobin and hemoglobin [34]. The decrease in b* values (yellowness) with increasing SIOPC addition may be attributed to enhanced WHC, as higher water retention can dilute surface pigments and reduce color intensity [8,32]. Moreover, the darker appearance of higher-SIOPC formulations could be partly due to the inherent color of the press cake itself, which may also contribute to lower b* values.

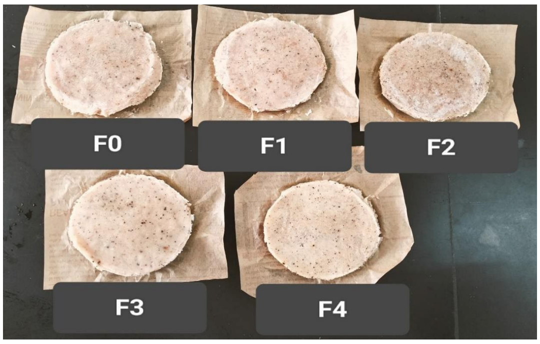

Fig. 1. Chicken patties treated with different formulations.

Texture profile analysis

The chicken patties were evaluated for textural properties, including hardness, cohesiveness, springiness, chewiness, and resilience. As shown in **Table 6**, sample F4 exhibited the highest values for hardness (4690 g), cohesiveness (1.01), and chewiness (4686.66 g), suggesting that increasing the amount of SIOPC in the formulation leads to greater hardness, cohesiveness, and chewiness in the patties. The elevated hardness observed in F4 may be attributed to the reduction in fat content, resulting in a firmer texture. Kumar [35] reported that decreasing fat content in meat products is associated with increased firmness. Furthermore, the increased dietary fiber content from SIOPC may have contributed to this effect, as fiber chain length is known to influence textural properties. Similar findings were reported by Özhamamcı [26], where the use of fat substitutes in chicken patties led to higher hardness values. The increase in chewiness may be closely related to the higher hardness, as these parameters are interdependent. Conversely, an increase in Sacha inchi oil press cake led to a decrease in both springiness and resilience, with F4 showing the lowest values for springiness (0.99 mm) and resilience (0.13).

Sensory evaluation

The results of the sensory evaluation for chicken patties formulated with SIOPC is presented in **Table 7**. Color is a key quality attribute, as it plays a significant role in shaping consumer perception, behavior, and overall assessment of food quality. No significant differences (p>0.05) in color were observed between the control sample and the other formulations. This similarity may be attributed to the Maillard reaction that occurs during frying, which leads to browning on the surface of the patties. Aroma and taste also showed no significant differences across the formulations (p > 0.05), indicating a consistent sensory profile. This outcome may be explained by the close interplay between aroma and taste in flavor perception, as highlighted by Wallace [36].

Table 6. Texture profile analysis of chicken patties.

Formulation	Hardness (g)	Cohesiveness (unitless)	Springiness (mm)	Chewiness (N·mm)	Resilience (unitless)
F0	4059.52±147.68^{b}	0.92 ± 0.01^{a}	1.01 ± 0.04^{a}	3891.95 ± 184.51^{b}	0.27 ± 0.04^{a}
F1	4208.72 ± 247.48^{ab}	0.96 ± 0.04^{a}	0.98 ± 0.01^{a}	3921.31 ± 118.79^{b}	0.25 ± 0.00^{a}
F2	4268.03 ± 61.90^{ab}	0.99 ± 0.02^{a}	0.99 ± 0.00^{a}	4252.57 ± 118.58^{ab}	0.14 ± 0.01^{b}
F3	4376.34 ± 72.25^{ab}	0.98 ± 0.07^{a}	0.99 ± 0.00^{a}	4660.11 ± 204.56^{b}	0.14 ± 0.03^{b}
F4	4690.29 ± 18.54^{a}	1.01 ± 0.00^{a}	0.99 ± 0.01^{a}	4686.66 ± 52.67^{a}	0.13 ± 0.00^{b}

Note: The treatments were formulated by: F0 (0% SIOPC + 10% fat), F1 (2.5% SIOPC + 7.5% fat), F2 (5% SIOPC + 5% fat), F3 (7.5% SIOPC + 2.5% fat), and F4 (10% SIOPC + 0% fat).
$^{a-c}$Equal letters in the same column are not statistically different (p>0.05).

Table 7. Sensory evaluation of chicken patties.

