resources

MDPI

*Article*

# Valorization of Potato Peel Waste as Natural Additive for Use in Meat Products

**Daniela Alejandra Espinoza-García [1], Brisa del Mar Torres-Martínez [2], Rey David Vargas-Sánchez [2], Gastón Ramón Torrescano-Urrutia [2] and Armida Sánchez-Escalante [2,*]**

[1] División de Ciencias Bioquímicas, Instituto Tecnológico Superior de Guasave, Carretera La Brecha SN, Guasave 81149, Mexico
[2] Coordinación de Tecnología de Alimentos de Origen Animal (CTAOA), Centro de Investigación en Alimentación y Desarrollo, A.C. (CIAD, A.C.), Carretera Gustavo Enrique Astiazarán Rosas 46, Hermosillo 83304, Mexico
* Correspondence: armida-sanchez@ciad.mx; Tel.: +52-662-289-2400 (ext. 622)

**Abstract:** Potato peel is a waste generated in large amounts in the food industry; however, it has been shown that these residues are an important source of antioxidant compounds. The effect of potato peel powder addition (2, 5, and 10%) on the physicochemical, sensory, and antioxidant status of pork patties during refrigerated storage (2 °C/9 days/under dark) was evaluated. Polyphenol content and antioxidant activity of potato peel powder ethanol extract were determined. Pork patties were subjected to proximate chemical composition, physicochemical, and sensory evaluations. Results showed that potato peel ethanol extract at the highest used concentration (500 µg/mL) is an important source of total phenolic (>50 mg gallic acid equivalents/g) and chlorogenic acid compounds (ca. 40 mg chlorogenic acid equivalents/g) and exerts free radical scavenging (>50% of DPPH inhibition) and reducing power activity (<0.5 abs) ($p < 0.05$). Additionally, potato peel powder incorporation in raw pork patties reduces changes in pH, lipid oxidation, water-holding capacity, cooking loss weight, and color values during storage. Although an effect was observed on texture and sensory values (color and appearance) of raw patties, depending on addition level ($p < 0.05$), no differences were found in color appearance, odor, flavor, juiciness, fat sensation, texture, and overall acceptability of cooked patties between treatments ($p > 0.05$). The use of potato peel powder as a natural antioxidant for meat products is recommended.

**Keywords:** agro-industrial waste; natural additives; meat quality; antioxidant activity



**Citation:** Espinoza-García, D.A.; Torres-Martínez, B.d.M.; Vargas-Sánchez, R.D.; Torrescano-Urrutia, G.R.; Sánchez-Escalante, A. Valorization of Potato Peel Waste as Natural Additive for Use in Meat Products. *Resources* **2023**, *12*, 148. https://doi.org/10.3390/resources12120148

Academic Editor: Athanasios Angelis Dimakis

Received: 1 November 2023
Revised: 1 December 2023
Accepted: 13 December 2023
Published: 18 December 2023



## 1. Introduction

Food waste represents an economic (waste of resources), environmental (generation of significant greenhouse gas emissions), and social threat (increased hunger, poverty, and risks to human health), making it an important issue research around the world [1]. In Mexico, potato production (*Solanum tuberosum* L.) was around 1.9 million metric tonnes in 2020, of which 56% was sold in the market as fresh product, 15% was used for specialized seed production, and 28% was used in the frying industry, while the per capita consumption was 15 kg [2]. Concerning the frying industry, its processing implies the generation of a large amount of waste (8% by weight), mainly the peel, which is discarded and causes an environmental impact. However, the nutritional value, the chemical composition, and the presence of bioactive compounds make it an attractive residue to be used for technological purposes for the food industry [3].

Regarding the food industry, meat and meat products play a key role in human diet and health due to being an important source of macronutrients like proteins and fat, as well as micronutrients like minerals and vitamins. These components are involved in a wide variety of human health benefits related to muscle function; they are anti-inflammatory, antioxidant detoxifiers, contributing to mitochondrial function, cell membrane stability,

muscle regeneration, cytoprotection, immunity booster, osmoregulation, transport, protein synthesis, among others [4]. However, differences in meat and meat product composition are related to the type of meat and processing conditions [5].

Regarding type of meat, it is known that high contents of proteins with essential amino acids and fats with essential fatty acids in pork meat can increase the oxidation process, which is a major cause of quality loss. Oxidative deterioration can cause unacceptable changes in meat quality [6]. Respecting pork meat processing, a pork patty is made with meat, previously minced in a mill with a mesh of a defined particle diameter, which is mixed with a known concentration of salt and loin fat. Subsequently, the mass obtained is shaped into a flat circle, raw or grilled, and stored for its consumption [7]. However, the chemical components of meat patties can be affected in each processing step, then the oxidative process increases, which promotes unacceptable changes in the physicochemical and sensory properties and antioxidant status of the meat product [7,8].

In the last decade, previous research has shown that the incorporation of plant materials (extracts and powders) as natural antioxidants has a great potential to reduce the oxidative process of meat products in comparison to synthetic antioxidants. Furthermore, the replacement of synthetic antioxidants has been considered a main way to improve the healthiness of meat products [9]. For example, in a previous study, it was shown that the extracts obtained from potato peel waste exert antioxidant activity, which was associated with the presence of phenolic compounds, and the use of this agro-industrial residue in freshly cut apples maintained the qualitative parameters during storage [10]. Also, it was shown that potato peel waste exerted a strong activity to prevent the oxidation of vegetable oils (sunflower oil stored at 25 °C for 60 days) at the highest concentration evaluated. Therefore, it was recommended to use potato peel waste as a natural antioxidant [11]. However, data on the effect of potato peel waste on meat quality during storage are still reduced.

Therefore, the objective of this study was to evaluate the antioxidant effect of potato peel waste powder in pork patties during refrigerated storage.

## 2. Materials and Methods

### *2.1. Potato Peel Waste Powder and Extract Preparation*

A commercial supplier (La Costeña SA de CV) in Guasave, Mexico, donated potato peel waste. The tubers were surface disinfected by submersion in a hypochlorite solution (100 ppm) for 15 min, rinsed three times with distilled water (soaking process) for 5 min each period, and subjected to a peeling process. After, the donate residue was dried (35 °C/8 d) and pulverized with a mesh of particle size 20 (model 5, Thomas scientific, Philadelphia, PA, USA). The obtained powder was packed under vacuum (Food Saver®, Boca Raton, FL, USA) and stored (25 °C) until its use and analysis.

Metabolites from potato peel waste powder were extracted by maceration method [12], with slight modifications. Potato peel waste powder was mixed with ethanol at a 1:10 ratio (150 rpm/25 °C/24 h/under dark). The resultant mixture was filtered (Whatman #1 filter paper), concentrated (model RE301BW, Yamato Scientific Co., Chuo-ku, Tokyo, Japan), and dried (model DC401, Yamato Scientific Co., Chuo-ku, Tokyo, Japan). The ethanol extract at different concentrations (62.5 to 500 µg/mL) was subsequently subjected to phenolic content and antioxidant assays.

