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Physicochemical and Storage Characteristics of Pork Tteokgalbi Treated with Watermelon Radish Powder

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Abstract: Here, we investigated the physicochemical and storage characteristics of Tteokgalbi using *n-3* fatty acid-enriched pork (*n-6*/*n-3* ratio: 3.220) and explored the effects of treatment with watermelon radish powder (W; 0–4%). Tteokgalbi groups were prepared with 0% W (control (CON)), 1% W (W1), 2% W (W2), 4% W (W3), or 0.05% ascorbic acid as a reference (REF) treatment. W addition to Tteokgalbi increased the moisture and ash contents and water-holding capacity, but reduced cooking loss. W-prepared Tteokgalbi had markedly decreased L* (brightness) and increased b* (yellowness) values, but significantly increased a* (redness) values. W treatment markedly altered the textural properties of Tteokgalbi by improving the hardness and chewiness (W3 treatment), but decreasing springiness (W3) and brittleness (W2 and W3). W addition dose-dependently increased the total polyphenol and flavonoid contents, thereby increasing the 2,2-diphenyl-1-picrylhydrazyl and 2,2′-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) radical-scavenging activities of Tteokgalbi over 7 days in cold storage. W-treatment Tteokgalbi decreased the pH slightly (compared to CON treatment) and significantly attenuated the induction of 2-thiobarbituric acid, volatile basic nitrogen, and total microbial counts during 7 days in cold storage. Therefore, W may be a suitable food antioxidant that can act as a natural radical scavenger in Tteokgalbi prepared from *n-3* fatty acid-enriched pork.

Keywords: watermelon radish powder; Tteokgalbi; physicochemical characteristic; storage characteristic

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1. Introduction

Currently, the home meal-replacement (HMR) market is growing steadily [1] and rapidly owing to restrictions on people's movements because of the coronavirus disease-2019 (COVID-19) pandemic [2]. The virus causing COVID-19 was first discovered after an outbreak in Wuhan, China, in December 2019, after which it spread worldwide, and multiple governments decided to restrict people's physical activities to minimize the chance of infection [3]. The prevalence of COVID-19 has altered trends in the purchasing methods and the number of HMRs purchased [2]. In the COVID-19 era, Koreans purchased HMR products more frequently from online platforms (rather than offline markets) with increased purchasing costs [2]. Before the outbreak of COVID-19, consumers considered the cost-effectiveness and ease of cooking when selecting HMR products. However, after the outbreak of COVID-19, people considered the taste of the HMR product as the most important influencing factor when selecting an HMR product [2], possibly as compensation for reduced physical activities.

Among HMR products, meat-based HMR products have been widely recognized as essential amino acid-rich protein resources [4], and Tteokgalbi is considered to meet the daily nutritional requirements (i.e., essential amino acids and fatty acids with a guaranteed calorie intake). Tteokgalbi is a royal Korean cousin made from beef, pork, and various vegetables [5]. Briefly, rib meat is minced and marinated with soy sauce, sugar, sesame oil, minced green onions, and garlic, and then shaped and cooked on a grill [5]. In the meat industry, pork-based Tteokgalbi is more price-competitive than beef-based Tteokgalbi, because beef is relatively more expensive than pork in Korea.

Similar to other meat products, the consumption of Tteokgalbi, as an HMR, also requires considerable caution because the meat naturally contains higher levels of saturated fatty acids (SFAs) than plant-based processed food products, and thus may induce dyslipidemia. In recent studies, the replacement of SFAs with polyunsaturated fatty acids (PUFAs) significantly prevented dyslipidemia in metabolically complicated rodents [6–9]. Moreover, the results from these experiments revealed that decreasing the *n-6*/*n-3* fatty acid ratio is highly important for controlling blood lipid panels [6–9]. Therefore, a growing demand exists for *n-3*-enhanced meat products, which can be obtained by feeding animals a special diet (i.e., pomace of perilla, a plant-based food ingredient that increases the *n-3* contents in meats).

Consuming *n-3*-enhanced meat products is beneficial for consumers. However, the meat industry should carefully consider the feasibility of maintaining the intact *n-3*-enhanced meat products owing to the instability of PUFAs. PUFAs are naturally more unstable than SFAs because they contain two or more double bonds. Multiple double bonds in PUFAs increase oxidative stress and require higher levels of antioxidants, such as alpha-tocopherol [10]. Therefore, *n-3*-enhanced meat offers both advantages and disadvantages, considering its biological functions and relative instability. Unstable meat products may undergo extra lipid peroxidation, which may deteriorate their physicochemical properties and storage characteristics.

Synthetic and artificial antioxidants have been widely applied by meat-based product producers to maintain the physiochemical properties and storage characteristics of their products [5]. However, recently, consumers have tended to select food products with natural ingredients rather than artificial food additives. Plant-based radical scavengers are primarily used as antioxidants in meat products containing vitamin C, polyphenols, and flavonoids. Moreover, functional components in plants (anthocyanin and non-anthocyanin) may serve beneficial biological functions beyond their antioxidant activity [11,12]. Therefore, in the meat industry, there is an increasing demand for research to identify proper and functional natural ingredients for use as additives to meat products [5,13,14].