Formulation	Color	Aroma	Taste	Texture	Overall acceptance
F0	5.42 ± 1.26[a]	5.86 ± 0.89[a]	5.63 ± 1.43[ab]	5.86 ± 1.13[a]	5.91 ± 0.95[a]
F1	5.30 ± 1.32[a]	5.51 ± 1.26[a]	5.53 ± 1.10[ab]	5.56 ± 1.22[a]	5.63 ± 1.02[a]
F2	5.44 ± 1.31[a]	5.70 ± 1.28[a]	5.70 ± 1.34[a]	5.56 ± 1.48[a]	5.67 ± 1.32[a]
F3	5.44 ± 1.52[a]	5.60 ± 1.07[a]	5.49 ± 1.44[ab]	5.33 ± 1.58[a]	5.37 ± 1.53[a]
F4	5.33 ± 1.52[a]	5.40 ± 1.37[a]	4.84 ± 1.84[b]	5.20 ± 1.47[a]	5.21 ± 1.70[a]

Note: The treatments were formulated by: F0 (0% SIOPC + 10% fat), F1 (2.5% SIOPC + 7.5% fat), F2 (5% SIOPC + 5% fat), F3 (7.5% SIOPC + 2.5% fat), and F4 (10% SIOPC + 0% fat).
[a-c]Equal letters in the same column are not statistically different ($p>0.05$).

F2 recorded the highest texture score (5.70), which was significantly higher than that of other samples, while F4 received the lowest texture score (4.84). Similar findings have been reported in previous studies, where formulations incorporating fat replacers demonstrated improved texture scores compared to control samples [17,21]. The low texture score for F4 may be attributed to its high hardness and chewiness values, along with a reduced animal fat content, which can negatively affect mouthfeel and overall texture perception. F4 received the lowest score for overall acceptance (5.21), likely due to its reduced moisture and fat content, as well as lower water-holding capacity, all of which can adversely impact sensory perception.

F2 showed a slightly higher mean score in overall acceptance and taste compared to the other samples, including the control. While these differences were not significant, the trend suggests that F2 may offer a promising balance between sensory acceptability and cost-effectiveness. Notably, F2 requires a lower amount of SIOPC than F3 and F4, reducing formulation costs while maintaining acceptable sensory quality.

CONCLUSION

Substituting animal fat with SIOPC in chicken patties demonstrated potential for reducing fat content without compromising sensory attributes. The proximate composition analysis of SIOPC revealed a high protein and fat content relative to its ash and moisture content. In the formulated chicken patties, the incorporation of SIOPC at levels of 2.5%, 5%, 7.5%, and 10% led to reductions in moisture, protein, and fat content, while ash content increased correspondingly. Additionally, the inclusion of SIOPC improved WHC, enhanced cooking yield, and contributed to a reduction in both pH value and cooking loss. Textural analysis indicated that increasing the proportion of SIOPC resulted in higher hardness, cohesiveness, and chewiness, but lowered springiness and resilience. Among all formulations, F2 achieved the highest overall acceptability score, likely attributed to favorable evaluations in aroma and taste. However, aftertaste or bitterness was not evaluated in this study, and future research should consider assessing these attributes to gain a more comprehensive understanding of consumer preferences. These findings suggest that Sacha inchi oil press cake is a promising ingredient for developing healthier meat products by reducing fat content while maintaining acceptable sensory qualities.

CONFLICT OF INTEREST

The authors have declared that no conflict of interest exists.