### *2.2. Phenolic Content and Antioxidant Activity*

#### 2.2.1. Total Phenolic Content (TPHC)

TPHC was determined by the Folin–Ciocalteu assay [13], with slight modifications. The ethanol extract (100 µL) was homogenized with 900 µL of distilled water, 250 µL of Folin–Ciocalteu reagent (2 M), and 750 µL of sodium carbonate (7%, *w*/*v*). The reaction mixture was incubated (25 °C/1 h/under dark), and the absorbance was measured at 760 nm in a spectrophotometer (model Genesys 5, Thermo Electron Corp., Madison, WI., USA). The results were expressed as mg of gallic acid equivalents/g (mg GAE/g).

#### 2.2.2. Chlorogenic Acid Content (CGA)

CGA was determined as described previously [14], with slight modifications. The ethanol extract (100 µL) was homogenized with 200 µL of urea (0.17 M), 200 µL of glacial acetic acid (0.1 M), and 500 µL of distilled water. The resultant mixture was homogenized with 500 µL of sodium nitrite (0.14 M) and 500 µL of sodium hydroxide (1 M), centrifuged at 2250× *g*/4 °C/10 min (model Sorvall ST18R, Thermo Fisher Scientific, Waltham, MA, USA). The absorbance was measured at 510 nm, and results were expressed as mg of chlorogenic acid equivalents/g (mg CGA/g).

#### 2.2.3. Free Radical Scavenging Activity (FRSA)

FRSA was carried out according to the 1,1-diphenyl-2-picrylhydrazyl ($DPPH^{\bullet}$) assay [15]. The ethanol extract (100 µL) was mixed with 100 µL of DPPH ethanol solution (300 µM). The reaction mixture was incubated (25 °C/30 min/under dark), and the absorbance was measured at 517 nm. The results were expressed as inhibition percentage and calculated as follows: [(blank abs at 0 min − sample abs at 30 min)/blank abs at 0 min] × 100.

#### 2.2.4. Reducing Power Ability (RPA)

RPA was determined by the Prussian blue assay [16]. The ethanol extract (100 µL) was homogenized with 300 µL of phosphate buffer (0.2 M, pH 6.6) and 300 µL of potassium ferricyanide (1%, *w*/*v*) and incubated (5°C/20 min/under dark). After, 300 µL of trichloroacetic acid (10%, *w*/*v*) was added and centrifuged (4200× *g*/5 °C/10 min). The supernatant (500 µL) was mixed with 100 µL of distilled water and 250 µL of ferric chloride (0.1%, *w*/*v*), and the absorbance was measured at 700 nm. The results were expressed as absorbance increase at the same wavelength.

### *2.3. Preparation of Pork Patties*

Pork meat (*Semimembranosus* m., 48 h postmortem) was purchased from a local processor, trimmed of all visible extra-muscular fat, and minced using a conventional meat grinder (model 4152, Hobart Corporation, Dayton, OH, USA) that had been equipped with a 4.5 mm orifice plate. Minced meat was mixed (model MM25, LEM, West Chester, OH, USA) with salt (1.5%, *w*/*w*) dissolved in water (5%, *w*/*w*). In each replication (thrice), the mass was divided into four different treatments: Control (without antioxidant); 2%, 5%, and 10%, potato peel waste powder at 2, 5, and 10% (*w*/*w*). Raw and cooked patties (preheated grill, cooked at 180 °C until they reached an internal temperature of 71 °C) were shaped using a manual patty former and placed on a Styrofoam tray. The trays with pork patties (90 g each) were wrapped with polyvinyl chloride film (17,400 $cm^3$ $O_2/m^2$/23 °C/24 h). Meat samples of each treatment were stored (2 °C/under dark) and assessed at each sampling point (0, 3, 6, and 9 days).

### *2.4. Meat Quality Measurements*

#### 2.4.1. Chemical Proximate Composition

The chemical proximate composition of potato peel waste powder and pork patties was determined following the AOAC standard procedures [17], including moisture by oven drying (procedure 930.30), crude fat content by extraction with petroleum ether in a Goldfish apparatus (procedure 985.01), total protein content by Kjeldahl apparatus (procedure 968.06), and ash content by incinerating dried samples at 550 °C. The carbohydrate content was estimated as follows: 100% − (moisture content + protein content + crude fat content + ash content)

#### 2.4.2. pH

Meat samples were homogenized with distilled water (1:10, *w*/*v*) at 6000 rpm/5 °C/1 min (model Ultraturrax T25, IKA, Braun, Germany), and the pH was measured with a potentiometer (pH211, Hanna Instruments Inc., Smithfield, RI, USA) following the 981.12 procedure [17].

#### 2.4.3. Lipid Oxidation

Lipid oxidation was determined by the thiobarbituric acid reactive substances (TBARS) assay [18]. Meat samples (10 g) were homogenized with 20 mL of trichloroacetic acid (10%, *w*/*v*) (4500 rpm/5 °C/1 min) and centrifuged (2500× *g*/5 °C/20 min). After that, 2 mL of the filtered supernatant was mixed with 2 mL of 2-thiobarbituric acid solution (20 mM) and incubated (97 °C/20 min). The absorbance was measured at 531 nm, and the results were expressed as mg of malondialdehyde/kg of pork meat (mg MDA/kg).

#### 2.4.4. Color Values

The packaging material of meat samples was removed to stabilize the color surface, exposing the meat to atmospheric $O_2$ (5 °C/30 min/under dark). The measurements on sample surfaces were performed using a spectrophotometer (model CM 508d, Konica Minolta Inc., Chiyoda-ku, Tokyo, Japan) with a D65 illuminant and a 10° observer calibrated with a white calibration cap (CM-A70). Recorded parameters consisted of lightness (L*), redness (a*), yellowness (b*), chroma (C*), and hue angle (h*) [19].

#### 2.4.5. Water-Holding Capacity (WHC)

WHC was determined gravimetrically [7], with slight modifications. Meat samples (5 g each) were placed on fine mesh nylon, inserted into a test tube with a screwcap, and centrifuged at 4200× *g*/4 °C/5 min (model Allerga X-12, Beckman Coulter Inc., Indianapolis, IN, USA). The results were expressed as percentage and calculated as follows: [(initial weight − weight after centrifugation)/initial weight] × 100.

#### 2.4.6. Cooking Loss Weight (CLW)

CLW was determined after cooking the samples in a preheated grill at 180 °C (until they reached an internal temperature of 71 °C) [7], with slight modifications. The results were expressed as percentage and calculated as follows: [(weight before cooking − weight after cooking)/weight before cooking] × 100.