Watermelon radish, *Raphanus sativus* L. Brassicaceae, belongs to the order *Raphanus sativus* L. and the Cruciferae family [15]. Diastase in *Raphanus sativus* L. is effective at helping with digestion and relieving the symptoms of food poisoning and hangovers by increasing the rate of ethanol breakdown, rapamycin is effective at suppressing microbial growth [16], and glucosinolate isomers are effective at preventing cancerous cellular growth [17]. In addition, *Raphanus sativus* L. helps increase skin elasticity and reduce wrinkle formation [18], elevate insulin sensitivity [19], and attenuate weight gain by altering the microbiome [20]. The biological functions of watermelon radish have not been intensively studied to date; however, previous reports have suggested that watermelon radish has antioxidative capacities because it contains a variety of vitamins, flavonoids, and phenolic compounds [17].

Therefore, in this study, we carefully investigated the antioxidative capacities of watermelon radish in pork-based Tteokgalbi, as well as the physicochemical and storage characteristics of Tteokgalbi.

2. Materials and Methods

2.1. Preparation of Watermelon Radish Powder from the Flesh

Raphanus sativus L. Brassicaceae, also known as watermelon radish, was purchased on 22 January 2021, from Bibongsan Farm (Yeongdong, Korea) and was washed three times with distilled water. The washed flesh of the watermelon radish was separated and frozen quickly in a deep freezer (MDF-U52V, Sanyo, Osaka, Japan) at around −70 °C. The isolated edible part of the watermelon radish was freeze-dried using a freeze dryer (MLU-9009, Mareuda Inc., Gwangju, Korea) at approximately −70 °C for 72 h and was powdered using an electric grinder (HR2904; Philips Co., Amsterdam, The Netherlands), after which the resulting watermelon radish powder (W) was kept in a deep freezer at approximately −70 °C [15].

2.2. Analysis of the Fatty Acid Composition of *n-3*-Enhanced Pork

The fatty acid profile of *n-3*-enhanced pork was identified, as previously described [6–9], by comparing the peak retention time using gas chromatography (GC-17A, Shimadzu Co., Kyoto, Japan) under the analytical conditions described in Table 1.

Table 1. Analytical gas chromatography conditions used to study the fatty acid compositions.

Item	Condition
Analytical instrument	GC-17A (Shimadzu, Japan)
Column	SP™-2560 capillary column (100 mm length × 0.25 mm inside diameter × 0.25 µm film thickness)
Detector	Flame ionization detector
Temperature	170 °C (5 min) → 4 °C/min → 250 °C (30 min)
Analytical time	80 min/sample

2.3. Recipe of Tteokgalbi Treated with Watermelon Radish Powder

Tteokgalbi was prepared using a peer-reviewed recipe [5]. Boneless, *n-3*-enriched, fat-trimmed, fresh shoulder meat from perilla-fed pigs was obtained from a retailer (Greengrass Bio, Chungju, Korea) and ground using a meat processor (diameter of 8 mm; M-12S, Hankook Fujee Industries Co., Hwaseong, Korea). CON Tteokgalbi was prepared with ground pork meat, soy sauce, tuna liquid, salt, minced garlic, ginger, onion, white sugar, green onion, honey, apple juice, pepper, and sesame oil, according to a peer-reviewed recipe [5]. All of the ingredients, except for the pork, were purchased from CJ Cheiljedang, Seoul, Korea. The REF and experimental samples were prepared by adding ascorbic acid (Sigma-Aldrich, St. Louis, MO, USA) or 1.00, 2.00, or 4.00% W (Table 2). Tteokgalbi was molded into a round shape using a sterile petri dish (diameter of 10.0 cm, thickness of 1.2 cm, weight of ~100 g; SPL Life Sciences, Pocheon, Korea), vacuum packed in nylon/polyethylene film, and kept cold at 4 °C for 0 or 7 days.

Table 2. Recipes for the indicated treatments of Tteokgalbi with watermelon radish powder.

Ingredients	Treatments [1] (%)				
	CON	**REF**	**W1**	**W2**	**W3**
Pork	74.00	73.95	73.50	73.00	72.00
Soy sauce	2.20	2.20	2.20	2.20	2.20
Tuna liquid	0.50	0.50	0.50	0.50	0.50
Salt	0.60	0.60	0.60	0.60	0.60
Garlic	2.20	2.20	2.20	2.20	2.20
Ginger	0.40	0.40	0.40	0.40	0.40
Onion	3.70	3.70	3.70	3.70	3.70
White sugar	2.40	2.40	2.40	2.40	2.40

Table 2. *Cont.*

Ingredients	Treatments [1] (%)				
	CON	REF	W1	W2	W3
Green onion	3.60	3.60	3.60	3.60	3.60
Honey	3.00	3.00	3.00	3.00	3.00
Apple juice	3.70	3.70	3.70	3.70	3.70
Black pepper	0.20	0.20	0.20	0.20	0.20
Sesame oil	3.50	3.50	3.50	3.50	3.50
Ascorbic acid	-	0.05	-	-	-
Watermelon radish powder (W)	-	-	1.00	2.00	4.00

[1] CON, Tteokgalbi treated with 0.00% watermelon radish powder (W); REF, Tteokgalbi treated with 0.05% ascorbic acid as a positive reference; W1, Tteokgalbi treated with 1.00% W; W2, Tteokgalbi treated with 2.00% W; W3, Tteokgalbi treated with 4.00% W.