REFERENCE

1. Skwarek P, Karwowska M. Fruit and vegetable processing by-products as functional meat product ingredients—a chance to improve the nutritional value. LWT. 2023; 115442. https://doi.org/10.1016/j.lwt.2023.115442
2. OECD. Meat consumption Internet. 2024 cited 2024 May 2. Available from: https://data.oecd.org/agroutput/meat-consumption.htm
3. Chiong AZY, Sulaiman NS, Zaini HM, Heong MH, Chai A, George R, Pindi W. The effects of Polod (*Arenga undulatifolia*) powder towards physicochemical properties and sensory attributes of chicken patties. Int J Food. 2024; 1(1):69-80. https://10.51200/ijf.v1i1.4882
4. Ferreira VCS, Morcuende D, Madruga MS, Silva FAP, Estévez M. Role of protein oxidation in the nutritional loss and texture changes in ready-to-eat chicken patties. Int J Food Sci Technol. 2018; 53(6):1518–1526. https://doi.org/10.1111/ijfs.13733
5. Zhang Y, Zhang P, Peng H, Chen Q, Jiao X, Jia J, Wang L. Effects of cooking processes on protein nutritional values and volatile flavor substances of silver carp (*Hypophthalmichthys molitrix*). Foods. 2023; 12(17):3169. https://doi.org/10.3390/foods12173169
6. Shaheen S, Kamal M, Zhao C, Farag MA. Fat substitutes and low-calorie fats: A compile of their chemical, nutritional, metabolic and functional properties. Food Rev Int. 2023; 39(8):5501-5527. https://doi.org/10.1080/87559129.2022.2073368
7. Ahmad M, Qureshi S, Akbar MH, Siddiqui SA, Gani A, Mushtaq M, et al. Plant-based meat alternatives: Compositional analysis, current development and challenges. Appl Food Res. 2022; 2(2):100154. https://doi.org/10.1016/j.afres.2022.100154
8. Sulaiman NS, Zaini HM, Akanda MJH, Heong MH, Chai A, Pindi W. Improving functionality of myofibrillar protein: A comparative study on fat types on the resulting gelling and microstructure properties. Food Bioprocess Tehcnol. 2024; 17:5260-5272. https://doi.org/10.1007/s11947-024-03436-7
9. Torres Sánchez EG, Hernández-Ledesma B, Gutiérrez LF. Sacha Inchi oil press-cake: Physicochemical characteristics, food-related applications, and biological activity. Food Rev Int. 2021; 1–12. https://doi.org/10.1080/87559129.2021.1900231
10. Vanegas-Azuero AM, Gutiérrez LF. Physicochemical and sensory properties of yogurts containing Sacha Inchi (*Plukenetia volubilis* L.) seeds and β-glucans from *Ganoderma lucidum*. J Dairy Sci. 2018; 101(2):1020–1033. https://doi.org/10.3168/jds.2017-13235
11. Gutiérrez LF, Quiñones-Segura Y, Sanchez-Reinoso Z, Díaz DL, Abril JI. Physicochemical properties of oils extracted from γ-irradiated Sacha Inchi (*Plukenetia volubilis* L.) seeds. Food Chem. 2017; 237:581–587. https://doi.org/10.1016/j.foodchem.2017.05.148
12. Wang S, Zhu F, Kakuda Y. Sacha Inchi (*Plukenetia volubilis* L.): Nutritional composition, biological activity, and uses. Food Chem. 2018; 265:316–328. https://doi.org/10.1016/j.foodchem.2018.05.055
13. Rawdkuen S, Murdayanti D, Ketnawa S, Phongthai S. Chemical properties and nutritional factors of pressed-cake from tea and Sacha Inchi seeds. Food Biosci. 2016; 15:64–71. https://doi.org/10.1016/j.fbio.2016.05.004
14. Rawdkuen S, D'Amico S, Schoenlechner R. Physicochemical, functional, and in vitro digestibility of protein isolates from Thai and Peru Sacha Inchi (Plukenetia volubilis L.) oil press-cakes. Foods. 2022; 11(13):1869. https://doi.org/10.3390/foods11131869
15. Mich M, Ung RP, Chab S, Net M, Kong S, Tan R, Tan CP. Alkaline extraction of protein from Sacha Inchi oil press-cake: Effect of pH, temperature, and extraction time. J Food Sci Nutr Res. 2024; 7(1):74-79. https://doi.org. 10.26502/jfsnr.2642-110000154
16. Pindi W, Siang OW, Munsu E, Mohd Zaini H, Sulaiman NS, Matanjun P, Wahab NA, Mantihal S. The influence of utilizing red tropical *Kappaphycus alvarezii* gel as a fat substitute on the quality of chicken patties. J Appl Phycol. 2023; 1-9. https://doi.org/10.1007/s10811-023-03018-8
17. Guedes-Oliveira JM, Salgado RL, Costa-Lima BR, Guedes-Oliveira J, Conte-Junior CA. Washed cashew apple fiber (*Anacardium occidentale* L.) as fat replacer in chicken patties. LWT-Food Sci Technol. 2016; 71:268-273. https://doi.org/10.1016/j.lwt.2016.03.067
18. Zheng H, Han M, Yang H, Xu X, Zhou G. The effect of pressure-assisted heating on the water holding capacity of chicken batters. Innov Food Sci Emerg Technol. 2018; 45:280–286. https://doi.org/10.1016/j.ifset.2017.12.020
19. Pindi W, Qin LW, Sulaiman NS, Mohd Zaini H, Munsu E, Wahab NA, Mohd Noor NQI. Effects of salt reduction and the inclusion of seaweed (*Kappaphycus alvarezii*) on the physicochemical