#### 2.4.7. Fracture Texture Analysis (FTA)

FTA was measured in a Texture Analyzer (model TAXT Plus kit, Stable Micro System Ltd., Godalming SY., UK). The settings were distance = 40 mm, pre-test speed = 60 mm/min, post-test speed = 600 mm/min, head speed = 100 mm/min, and force = 5 g. The fracturability values were expressed as kg force (kg-f) [7], with slight modifications.

#### 2.4.8. Sensory Evaluation

A sensory panel conformed by 25 laboratory co-workers and students, was used to evaluate the sensory analysis of meat samples [8]. Uncooked meat samples were subjected to sensory evaluation of color and appearance. After that, cooked meat samples were subjected to sensory evaluation of color, appearance, odor, flavor, fat sensation, texture, and overall acceptability. A descriptive seven-point scale was used (1 = extremely poor to 7 = excellent).

### *2.5. Statistical Analysis*

The results were described as mean ± standard deviation (SD). Obtained data from TPHC, CGA, FRSA, RPA, and sensory evaluation were subjected to a one-way analysis of variance (ANOVA) using the treatments control, T1, T2, and T3. The data from meat quality measurements were subjected to a two-way ANOVA using the treatments (control, T1, T2, and T3) and storage time (0, 3, 6, and 9 days) as the fixed effect and the interaction. A Tukey–Kramer test was performed at $p < 0.05$ (NCSS ver2007).

## 3. Results and Discussion

### *3.1. Phenolic Content and Antioxidant Activity of Potato Peel Waste Powder*

Figure 1 shows the results of polyphenols and antioxidant activity of potato peel waste powder, expressed as total phenolic (TPHC) and chlorogenic acid (CGA) content, as well as free radical scavenging activity (FRSA) and reducing power activity (RPA). The results showed that potato peel waste powder presented high values of TPHC (>50 µg GAE/mL) and CGA (ca. 40 µg CGA/mL) at the highest concentration evaluated ($p < 0.05$). In addition, potato peel waste powder exerted high FRSA (>50% of DPPH inhibition) at the highest concentration evaluated ($p < 0.05$). Regarding RPA values, potato peel waste powder showed low values (<0.5 abs) at the highest concentration evaluated ($p < 0.05$).

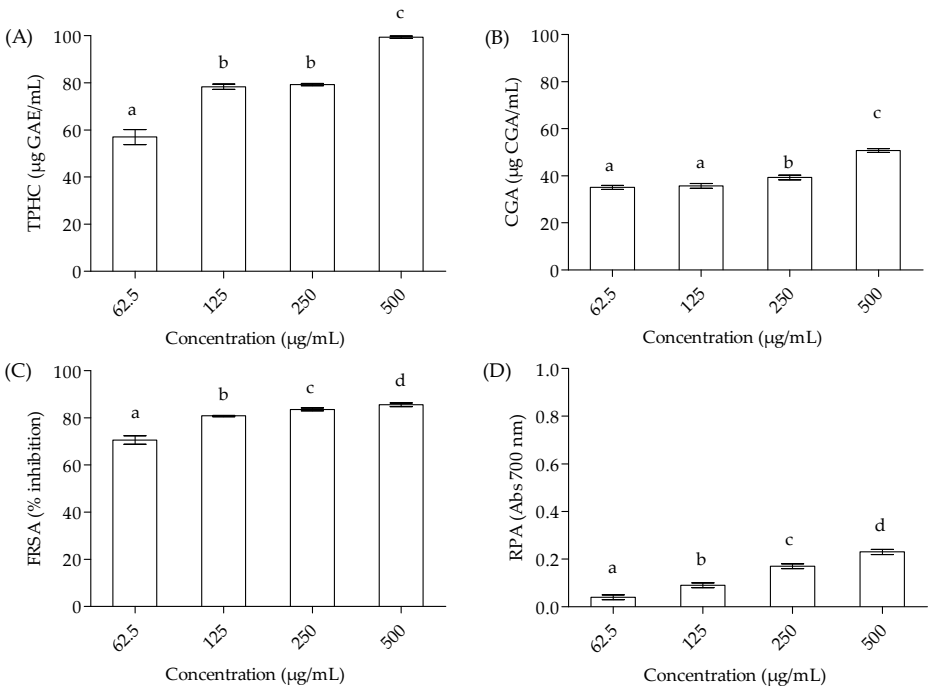


**Figure 1.** Total phenolic content (**A**), chlorogenic acid content (**B**), free radical scavenging activity (**C**), and reducing power ability (**D**) of potato peel waste powder. Values expressed as mean ± SD. Lowercase letters indicate differences with respect to concentration ($p < 0.05$).

The results obtained show that potato peel waste powder is a promising source of polyphenols and exerted antioxidant activities at the highest concentration evaluated. It is worth mentioning that a possible negative effect on the consumer's health has been reported due to the presence of glycoalkaloids in potato peel wastes; however, it has been shown that short periods of soaking contribute to the removal of glycoalkaloids in the potato peel [20]. Regarding polyphenols, it has been reported that the presence of phenolic acids (chlorogenic, caffeic, and ferulic) is higher than that of the flavonoids group (rutin and quercetin) [3,21], while chlorogenic acid and its isomers are the major compounds identified [3,10]. Chlorogenic acid is widely recognized as exerting antioxidant activities, mainly through the hydrogen atom transfer mechanism (HAT), which can be measured by antioxidant O–H bond dissociation enthalpy (BDE = $H_{(ArO\bullet)} + H_{(H\bullet)} - H_{(ArOH)}$). In addition, low BDE values indicate a high capacity to transfer hydrogen atoms or high radical scavenging activity, and it has been shown that chlorogenic acid has lower BDE values (main reactive groups 3′-OH > 4′-OH > 2-OH > 1-OH) comparted to caffeic, ferulic, rosmarinic, sinapic, vanillic, syringic, ellagic, *p*-coumaric, and *p*-hydroxybenzoic acids [22]. In the same way, the concentration-dependent reducing power ability of chlorogenic acid has been demonstrated [23], which involves the reduction of ferric ions through antioxidants ($Fe^{3+}$ + ArOH <–> $Fe^{2+}$ + $ArO^{\bullet}$) [16].

### *3.2. Chemical Proximate Composition of Potato Peel Waste Powder and Meat Samples*

The presence of nutrients and bioactive compounds in peel waste makes it a potential ingredient to be incorporated during meat products formulation [24]. Table 1 shows the results of the chemical proximate composition of potato peel waste powder and meat product treated with this waste. The results show that the chemical components of potato peel waste powder were mainly carbohydrates, followed by proteins and moisture, and, in minor proportions, fats and ashes. Regarding the pork patties, no significant differences ($p > 0.05$) were observed in fat content, while incorporation of potato peel waste powder in meat samples decreased moisture and protein content and increased ash and carbohydrates content ($p < 0.05$).