2.4. Antioxidative Properties and Proximate Compositions of Watermelon Radish Powder-Treated Tteokgalbi

To determine the antioxidative properties of Tteokgalbi, 10 g of the Tteokgalbi specimen was suspended in 100 mL of distilled water three times and then homogenized in a Stomacher 400 Circulator (Seward, London, UK) for 2 min. The total polyphenol content (TPC), total flavonoid content (TFC), and 2,2-diphenyl-1-picrylhydrazyl (DPPH) and 2,2′-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid (ABTS) radical-scavenging activities of the Tteokgalbi homogenate were measured as previously reported [5,21,22]. The moisture and crude protein, fat, and ash content of the Tteokgalbi suspension were also assessed [5,23].

2.5. Water-Holding Capacity (WHC) and Cooking Loss of Tteokgalbi

The WHC and cooking loss of Tteokgalbi were determined according to previous peer-reviewed methods and formulas [5].

2.6. Color of Tteokgalbi before and after Cooking

The L* (brightness), a* (redness), and b* (yellowness) values from either the uncooked or cooked Tteokgalbi were determined using a peer-reviewed method [5].

2.7. Texture-Profile Analysis (TPA) of Tteokgalbi

We assessed the TPA values (hardness, springiness, cohesiveness, and chewiness) of a 1 cm^3 minced Tteokgalbi cube using a rheometer (Sun Scientific Co., Ltd., Tokyo, Japan, v 3.0) with a constant table speed of 60 mm/min, as described previously [5].

2.8. Storage Characteristics of Tteokgalbi

All Tteokgalbi samples were prepared as described in Section 2.3. The pH, 2-thiobarbituric acid reactive substances (TBARS), volatile basic nitrogen (VBN), and total microbial count (TMC) values were determined using previously reported methods [5] at 0 and 7 days after storage at 4 °C.

2.9. Statistical Analysis

Differences in the results after different treatments were analyzed using Duncan's multiple-range test (SAS, 2012). The effects of the differences in storage (before or after cooking) were analyzed by Student's *t*-test using GraphPad Prism 5 for Windows (GraphPad Software Inc., San Diego, CA, USA).

3. Results and Discussion

3.1. Fatty Acid Composition of n-3-Enhanced Pork

We detected four major fatty acids in *n-3*-enhanced pork (Table 3), namely oleic acid (31.992%), palmitic acid (23.753%), stearic acid (13.864%), and linoleic acid (12.739%). Interestingly, the total amounts of *n-3* and *n-6* fatty acids were 3.953 and 12.739%, respectively; thus, the *n-6*/*n-3* ratio was 3.220, which is comparable to the *n-6*/*n-3* ratio of normal pork as 29.40 [24].

Table 3. Fatty acid composition of pork.

Fatty Acid	% of Total Fatty Acids (g/100 g)
Caproic acid (C6:0)	0.767
Lauric acid (C12:0)	0.253
Myristic acid (C14:0)	1.855
Palmitic acid (C16:0)	23.753
Palmitoleic acid (C16:1)	0.523
Heptadecanoic acid (C17:0)	0.229
cis-10-Heptadecenoic acid (C17:1)	0.229
Stearic acid (C18:0)	13.864
Oleic acid (C18:1*n-9*c)	31.992
Linolelaidic acid (C18:2*n-6*ct)	1.496
Linoleic acid (C18:2*n-6*c)	12.739
α-Linolenic acid (C18:3*n-3*)	1.908
cis-11,14-Eicosatrienoic acid (C20:2)	0.426
cis-4,7,10,13,16,19-Docosahexaenoic acid (C22:6*n-3*)	2.045
n-3 fatty acid	3.953
n-6 fatty acid	12.739
n-6/*n-3* ratio	3.220
Total fatty acids	92.079

3.2. Proximate Composition of Tteokgalbi

The proximate compositions of Tteokgalbi after treatment with various concentrations of W are presented in Table 4. The moisture content of Tteokgalbi was the highest in the CON group, whereas W3 treatment significantly decreased the moisture content compared with that in the CON group. In addition, the crude protein content in Tteokgalbi was the highest in the CON group; however, W treatment gradually decreased the crude protein content in Tteokgalbi because the pork was replaced by the added W. Therefore, W2 and W3 treatments remarkably decreased the crude protein content of Tteokgalbi, as reported previously [5]. REF treatment significantly decreased the crude fat content versus that in the CON group, whereas the W treatment did not. The crude ash and carbohydrate contents increased in all W-treated groups, regardless of the W concentration, compared with those in the CON group.