properties of chicken patties. Appl Sci. 2023; 13(9):5447. https://doi.org/10.3390/app13095447
20. Feng J, Kong B, Sun F, Xia X. Effect of potato dietary fiber on the quality, microstructure, and thermal stability of chicken patty. Foods. 2022; 11(24):3978. https://doi.org/10.3390/foods11243978
21. Ismail-Fitry M, Abas N. Potential use of jackfruit (Artocarpus heterophyllus) and breadfruit (Artocarpus altilis) as fat replacer to produce low-fat chicken patties. Int J Eng Technol. 2018; 7:292-296. https://doi.org/10.14419/ijet.v7i4.14.27659
22. Jukić M, Lukinac J, Čuljak J, Pavlović M, Šubarić D, Koceva Komlenić D. Quality evaluation of biscuits produced from composite blends of pumpkin seed oil press cake and wheat flour. Int J Food Sci Technol. 2019; 54(3):602-609. https://doi.org/10.1111/ijfs.13838
23. Vasudha C, Sarla L. Nutritional quality analysis of sunflower seed cake (SSC). Pharma Innov J. 2021; 10(4):720-728.
24. Torres Sánchez EG, Hernández-Ledesma B, Gutiérrez LF. Sacha inchi oil press-cake: Physicochemical characteristics, food-related applications and biological activity. Food Rev Int. 2023; 39(1):148-159. https://doi.org/10.1080/87559129.2021.1900231
25. Nielsen SS. Moisture content determination. Food Sci Text Ser. USA: Springer, Cham; 2017. p. 105–115.
26. Özhamamcı İ. Coffee silverskin as a fat replacer in chicken patty formulation and its effect on physicochemical, textural, and sensory properties. Appl Sci. 2024; 14(15):6442. https://doi.org/10.3390/app14156442
27. Kerner K, Jõudu I, Tänavots A, Venskutonis PR. Application of raw and defatted by supercritical CO2 hemp seed press-cake and sweet grass antioxidant extract in pork burger patties. Foods. 2021; 10(8):1904. https://doi.org/10.3390/foods10081904
28. Warner RD. The eating quality of meat: IV—Water holding capacity and juiciness. In: Lawrie's Meat Science. Woodhead Publishing; 2023. p. 457-508.
29. Varga-Visi É, Toxanbayeva B. Application of fat replacers and their effect on quality of comminuted meat products with low lipid content: A review. Acta Aliment. 2017; 46(2):181-186. https://doi.org/10.1556/066.2016.0008
30. Kirkyol M, Akköse A. Effects of animal fat replacement with almond flour on quality parameters of beef patties. Food Sci Nutr. 2023; 11(11):7091-7099. https://doi.org/10.1002/fsn3.3633
31. Bin Mohd Zaini H, Bin Sintang MD, Dan YN, Ab Wahab N, Bin Abdul Hamid M, Pindi W. Effect of addition of banana peel powder (Musa balbisiana) on physicochemical and sensory properties of fish patty. Br Food J. 2019; 121(9):2179-89. DOI 10.1108/BFJ-02-2019-0130. https://doi.org/10.1108/BFJ-02-2019-0130
32. Bastos SC, Pimenta MESG, Pimenta CJ, Reis TA, Nunes CA, Pinheiro ACM, Leal RS. Alternative fat substitutes for beef burger: technological and sensory characteristics. J Food Sci Technol. 2014;51(9):2046–53. https://doi.org/10.1007/s13197-013-1233-2
33. Wirkowska-Wojdyła M, Bryś J, Ostrowska-Ligęza E, Górska A, Chmiel M, Słowiński M, Piekarska J. Quality and oxidative stability of model meat batters as affected by interesterified fat. Int J Food Prop. 2019; 22(1):607-617. https://doi.org/10.1080/10942912.2019.1596125
34. Hamidon FN, Faridah MR, Asyrul-Izhar AB, Sani MSA, Ismail-Fitry MR. Effect of fat replacement with different types of eggplants on the physicochemical and sensorial properties of chicken sausages: A chemometric approach. Malays J Anal Sci. 2022;26(6):1313-1331. https://doi.org/10.11113/mjas.v26n6.14
35. Kumar Y. Development of low-fat/reduced-fat processed meat products using fat replacers and analogues. Food Rev Int. 2019; 37(3):296–312. https://doi.org/10.1080/87559129.2019.1704001
36. Wallace MT. Multisensory perception: The building of flavor representations. Curr Biol. 2015; 25(20):986–988. https://doi.org/10.1016/j.cub.2015.09.009