**Table 1.** Chemical proximate composition of potato peel waste powder and pork patties.

| Item | Powder | Treatments | | | |
|---|---|---|---|---|---|
| | | Control | T1 | T2 | T3 |
| Moisture | 5.27 ± 1.74 | 70.62 ± 0.24 $^{d}$ | 69.61 ± 0.38 $^{c}$ | 67.28 ± 0.15 $^{b}$ | 63.44 ± 0.49 $^{a}$ |
| Fat | 2.26 ± 0.64 | 7.02 ± 0.29 | 6.81 ± 0.44 | 7.16 ± 0.21 | 7.12 ± 0.17 |
| Protein | 9.11 ± 0.42 | 17.74 ± 0.34 $^{c}$ | 17.56 ± 0.60 $^{bc}$ | 16.84 ± 0.45 $^{ab}$ | 16.01 ± 0.65 $^{a}$ |
| Ash | 3.11 ± 0.23 | 2.30 ± 0.02 $^{a}$ | 2.32 ± 0.03 $^{a}$ | 2.41 ± 0.03 $^{b}$ | 2.62 ± 0.02 $^{c}$ |
| Carbohydrate | 80.25 ± 1.71 | 2.42 ± 0.27 $^{a}$ | 3.69 ± 0.61 $^{b}$ | 6.32 ± 0.53 $^{c}$ | 10.81 ± 0.41 $^{d}$ |

Values expressed as mean ± SD. Control, without antioxidants; T1, potato peel waste powder at 2%; T2, potato peel waste powder at 5%; T3, potato peel waste powder at 10%. Lowercase letters indicate differences between treatments ($p < 0.05$).

In agreement with the obtained results, it has been reported that the main chemical components of potato peel waste powder are carbohydrates, followed by proteins, moisture, fats, and ashes [25]. Although studies on the incorporation effect of potato peel waste powder on the chemical composition of meat products are still limited, it has been shown that incorporation of banana peel waste powder decreased protein content and increased ash and carbohydrates content, without differences in fat content, of raw fish patties. However, in contrast, moisture content increased [26]. In another study, it has been demonstrated that incorporation of pomegranate peel waste powder decreased moisture and protein content and increased ash and carbohydrate content of cooked chicken patties [27]. Also, a decrease in proteins content and an increase in ashes and carbohydrates content of cooked beef patties incorporated with 2.25% of sweet potato peel waste powder have been reported [25].

### *3.3. pH and Lipid Oxidation of Meat Samples*

Pork is consumed in a wide variety of products, made from whole cuts or ground meat; however, its final quality results from a combination of the state or properties of the raw material and the processing stages to obtain the final product [28]. For example, the process required to obtain ground meat involves an increase in temperature and contact with atmospheric oxygen, which promotes changes in pH and lipid oxidation values [29]. Figure 2 shows the results of the incorporation effect of potato peel waste powder and storage time in pH and lipid oxidation parameters. The results indicate that pH and TBARS values of pork patties were affected by treatment and storage time ($p < 0.05$). Regarding pH values, on the initial day of storage (day 0), no significant differences ($p > 0.05$) were found in this parameter between treatments. During the storage time, the pH values decreased ($p < 0.05$), and, at the end of storage (day 9), pork patties incorporated with potato peel waste powder showed higher ($p < 0.05$) pH values than control samples. Respecting lipid oxidation, at day 0, T1 and T2 samples showed the lowest TBARS values ($p < 0.05$). However, during the storage time, TBARS values increased for all treatments ($p < 0.05$). At day 9, T1 and T2 showed the lowest TBARS values ($p < 0.05$).

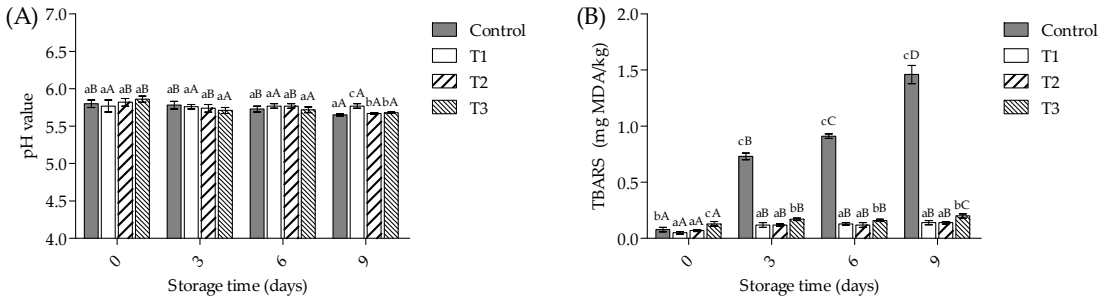


**Figure 2.** pH value (**A**) and lipid oxidation (**B**) of pork patties during storage. Values expressed as mean ± SD. Control, without antioxidants; T1, potato peel waste powder at 2%; T2, potato peel waste powder at 5%; T3, potato peel waste powder at 10%. Lowercase letters indicate differences between treatments on each sampling day and capital letters indicate differences in each treatment through the storage period ($p < 0.05$).

Although studies on the incorporation effect of potato peel waste powder on the chemical composition of meat products are still limited, in agreement with the obtained results, it has been reported that incorporation of potato peel waste extracts (water and ethanol) did not affect the pH values of raw minced mackerel on the initial day [30]. In another study, a non-significant effect on pH values by incorporation of mango peel powder (1–3%) in raw chicken patties has been demonstrated [31]. Subsequently, it has been extensively demonstrated that a reduction in pH values promotes an increase in lipid oxidation levels [32]. In this context, lipid oxidation occurs through a free radical chain mechanism that generates many end products such as malondialdehyde (MDA), which is associated with unpleasant flavors and aromas in meat and meat products [33]. In agreement with the obtained results, it has been reported that incorporation of potato peel waste ethanol extract decreased the MDA content of raw beef patties stored at 5 °C for 12 days [34]. In another study, it has been demonstrated that incorporation of potato peel waste ethanol extract decreased the lipid oxidation of raw lamb rib stored at 3 °C for 7 days. These results were associated with the presence of phenolic compounds (gallic, chlorogenic, and caffeic acids) and their ability to reduce free radicals and metal ions [21]. Also, a decrease in lipid oxidation of raw chicken patties incorporated with 1% of potato peel waste powder stored at −18 °C for 60 days has been reported [35].

### *3.4. Color Changes of Meat Samples*

The color of fresh meat is a quality attribute that influences the consumer's purchasing decision and is related to myoglobin (sarcoplasmic heme protein); however, the interaction of this protein with oxidation products (e.g., MDA) is a main mechanism that affect color stability [36–38]. Table 2 shows the results of the incorporation effect of potato peel waste powder and storage time in color values of pork patties. The results indicate that L*, a*, b*, C*, and h* values of pork patties were affected by treatment and storage time ($p < 0.05$). On day 0, T3 showed the lowest L*, a*, and C* values, as well as the highest b* and h* values ($p < 0.05$). During the storage time, L* and C* values increased, while a*, b*, and C* values decreased ($p < 0.05$). On day 9, T2 and T3 showed the lowest L* values ($p < 0.05$). In addition, T1–T3 samples showed higher a*, b*, and C* values with respect to control samples, as well as the lower h* values ($p < 0.05$).