Table 4. Proximate composition of watermelon radish powder.

Proximate Composition	Treatments [1] (Dry Weight Basis)				
	CON	REF	W1	W2	W3
Moisture	68.78 ± 0.11 [2a]	67.99 ± 0.88 [ab]	67.27 ± 0.52 [ab]	66.26 ± 2.26 [ab]	65.59 ± 0.79 [b]
Crude protein	14.44 ± 0.11 [a]	13.89 ± 0.49 [ab]	14.26 ± 0.20 [ab]	13.11 ± 0.92 [b]	13.02 ± 0.17 [b]
Crude fat	10.87 ± 0.59 [a]	9.04 ± 0.32 [b]	10.53 ± 0.18 [a]	10.35 ± 0.34 [a]	10.16 ± 0.56 [a]
Crude ash	1.65 ± 0.04 [c]	1.77 ± 0.06 [bc]	1.83 ± 0.06 [ab]	1.90 ± 0.06 [ab]	1.93 ± 0.05 [a]
Carbohydrate [3]	4.26 ± 0.61 [b]	7.32 ± 0.08 [a]	6.77 ± 1.22 [a]	8.39 ± 1.33 [a]	9.30 ± 1.18 [a]

[1] The treatments are described in Table 2. [2] Values are presented as the mean ± standard deviation (n = 3). [3] Carbohydrate content = 100 − (moisture + crude protein + crude fat + crude ash). Significant differences ($p < 0.05$) are indicated by the lack of a common superscripted letter for different entries in the same row, as determined by Duncan's multiple-range test.

3.3. WHC and Cooking Loss

The WHC and cooking-loss characteristics of W-prepared Tteokgalbi are portrayed in Table 5. The WHC of Tteokgalbi tended to escalate as the amount of W increased when compared with the CON group. The CON group had the lowest WHC, whereas the W3 group had the highest WHC ($p < 0.05$). Phosphate, which is often used as a food additive for manufacturing various processed meat products, can affect the emulsification, texture, color, and abnormal odor of meat products [25]. Using phosphate as a food additive has distinctive advantages and disadvantages; it enhances the product yield by increasing WHC, but leads to excessive deterioration of the meat quality. As excessive phosphate intake may trigger a homeostatic imbalance of other minerals, such as magnesium, calcium, and iron [26,27], consumers have recently become cautious when consuming phosphate-added meat products [28]. To avoid excess usage of phosphate in processed meat products, a study was conducted to identify alternative natural-ingredient replacements [29,30]. The results showed that ascorbic acid (a natural antioxidant) had a similar effect as phosphate. In this study, all W groups exhibited higher WHC values than the REF group; therefore, W can potentially be used as a functional food.

Table 5. Water-holding capacity (WHC) and cooking loss of Tteokgalbi supplemented with different W levels.

Content	Treatments [1]				
	CON	REF	W1	W2	W3
WHC (%)	27.98 ± 0.253 ^{c2}	29.99 ± 0.60 ^{bc}	31.65 ± 0.99 ^{b}	34.50 ± 1.29 ^{a}	35.22 ± 0.40 ^{a}
Cooking loss (%)	26.32 ± 2.15 ^{a}	17.83 ± 1.40 ^{b}	20.97 ± 0.85 ^{b}	18.94 ± 1.07 ^{b}	14.02 ± 1.15 ^{c}

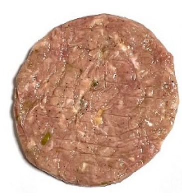
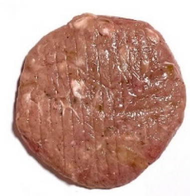
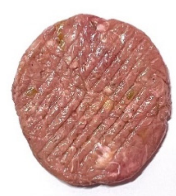
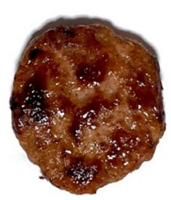
[1] The treatments are described in Table 2. [2] Values are presented as the mean ± standard deviation (n = 3). Significant differences ($p < 0.05$) are indicated by the lack of a common superscripted letter, which differ for entries in the same row, as determined by Duncan's multiple-range test.

The cooking loss of the CON group was highest, and the cooking loss gradually decreased as the amount of W in Tteokgalbi increased ($p < 0.05$). Similarly, seaweed power-treated pork patties also showed decreased cooking loss compared with the control patties [31]. Both seaweed and W contain a considerable amount of fiber; therefore, less cooking loss after W addition may be related to the higher fiber content in W, together with the aforementioned WHC. Cooking loss stems from moisture and fat loss during heating, and heating meat products alters the original protein structure via denaturation and coagulation [32]. Generally, cooking loss increases with slower, higher, and longer heating processes; a lower pH; and an increased surface area and weight of the meat product [5]. Water loss from the meat product occurs when the binding force between water molecules and proteins is weakened and is also affected by the pH of the meat product [33]. When the fat and moisture contents of processed meat products are reduced, their texture, juiciness, and palatability are also reduced [34].