Studies related to the incorporation of potato peel waste powder and its effect on color in meat products are limited; however, in agreement with the obtained results, it has been reported that incorporation of sweet potato peel waste ethanol extract reduced the color changes of raw beef patties stored at 5 °C for 12 days [34]. In another study, it has been reported that incorporation of tangerine peel powder (1%) in raw pork patties reduced color changes [39]. Also, it has been demonstrated that incorporation of 1% of fruit peel powders (lemon, orange, grapefruit, and banana) increased the color stability of raw chicken patties stored at −18 °C for 3 months [40].

**Table 2.** Instrumental color of pork patties during storage.

| Item | Day | Treatments | | | |
|---|---|---|---|---|---|
| | | Control | T1 | T2 | T3 |
| L* | 0 | 59.12 ± 1.65 $^{cA}$ | 54.89 ± 1.71 $^{bA}$ | 53.01 ± 1.99 $^{bA}$ | 49.80 ± 1.20 $^{aA}$ |
| | 3 | 59.10 ± 1.34 $^{dA}$ | 55.01 ± 1.47 $^{cA}$ | 52.29 ± 1.64 $^{bA}$ | 48.32 ± 1.27 $^{aA}$ |
| | 6 | 63.03 ± 0.69 $^{cB}$ | 54.01 ± 1.29 $^{bA}$ | 52.30 ± 1.22 $^{bA}$ | 47.90 ± 1.48 $^{aA}$ |
| | 9 | 63.06 ± 1.60 $^{cB}$ | 58.07 ± 1.10 $^{bB}$ | 51.34 ± 1.97 $^{aA}$ | 47.37 ± 1.50 $^{aA}$ |
| a* | 0 | 18.69 ± 1.08 $^{cC}$ | 16.41 ± 1.26 $^{bC}$ | 14.89 ± 0.97 $^{bC}$ | 12.81 ± 0.55 $^{aC}$ |
| | 3 | 16.03 ± 1.57 $^{cB}$ | 14.71 ± 0.91 $^{bB}$ | 12.84 ± 1.04 $^{bB}$ | 10.44 ± 0.56 $^{aB}$ |
| | 6 | 13.12 ± 1.83 $^{bB}$ | 11.38 ± 1.12 $^{bB}$ | 11.04 ± 0.99 $^{bB}$ | 9.06 ± 0.46 $^{aA}$ |
| | 9 | 7.20 ± 0.56 $^{aA}$ | 8.54 ± 0.58 $^{bA}$ | 8.96 ± 0.49 $^{bA}$ | 8.96 ± 0.47 $^{bA}$ |
| b* | 0 | 17.70 ± 0.75 $^{aB}$ | 18.49 ± 1.40 $^{abB}$ | 19.63 ± 1.42 $^{abB}$ | 20.08 ± 0.65 $^{bB}$ |
| | 3 | 17.35 ± 1.39 $^{aB}$ | 18.25 ± 1.03 $^{aB}$ | 18.04 ± 1.19 $^{aB}$ | 18.25 ± 0.72 $^{aA}$ |
| | 6 | 16.17 ± 1.24 $^{aB}$ | 15.98 ± 0.87 $^{aA}$ | 16.86 ± 1.26 $^{aA}$ | 18.12 ± 0.73 $^{aA}$ |
| | 9 | 13.56 ± 1.09 $^{aA}$ | 14.71 ± 1.76 $^{abA}$ | 16.60 ± 1.84 $^{bcA}$ | 17.48 ± 0.82 $^{cA}$ |
| C* | 0 | 26.09 ± 1.65 $^{bC}$ | 24.72 ± 1.82 $^{abB}$ | 24.64 ± 1.70 $^{abB}$ | 23.82 ± 0.63 $^{aB}$ |
| | 3 | 23.90 ± 2.07 $^{aC}$ | 23.81 ± 1.76 $^{aB}$ | 22.15 ± 1.41 $^{aB}$ | 21.02 ± 0.86 $^{aA}$ |
| | 6 | 20.61 ± 1.57 $^{aB}$ | 19.07 ± 1.59 $^{aA}$ | 19.92 ± 1.17 $^{aA}$ | 20.30 ± 0.84 $^{aA}$ |
| | 9 | 15.46 ± 0.78 $^{aA}$ | 16.77 ± 1.80 $^{abA}$ | 18.96 ± 1.64 $^{abA}$ | 19.61 ± 0.91 $^{bA}$ |
| h* | 0 | 44.20 ± 1.07 $^{aA}$ | 48.41 ± 1.17 $^{bA}$ | 52.81 ± 0.61 $^{cA}$ | 57.47 ± 1.38 $^{dA}$ |
| | 3 | 46.60 ± 0.83 $^{aA}$ | 51.32 ± 1.20 $^{bA}$ | 54.55 ± 1.84 $^{cB}$ | 60.23 ± 0.84 $^{dB}$ |
| | 6 | 56.90 ± 0.98 $^{aB}$ | 62.01 ± 0.69 $^{bB}$ | 62.36 ± 0.71 $^{bC}$ | 63.23 ± 1.19 $^{bC}$ |
| | 9 | 65.47 ± 1.05 $^{bC}$ | 61.08 ± 0.91 $^{aB}$ | 61.97 ± 0.81 $^{aC}$ | 63.08 ± 0.89 $^{abC}$ |

Values expressed as mean ± SD. Control, without antioxidants; T1, potato peel waste powder at 2%; T2, potato peel waste powder at 5%; T3, potato peel waste powder at 10%. Lowercase letters indicate differences between treatments on each sampling day and capital letters indicate differences in each treatment through the storage period ($p < 0.05$).

### *3.5. Water Retention and Texture of Meat Samples*

Moreover, it has been extensively demonstrated that a reduction in pH values promotes a negative effect on water retention and texture values of the meat products [38,41]. Table 3 shows the results of the incorporation effect of potato peel waste powder in water-holding capacity (WHC), cooking loss weight (CLW), and fracture texture analysis (FTA). At day 0, T3 showed the highest WHC and FTA values in pork patties, as well as the lowest CLW values in meat samples ($p < 0.05$). During the storage time, WHC and CLW values decreased, while FTA values increased ($p < 0.05$). At day 9, T3 showed the highest WHC and the lowest CLW, while T3 and T2 presented the highest FTA values ($p < 0.05$).

In agreement with the obtained results, it has been reported that incorporation of potato peel waste powder increased water retention of beef patties after they were subjected to a cooking process, and these results were associated with the fiber content (ca. 13 g/100 g) of the used material [25]. In contrast, there was a non-significant effect on the WHC and CLW of pork patties incorporated with tangerine peel powder (1%) after cooking [39]. In addition, a previous work demonstrated an increase in FTA values by incorporation of passion fruit albedo powder in raw and cooked pork patties [42].

### *3.6. Sensory Attributes of Meat Samples*

Meat and meat products incorporated with natural additives are commonly subjected to sensory analysis to determine consumer acceptance; therefore, sensory attributes also determine their purchase intention [43]. Table 4 shows the results of the incorporation effect of potato peel waste powder in sensory properties of uncooked and cooked pork patties. The results show that incorporation of potato peel powder in uncooked meat samples reduced color and appearance ($p < 0.05$). Regarding cooked pork patties, no significant differences ($p > 0.05$) were found in color, appearance, odor, flavor, juiciness fat sensation, break strength, and overall acceptability.

**Table 3.** Water retention and texture of pork patties during storage.

| Item | Day | Treatments | | | |
|---|---|---|---|---|---|
| | | Control | T1 | T2 | T3 |
| WHC (%) | 0 | $94.43 \pm 0.47^{aB}$ | $95.64 \pm 0.64^{bA}$ | $95.40 \pm 0.56^{bA}$ | $97.91 \pm 0.55^{cA}$ |
| | 3 | $94.45 \pm 1.17^{aB}$ | $95.16 \pm 0.48^{aA}$ | $95.17 \pm 0.75^{aA}$ | $98.34 \pm 0.37^{bA}$ |
| | 6 | $94.60 \pm 0.85^{aB}$ | $95.54 \pm 0.66^{aA}$ | $95.10 \pm 0.55^{aA}$ | $97.95 \pm 0.77^{bA}$ |
| | 9 | $91.02 \pm 0.30^{aA}$ | $95.04 \pm 0.82^{bA}$ | $95.14 \pm 0.81^{bA}$ | $98.10 \pm 0.64^{cA}$ |
| CLW (%) | 0 | $18.10 \pm 0.17^{dC}$ | $11.70 \pm 1.01^{cB}$ | $8.64 \pm 0.63^{bB}$ | $7.26 \pm 0.42^{aA}$ |
| | 3 | $16.22 \pm 0.49^{dB}$ | $10.10 \pm 0.89^{cA}$ | $7.50 \pm 0.17^{bA}$ | $6.54 \pm 0.70^{aA}$ |
| | 6 | $13.76 \pm 0.59^{cA}$ | $10.38 \pm 0.75^{bA}$ | $7.21 \pm 0.31^{aA}$ | $6.51 \pm 0.68^{aA}$ |
| | 9 | $13.83 \pm 0.67^{cA}$ | $8.92 \pm 1.17^{bA}$ | $7.30 \pm 0.41^{aA}$ | $6.23 \pm 0.68^{aA}$ |
| FTA (kg-f) | 0 | $2.77 \pm 0.11^{aA}$ | $3.25 \pm 0.22^{bA}$ | $3.64 \pm 0.22^{bA}$ | $4.15 \pm 0.39^{cA}$ |
| | 3 | $2.80 \pm 0.24^{aAB}$ | $3.27 \pm 0.35^{aA}$ | $4.03 \pm 0.30^{bAB}$ | $4.74 \pm 0.23^{cA}$ |
| | 6 | $2.93 \pm 0.20^{aAB}$ | $3.72 \pm 0.16^{bA}$ | $4.22 \pm 0.57^{bcAB}$ | $4.70 \pm 0.38^{cA}$ |
| | 9 | $3.36 \pm 0.24^{aB}$ | $3.63 \pm 0.37^{aA}$ | $4.46 \pm 0.32^{bB}$ | $4.41 \pm 0.40^{bA}$ |

Values expressed as mean ± SD. WHC, water-holding capacity; CLW, cooking loss weight; FTA, fracture texture analysis; Control, without antioxidants; T1, potato peel waste powder at 2%; T2, potato peel waste powder at 5%; T3, potato peel waste powder at 10%. Lowercase letters indicate differences between treatments on each sampling day and capital letters indicate differences in each treatment through the storage period ($p < 0.05$).

**Table 4.** Sensory attributes of pork patties.

| Patties | Item | Treatments | | | |
|---|---|---|---|---|---|
| | | Control | T1 | T2 | T3 |
| Uncooked | Color | $6.87 \pm 0.35^{c}$ | $6.00 \pm 0.88^{bc}$ | $5.07 \pm 1.28^{ab}$ | $4.40 \pm 1.58^{a}$ |
| | Appearance | $6.73 \pm 0.46^{c}$ | $5.87 \pm 0.92^{bc}$ | $4.87 \pm 1.36^{ab}$ | $4.20 \pm 1.61^{a}$ |
| Cooked | Color | $5.33 \pm 1.29$ | $5.13 \pm 1.06$ | $5.53 \pm 1.13$ | $5.07 \pm 1.10$ |
| | Appearance | $5.87 \pm 0.99$ | $5.33 \pm 0.72$ | $5.93 \pm 0.88$ | $5.20 \pm 1.37$ |
| | Odor | $5.27 \pm 1.39$ | $5.33 \pm 1.05$ | $4.73 \pm 1.49$ | $4.40 \pm 1.45$ |
| | Flavor | $6.13 \pm 0.92$ | $5.73 \pm 1.03$ | $5.33 \pm 1.05$ | $4.20 \pm 1.15$ |
| | Juiciness | $6.47 \pm 1.64$ | $6.07 \pm 1.10$ | $5.13 \pm 1.51$ | $4.20 \pm 1.32$ |
| | Fat sensation | $5.80 \pm 1.21$ | $5.60 \pm 1.24$ | $5.13 \pm 1.13$ | $4.47 \pm 1.55$ |
| | Break strength | $6.60 \pm 0.63$ | $6.40 \pm 0.91$ | $5.80 \pm 1.26$ | $4.93 \pm 1.58$ |
| | Overall acceptability | $6.03 \pm 0.93$ | $6.10 \pm 0.60$ | $5.53 \pm 0.74$ | $4.67 \pm 1.05$ |

Values expressed as mean ± SD. Control, without antioxidants; T1, potato peel waste powder at 2%; T2, potato peel waste powder at 5%; T3, potato peel waste powder at 10%. Lowercase letters indicate differences between treatments ($p < 0.05$).

In agreement with the obtained results, a non-significant effect on sensory attributes (taste, texture, juiciness, and palatability) by incorporation of tangerine peel powder (1%) in raw pork patties has been reported [39]. In contrast with the obtained results, it has been reported that incorporation of sweet potato peel waste powder reduced the sensory parameters such as appearance, color, odor, flavor, texture, and overall acceptability of cooked beef patties [25]. Also, it has been demonstrated that incorporation of 1% of fruit peel powders (lemon, orange, grapefruit, and banana) increased sensory attributes of cooked chicken patties, including appearance, flavor, tenderness, and overall acceptability [40]. In another study, a reduction in sensory attributes, including color, appearance, flavor, texture, and overall acceptability, by incorporation of mango peel powder (1–3%) in raw chicken patties has been demonstrated [31]. In addition, a previous work demonstrated an increase in FTA values by incorporation of passion fruit albedo powder in raw and cooked pork patties [42].