3.4. Chromaticity of Tteokgalbi before and after Cooking

The appearance and colorimetric parameters of Tteokgalbi treated with W before and after cooking are shown in Tables 6 and 7, respectively. Regarding the chromaticity before cooking, the L* value was remarkably high in the CON group (60.10), and REF treatment decreased the L* value (52.83). W treatment decreased the L* value of Tteokgalbi, and the L* values of the W1, W2, and W3 groups were 46.75, 41.83, and 41.55, respectively ($p < 0.05$). The a* value was the lowest in the CON (6.06) and REF (6.24) groups, and the a* value dramatically increased as the amount of W treatment escalated ($p < 0.05$). The REF group exhibited the highest b* value (19.26), which declined as W was added in a dose-dependent fashion ($p < 0.05$).

Table 6. Appearance of Tteokgalbi treated with watermelon radish powder before and after cooking.

Content	Treatments [1] (%)				
	CON	REF	W1	W2	W3
Before cooking					
After cooking					

[1] The treatments are described in Table 2.

Table 7. Chromaticity of Tteokgalbi prepared with watermelon radish powder, before and after cooking.

Contents		Treatments [1]				
		CON	REF	B1	B2	B3
Before cooking	L* [2]	60.10 ± 3.205 ^{a56}	52.83 ± 0.22 ^{b}	46.75 ± 1.91 ^{c}	41.83 ± 0.02 ^{d}	41.55 ± 0.19 ^{d}
	a* [3]	6.06 ± 0.40 ^{d}	6.24 ± 0.09 ^{d}	9.11 ± 0.37 ^{c}	17.29 ± 0.10 ^{b}	19.28 ± 0.07 ^{a}
	b* [4]	16.40 ± 0.81 ^{b}	19.26 ± 0.32 ^{a}	14.60 ± 0.70 ^{c}	10.98 ± 0.20 ^{d}	9.09 ± 0.23 ^{e}
After cooking	L*	61.03 ± 1.15 ^{a}	54.30 ± 0.67 ^{b7*}	54.48 ± 0.94 ^{b**}	53.31 ± 2.75 ^{b**}	51.73 ± 1.88 ^{b**}
	a*	6.08 ± 0.99 ^{c}	9.84 ± 1.61 ^{b}	11.37 ± 0.95 ^{ab*}	13.83 ± 0.58 ^{a**}	13.86 ± 2.10 ^{a*}
	b*	15.28 ± 2.34 ^{b}	17.21 ± 4.92 ^{ab}	25.57 ± 6.37 ^{a*}	14.30 ± 2.67 ^{b}	7.59 ± 2.59 ^{b}

[1] The treatments are listed in Table 2. [2] L*, brightness. [3] a*, redness. [4] b*, yellowness. [5] All values are presented as the mean ± standard deviation (n = 3). [6] $^{a–e}$: means ± standard deviation; different superscripted lowercase letters within the same row indicate significant differences ($p < 0.05$), as analyzed by Duncan's multiple-range test. [7] *, ** Means ± standard deviation with different superscript asterisks within the same column indicate significant differences, as analyzed by Student's *t*-test (* $p < 0.05$, ** $p < 0.01$).

After cooking Tteokgalbi, the L* values were not significantly different between the CON (61.03) and REF (54.30) groups compared with those before cooking. However, in all W-treated Tteokgalbi groups, the L* values were higher after cooking (51.73–54.48) than before cooking (41.55~46.75). After cooking Tteokgalbi, the a* value did not differ in the CON after (6.08) and before cooking (6.06). However, the a* values of the REF (9.84) and W1 (11.37) were significantly higher after cooking than before cooking. Moreover, relatively greater additions of W (W2 and W3) markedly decreased the a* value of Tteokgalbi after cooking. Overall, the b* value was not altered by the W treatment, except for that of the W1 group. Intriguingly, the b* value in the W1 group increased more than two-fold after cooking compared with that before cooking.

Meat color varies depending on the ratio and distribution of oxymyoglobin and metmyoglobin. For example, when metmyoglobin formation increases in the meat product, the meat color becomes brighter [35,36]. The a* value has been positively correlated with the total amount of pigment from additives, the myoglobin content, and the ion concentration [37,38]. In our experimental setting, the L* value of Tteokgalbi with added W may have reflected a browning reaction due to amino acids and reducing sugars, whereas the alteration of the a* value may have been closely related to the high anthocyanin contents in W, which could change the pigmentation of Tteokgalbi. After evaluating the chromaticity before and after cooking Tteokgalbi, we concluded that the colorimetric change was closely related to the degree of browning reaction that occurred during heating and cooking and/or the levels of anthocyanin components from natural additives in W.

3.5. Textural Properties of Tteokgalbi

The textural properties of W-treated Tteokgalbi are listed in Table 8. W-prepared Tteokgalbi exhibited a higher hardness than CON Tteokgalbi, and the W addition increased the hardness of Tteokgalbi in a dose-dependent fashion; therefore, W3 showed the highest hardness. Similarly, W-prepared Tteokgalbi also increased the chewiness in a dose-dependent manner. However, the springiness gradually attenuated with increasing W concentrations in Tteokgalbi; therefore, B3 exhibited the lowest springiness. The cohesiveness value did not vary with W treatment. Previous reports showed that adding seaweed paste to meat patties increased the WHC due to the high content of dietary fibers, such as alginic acid; thus, the meat patties showed increased hardness and chewiness [39,40]. The textures of meat products vary depending on various factors, such as the fat and moisture content, quality of the raw meat, heating temperature, food additives, and dietary fiber [41,42]. Among these factors, the fat content greatly affects the hardness of meat products; therefore, the lower the fat content, the higher the hardness of our products in previous studies [43,44].

Table 8. Textural properties of Tteokgalbi prepared with watermelon radish powder.

Textural Properties	Treatments [1]				
	CON	REF	W1	W2	W3
Hardness (g)	1034.67 ± 45.002 ^{2b}	1056.00 ± 61.22 ^{b}	1061.67 ± 48.05 ^{b}	1154.00 ± 57.17 ^{ab}	1255.00 ± 91.92 ^{a}
Springiness (%)	74.15 ± 0.56 ^{a}	74.07 ± 0.51 ^{a}	74.03 ± 0.35 ^{a}	73.05 ± 0.42 ^{ab}	72.63 ± 0.75 ^{b}
Cohesiveness (%)	55.54 ± 0.29 ^{3NS}	55.37 ± 0.21	55.02 ± 0.30	54.97 ± 0.38	54.85 ± 0.04
Chewiness (g)	958.71 ± 161.99 ^{c}	1323.00 ± 248.92 ^{bc}	1266.98 ± 200.40 ^{bc}	1525.69 ± 182.39 ^{b}	2214.10 ± 203.33 ^{a}
Brittleness (g)	29,428.87 ± 111.24 ^{a}	29,178.57 ± 149.47 ^{a}	29,295.62 ± 90.89 ^{a}	28,764.88 ± 127.86 ^{b}	28,602.43 ± 62.53 ^{b}

[1] The treatments are described in Table 2. [2] All values are presented as the mean ± standard deviation (n = 3). Different superscripted lowercase letters within the same row indicate significant differences ($p < 0.05$), as analyzed by Duncan's multiple-range test. [3] NS, not significantly different among treatments.

3.6. Antioxidative Properties

The TPC and TFC values of W-treated Tteokgalbi samples are summarized in Table 9. The TPC and TFC in Tteokgalbi increased proportionally with increasing amounts of watermelon radish; therefore, TPC was the highest in the W3 group, followed by the W2, W1, REF, and CON groups. As the amount of W added increased, the TPC and TFC values increased gradually ($p < 0.05$) in a dose-dependent manner, regardless of the storage period (0 or 7 days). After the 7-day storage period, the TPC and TFC values were significantly lower than those before storage, regardless of the treatment.

Table 9. The total polyphenol and flavonoid contents of Tteokgalbi prepared with watermelon radish powder during storage.

Contents	Storage Days	Treatments [1]				
		CON	REF	W1	W2	W3
TPC (mg GAE [2]/g)	0	156.48 ± 0.46 ^{4e5}	161.19 ± 0.51 ^{d}	165.20 ± 0.42 ^{c}	170.14 ± 0.77 ^{b}	184.73 ± 0.67 ^{a}
	7	143.90 ± 0.99 ^{e6****}	150.73 ± 1.02 ^{d****}	155.69 ± 0.27 ^{c****}	157.75 ± 0.27 ^{b****}	173.87 ± 0.42 ^{a****}
TFC (mg QE [3]/g)	0	7.86 ± 0.31 ^{e}	10.94 ± 0.14 ^{d}	24.88 ± 0.54 ^{c}	32.83 ± 0.10 ^{b}	45.46 ± 0.37 ^{a}
	7	5.42 ± 0.24 ^{e***}	6.68 ± 0.28 ^{d****}	13.84 ± 0.14 ^{c****}	21.69 ± 0.42 ^{b****}	35.63 ± 0.19 ^{a****}

[1] The treatments are described in Table 2. [2] Gallic acid equivalent. [3] Quercetin equivalent. [4] All values are presented as mean ± standard deviation (n = 3). [5] a–e Different superscripted lowercase letters within the same row indicate significant differences ($p < 0.05$), as determined by Duncan's multiple-range test. [6] ***, **** Means ± standard deviation with different superscripted asterisks within the same column indicate significant differences, as determined by Student's t-test (*** $p < 0.001$, **** $p < 0.0001$).