## 4. Conclusions

Potato peel waste powder incorporation in raw pork patties reduced changes in pH, lipid oxidation, water-holding capacity, cooking loss weight, and color values during storage. Although an effect was observed in the texture and sensory (color and appearance

of raw patties) values of raw patties, no differences were found in color appearance, odor, flavor, juiciness, fat sensation, texture, and overall acceptability of cooked patties. The use of potato peel waste powder as a natural antioxidant for meat products is recommended.

**Author Contributions:** Conceptualization, D.A.E.-G. and A.S.-E.; Methodology, D.A.E.-G. and A.S.-E.; formal analysis, D.A.E.-G., R.D.V.-S. and A.S.-E.; Investigation, D.A.E.-G., B.d.M.T.-M., R.D.V.-S., G.R.T.-U. and A.S.-E.; Writing—original draft preparation, B.d.M.T.-M., R.D.V.-S., G.R.T.-U. and A.S.-E.; writing—review and editing, B.d.M.T.-M., R.D.V.-S., G.R.T.-U. and A.S.-E. All authors have read and agreed to the published version of the manuscript.

**Funding:** Authors gratefully acknowledge the fellowship received from La Costeña SA de CV and "Investigadoras e Investigadores por Mexico program from CONAHCYT".

**Data Availability Statement:** Data are available from the corresponding author upon request.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

1. Schrank, J.; Hanchai, A.; Thongsalab, S.; Sawaddee, N.; Chanrattanagorn, K.; Ketkaew, C. Factors of food waste reduction underlying the extended theory of planned behavior: A study of consumer behavior towards the intention to reduce food waste. *Resources* **2023**, *12*, 93. [CrossRef]
2. SADER Potato as an Essential Food. Available online: https://www.gob.mx/agricultura/articulos/la-papa-como-alimento-basico (accessed on 12 September 2023).
3. Sampaio, S.L.; Petropoulos, S.A.; Alexopoulos, A.; Heleno, S.A.; Santos-Buelga, C.; Barros, L.; Ferreira, I.C. Potato peels as sources of functional compounds for the food industry: A review. *Trends Food Sci. Technol.* **2020**, *103*, 118–129. [CrossRef]
4. di Corcia, M.; Tartaglia, N.; Polito, R.; Ambrosi, A.; Messina, G.; Francavilla, V.C.; Cincione, R.I.; Malva, A.D.; Ciliberti, M.G.; Sevi, A.; et al. Functional properties of meat in athletes' performance and recovery. *IJERPH* **2022**, *19*, 5145. [CrossRef] [PubMed]
5. Cobos, A.; Díaz, O. Chemical composition of meat and meat products. In *Handbook of Food Chemistry*; Cheung, P.C.K., Ed.; Springer: Taipei City, China, 2015; pp. 471–510.
6. Falowo, A.B.; Fayemi, P.O.; Muchenje, V. Natural antioxidants against lipid–protein oxidative deterioration in meat and meat products: A review. *Food Res. Int.* **2014**, *64*, 171–181. [CrossRef] [PubMed]
7. Torres-Martínez, B.D.M.; Vargas-Sánchez, R.D.; Torrescano-Urrutia, G.R.; González-Ávila, M.; Rodríguez-Carpena, J.G.; Huerta-Leidenz, N.; Pérez-Alvarez, J.A.; Fernández-López, J.; Sánchez-Escalante, A. Use of *Pleurotus ostreatus* to enhance the oxidative stability of pork patties during storage and in vitro gastrointestinal digestion. *Foods* **2022**, *11*, 4075. [CrossRef]
8. Ramírez-Rojo, M.I.; Vargas-Sánchez, R.D.; Torres-Martínez, B.D.M.; Torrescano-Urrutia, G.R.; Lorenzo, J.M.; Sánchez-Escalante, A. Inclusion of ethanol extract of mesquite leaves to enhance the oxidative stability of pork patties. *Foods* **2019**, *8*, 631. [CrossRef]
9. Teixeira, A.; Rodrigues, S. Consumer perceptions towards healthier meat products. *Curr. Opin. Food Sci.* **2021**, *38*, 147–154. [CrossRef]
10. Venturi, F.; Bartolini, S.; Sanmartin, C.; Orlando, M.; Taglieri, I.; Macaluso, M.; Lucchesini, M.; Trivellini, A.; Zinai, A.; Mensuali, A. Potato peels as a source of novel green extracts suitable as antioxidant additives for fresh-cut fruits. *Appl. Sci.* **2019**, *9*, 2431. [CrossRef]
11. Saeed, A.; Shabbir, A.; Khan, A. Stabilization of sunflower oil by using potato peel extract as a natural antioxidant. *Biomass Convers. Biorefinery* **2022**, *1*, 1–10. [CrossRef]
12. Orduño, G.R.D.; Santana, T.J.M.; Amavizca, R.M.; Vega, A.F.; Torreblanca, J.N.S.; Escalante, A.S.; Urrutia, G.R.T. Composición y actividad antioxidante de extractos de cáscara de papa esterilizados con autoclave e irradiación. *Biotecnia* **2018**, *20*, 51–58. [CrossRef]
13. Ainsworth, E.A.; Gillespie, K.M. Estimation of total phenolic content and other oxidation substrates in plant tissues using Folin-Ciocalteu reagent. *Nat. Protoc.* **2007**, *2*, 875–877. [CrossRef] [PubMed]
14. Griffiths, D.W.; Bain, H.; Dale, M.F.B. Development of a rapid colorimetric method for the determination of chlorogenic acid in freeze-dried potato tubers. *J. Sci. Food Agric.* **1992**, *58*, 41–48. [CrossRef]
15. Molyneux, P. The use of the stable free radical diphenylpicrylhydrazyl (DPPH) for estimating antioxidant activity. *SJST* **2004**, *26*, 211–219.
16. Işıl Berker, K.; Güçlü, K.; Tor, İ.; Demirata, B.; Apak, R. Total antioxidant capacity assay using optimized ferricyanide/prussian blue method. *Food Anal. Methods* **2010**, *3*, 154–168. [CrossRef]
17. AOAC. Official methods of analysis. In *Association of Official Analytical Chemists*, 18th ed.; Association of Official Analytical Chemists: Gaitherburg, MD, USA, 2005.
18. Pfalzgraf, A.; Frigg, M.; Steinhart, H. Alpha-Tocopherol contents and lipid oxidation in pork muscle and adipose tissue during storage. *J. Agric. Food Chem.* **1995**, *43*, 1339–1342. [CrossRef]

19. Robertson, A.R.; Lozano, R.D.; Alman, D.H.; Orchard, S.E.; Keitch, J.A.; Connely, R.; Graham, L.A.; Acree, W.L.; John, R.S.; Hoban, R.F.; et al. CIE Recommendations on uniform color spaces, color-difference equations, and metric color terms. *Color Res. Appl.* **1977**, *2*, 5–6.
20. Zhao, J.; Camire, M.E.; Bushway, R.J.; Bushway, A.A. Glycoalkaloid content and in vitro glycoalkaloid solubility of extruded potato peels. *J. Agric. Food Chem.* **1994**, *42*, 2570–2573. [CrossRef]
21. Kanatt, S.R.; Chander, R.; Radhakrishna, P.; Sharma, A. Potato peel extract a natural antioxidant for retarding lipid peroxidation in radiation processed lamb meat. *J. Agric. Food Chem.* **2005**, *53*, 1499–1504. [CrossRef]
22. Saqib, M.; Iqbal, S.; Mahmood, A.; Akram, R. Theoretical investigation for exploring the antioxidant potential of chlorogenic acid: A density functional theory study. *Int. J. Food Prop.* **2016**, *19*, 745–751. [CrossRef]
23. Choi, Y.E.; Choi, S.I.; Han, X.; Men, X.; Jang, G.W.; Kwon, H.Y.; Kang, S.R.; Han, J.S.; Lee, O.H. Radical scavenging-linked anti-adipogenic activity of *Aster scaber* ethanolic extract and its bioactive compound. *Antioxidants* **2020**, *9*, 1290. [CrossRef]
24. Aqilah, N.M.N.; Rovina, K.; Felicia, W.X.L.; Vonnie, J.M. A review on the potential bioactive components in fruits and vegetable wastes as value-added products in the food industry. *Molecules* **2023**, *28*, 2631. [CrossRef] [PubMed]
25. Marconato, A.M.; Hartmann, G.L.; Santos, M.M.R.; Amaral, L.A.D.; Souza, G.H.O.D.; Santos, E.F.D.; Novello, D. Sweet potato peel flour in hamburger: Effect on physicochemical, technological and sensorial characteristics. *Braz. J. Food Technol.* **2020**, *23*, e2019115. [CrossRef]
26. Bin Mohd Zaini, H.; Bin Sintang, M.D.; Dan, Y.N.; 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*, 2179–2189. [CrossRef]
27. Sharma, P.; Yadav, S. Effect of incorporation of pomegranate peel and bagasse powder and their extracts on quality characteristics of chicken meat patties. *Food Sci. Anim. Resour.* **2020**, *40*, 388. [CrossRef] [PubMed]
28. Lebret, B.; Čandek-Potokar, M. Pork quality attributes from farm to fork. Part II. Processed pork products. *Animal* **2022**, *16*, 100383. [CrossRef] [PubMed]
29. Shimizu, H.; Iwamoto, S. Problems of lipid oxidation in minced meat products for a ready-made meal during cooking, processing, and storage. *Rev. Agric. Sci.* **2022**, *10*, 24–35. [CrossRef] [PubMed]
30. Farvin, K.S.; Grejsen, H.D.; Jacobsen, C. Potato peel extract as a natural antioxidant in chilled storage of minced horse mackerel (*Trachurus trachurus*): Effect on lipid and protein oxidation. *Food Chem.* **2012**, *131*, 843–851. [CrossRef]
31. Chappalwar, A.M.; Pathak, V.; Goswami, M.; Verma, A.K. Development of functional chicken patties with incorporation of mango peel powder as fat replacer. *Nutr. Food Sci.* **2020**, *50*, 1063–1073. [CrossRef]
32. Domínguez, R.; Pateiro, M.; Gagaoua, M.; Barba, F.J.; Zhang, W.; Lorenzo, J.M. A comprehensive review on lipid oxidation in meat and meat products. *Antioxidants* **2019**, *8*, 429. [CrossRef]
33. Ghani, M.A.; Barril, C.; Bedgood, D.R., Jr.; Prenzler, P.D. Measurement of antioxidant activity with the thiobarbituric acid reactive substances assay. *Food Chem.* **2017**, *230*, 195–207. [CrossRef]
34. Mansour, E.H.; Khalil, A.H. Evaluation of antioxidant activity of some plant extracts and their application to ground beef patties. *Food Chem.* **2000**, *69*, 135–141. [CrossRef]
35. Thanoun, E.A.; Al-Jammaas, O.H.A. Storage stability of chicken patties after treatment with pomegranate, potato and apple peel extracts. *J. Agric. Sci.* **2022**, *2*, 442–448.
36. Tomasevic, I.; Djekic, I.; Font-i-Furnols, M.; Terjung, N.; Lorenzo, J.M. Recent advances in meat color research. *Curr. Opin. Food Sci.* **2021**, *41*, 81–87. [CrossRef]
37. King, D.A.; Hunt, M.C.; Barbut, S.; Claus, J.R.; Cornforth, D.P.; Joseph, P.; Kim, Y.H.; Lindahl, G.; Mancini, R.A.; Nair, M.N.; et al. American Meat Science Association Guidelines for Meat Color Measurement. *Meat Muscle Biol.* **2023**, *6*, 12473. [CrossRef]
38. Fernández-López, J.; Sayas-Barberá, E.; Pérez-Alvarez, J.A.; Aranda-Catalá, V. Effect of sodium chloride, sodium tripolyphosphate and pH on color properties of pork meat. *Color Res. Appl.* **2004**, *29*, 67–74. [CrossRef]
39. Choi, G.W.; Lee, J.W. Physicochemical quality characteristics of pork patty with tangerine (*Citrus unshiu*) peel. *J. Life Sci.* **2017**, *27*, 123–130. [CrossRef]
40. Abdel-Naeem, H.H.; Elshebrawy, H.A.; Imre, K.; Morar, A.; Herman, V.; Paşcalău, R.; Sallam, K.I. Antioxidant and antibacterial effect of fruit peel powders in chicken patties. *Foods* **2022**, *11*, 301. [CrossRef]
41. Andrés-Bello, A.; Barreto-Palacios, V.; García-Segovia, P.; Mir-Bel, J.; Martínez-Monzó, J. Effect of pH on color and texture of food products. *Food Eng. Rev.* **2013**, *5*, 158–170. [CrossRef]
42. López-Vargas, J.H.; Fernández-López, J.; Pérez-Álvarez, J.Á.; Viuda-Martos, M. Quality characteristics of pork burger added with albedo-fiber powder obtained from yellow passion fruit (*Passiflora edulis* var. flavicarpa) co-products. *Meat Sci.* **2014**, *97*, 270–276. [CrossRef]
43. Fiorentini, M.; Kinchla, A.J.; Nolden, A.A. Role of sensory evaluation in consumer acceptance of plant-based meat analogs and meat extenders: A scoping review. *Foods* **2020**, *9*, 1334. [CrossRef]