The DPPH radical-scavenging capacities of W-treated Tteokgalbi after 7 days of cold storage at 4 °C are summarized in Table 10. The DPPH radical-scavenging activities of the

REF and W3 groups were significantly higher than those of the other treatment groups after 0 or 7 days of cold storage. After 7 days of storage, the DPPH radical-scavenging activities were remarkably decreased for all treatments. The ABTS radical-scavenging activities in the Tteokgalbi samples increased proportionally with increasing amounts of watermelon radish; therefore, the ABTS radical-scavenging activity was the highest in the W3 group, followed by those in the W2, W1, REF, and CON groups. As the amount of added W increased, the ABTS radical-scavenging activity increased gradually ($p < 0.05$) in a dose-dependent manner, regardless of the storage period (0 or 7 days). During the storage period, the ABTS radical-scavenging capacities decreased significantly compared with those before storage, regardless of the treatment. Storing meat products requires higher demands for antioxidative activities due to temporal increases in microbial growth and lipid peroxidation. However, adding certain natural ingredients to meat products can help maintain higher radical-scavenging activities than the control products, because they possess higher levels of TPC and/or TFC [5,45,46].

Table 10. Anti-oxidative properties of Tteokgalbi prepared with watermelon radish powder during storage.

Contents	Storage Days	Treatments [1]				
		CON	REF	W1	W2	W3
DPPH [2] radical scavenging-activities	0	11.61 ± 0.93 [4c5]	16.02 ± 1.03 [b]	12.49 ± 0.62 [c]	12.56 ± 0.72 [c]	20.36 ± 0.35 [a]
	7	8.28 ± 0.28 [e****]	11.16 ± 0.27 [b**]	9.19 ± 0.42 [d**]	10.25 ± 0.15 [c**]	12.48 ± 0.15 [a****]
ABTS [3] radical-scavenging activities	0	64.54 ± 0.54 [d]	73.63 ± 0.32 [c]	73.48 ± 0.31 [c]	76.01 ± 0.13 [b]	86.73 ± 0.31 [a]
	7	41.47 ± 0.27 [e****]	45.71 ± 0.46 [d****]	47.25 ± 0.19 [c****]	51.26 ± 0.55 [b****]	56.73 ± 0.22 [a****]

[1] The treatments are described in Table 2. [2] DPPH, 2,2-diphenyl-1-picrylhydrazyl. [3] ABTS, 2,2′-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid). [4] All of the values are presented as mean ± standard deviation (n = 3). [5 a–e] Different superscripted small letters within the same row indicate significant differences ($p < 0.05$), as analyzed by Duncan's multiple-range test. [6] **, ***, **** Different superscripted asterisks within the same column indicate significant differences, as analyzed by Student's *t*-test (** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$).

3.7. Storage Characteristics

Variations in the pH, TBARS, VBN, and TMC values in Tteokgalbi specimens during 7 days of cold storage at 4 °C are presented in Table 11. At the initial storage time (day 0), no remarkable differences in pH were observed between the Tteokgalbi groups. After 7 days of cold storage, the pH of the CON increased significantly; however, the pHs of the REF and W1 groups decreased significantly, and no statistical difference occurred in the pHs of the W2 and W3 groups.

Table 11. Changes in pH, 2-thiobarbituric acid (TBA), volatile basic nitrogen (VBN), and total microbial count (TMC) levels of Tteokgalbi samples prepared with watermelon radish powder during storage at 4 °C for 7 days.

Contents	Storage Days	Treatments [1]				
		CON	REF	W1	W2	W3
pH	0	6.03 ± 0.04 [5NS6B7]	6.06 ± 0.08 [A]	6.07 ± 0.01 [A]	5.97 ± 0.06 [A]	5.96 ± 0.03 [A]
	7	6.15 ± 0.05 [a8A]	5.72 ± 0.04 [dB]	5.74 ± 0.02 [dB]	5.89 ± 0.03 [cA]	6.02 ± 0.04 [bA]
TBARS [2] (mg malonaldehyde/kg)	0	0.08 ± 0.02 [aB]	0.06 ± 0.01 [abB]	0.04 ± 0.01 [bcB]	0.02 ± 0.01 [cB]	0.02 ± 0.01 [cB]
	7	1.49 ± 0.01 [aA]	0.22 ± 0.00 [eA]	0.90 ± 0.01 [bA]	0.71 ± 0.01 [cA]	0.41 ± 0.01 [dA]
VBN [3] (mg/100 g)	0	10.85 ± 0.18 [aB]	10.47 ± 0.03 [bB]	10.54 ± 0.06 [bB]	10.40 ± 0.15 [bB]	10.03 ± 0.07 [cB]
	7	17.45 ± 0.25 [aA]	14.87 ± 0.02 [cA]	17.41 ± 0.08 [aA]	15.42 ± 0.06 [bA]	13.13 ± 0.00 [dA]
TMC [4] (log CFU [5]/g)	0	5.50 ± 0.06 [aB]	5.12 ± 0.02 [bB]	5.17 ± 0.01 [bB]	5.11 ± 0.01 [bB]	5.00 ± 0.02 [cB]
	7	6.94 ± 0.02 [aA]	6.32 ± 0.06 [cA]	6.55 ± 0.03 [bA]	6.34 ± 0.05 [cA]	6.18 ± 0.03 [dA]

[1] The treatments are described in Table 2. [2] TBARS, 2-thiobarbituric acid. [3] VBN, volatile basic nitrogen. [4] TMC, total microbial count, based on the number of colony-forming units (CFUs). [5] All values are presented as mean ± standard deviation (n = 3). [6] NS, not significantly different among treatments. [7 A, B] Different superscripted uppercase letters within the same column indicate significant differences ($p < 0.05$), as analyzed by Student's *t*-test. [8 a–d] Different superscripted lowercase letters within the same row indicate significant differences ($p < 0.05$), as analyzed by Duncan's multiple-range test.

At the initial storage, the CON group showed a higher TBARS level (0.08), whereas the TBARS levels in the W1 (0.04), W2 (0.02), and W3 (0.02) groups were relatively lower. With all treatment groups, after 7 days of cold storage, the TBARS levels increased dramatically ($p < 0.001$), as reported previously for ground meat [47]. After 7 days of cold storage, the TBARS level was the highest in the CON group, which decreased as W was added ($p < 0.05$). The suppressive effect on TBARS in W-prepared Tteokgalbi may be due to the numerous antioxidants—flavonoids, polyphenols, and anthocyanins—present in W, which might prevent lipid peroxidation by suppressing the levels of malonaldehyde and thiobarbituric acid.

The VBN content is an important quantifiable index for judging the freshness of meat products by determining the nitrogen-containing components, such as dimethyl amine, trimethyl amine, and ammonia. The VBN content in fresh meat products ranges from 5 to 10 mg/100 g, or from 30 to 40 mg/100 g in the early stages of spoilage [13]. The Korean Food Sanitation Act states that the VBN contents of packaged meat and raw meat should be less than 20 mg/100 g [48]. At the initial storage, the VBN content of the Tteokgalbi samples ranged from 10.03 to 10.85 mg/100 g. As expected, the CON group had the highest VBN content (10.85), whereas the W3 group had the lowest (10.03). After 7 days of storage, the VBN content of all experimental groups escalated significantly and ranged from 13.13 to 17.45 mg/100 g. After storage, the CON group again had the highest VBN content (17.45), the W3 group had the lowest VBN content (13.13), and W2 (15.42) had the second lowest VBN content ($p < 0.05$).

The TMC was determined to be 5.00–5.50 log colony-forming units (CFUs)/g at the initial storage time and 6.18–6.94 log CFUs/g after 7 days of cold storage. At the initial storage, TMC was the highest in the CON group (5.50 log CFUs/g); however, all W treatments significantly decreased the TMC values in the Tteokgalbi samples. After 7 days of cold storage, the total number of microorganisms in the Tteokgalbi samples had increased significantly ($p < 0.05$). After 7 days of cold storage, the TMC values were the highest in the CON group (6.94 log CFUs/g); however, W treatment gradually decreased the TMC of Tteokgalbi in a dose-dependent fashion. The International Commission on Microbiological Specifications for Foods institutionalizes that the total number of bacteria should not exceed 7 log CFUs/g [49]. In Korea, the Livestock Products Processing Act sets a standard for the freshness of meat products that the total number of bacteria should be less than 5 log CFUs/cm^3 [50].

4. Conclusions

We investigated the suitability of W as a natural ingredient in *n-3*-enriched pork-based Tteokgalbi. The addition of W to *n-3*-enriched pork-based Tteokgalbi escalated the WHC and chewiness but lowered the cooking loss and brittleness. W addition dramatically increased antioxidative properties, partially preventing fatty acid oxidation and microbial growth in *n-3*-enriched pork-based Tteokgalbi. Therefore, W can be applied as a natural component of *n-3*-enriched pork-based Tteokgalbi for potential use in meat processing.

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References

1. Byeon, Y.-S.; Kim, H.-Y. Antioxidative Characteristics of Dried Type Sodium Reduced Chicken Bibimbap Using Dandelion Complex Extract Powder of AF-343 as a Home Meal Replacement. *Korean J. Food Cook. Sci.* **2015**, *31*, 378–386. [CrossRef]
2. Choi, J. *Impact of Social Risk by COVID-19 on Consumption Psychology and Consumption Behavior*; Yonsei University: Seoul, Korea, 2020.
3. Zoumpourlis, V.; Goulielmaki, M.; Rizos, E.; Baliou, S.; Spandidos, D.A. The COVID-19 Pandemic as a Scientific and Social Challenge in the 21st Century. *Mol. Med. Rep.* **2020**, *22*, 3035–3048. [CrossRef] [PubMed]
4. Kim, H.; Park, D.H.; Geun-PyoLee, S.-Y.; Choi, M.J.; Cho, Y. The Change in Quality Characteristics of Hanwoo in Home Meal Replacement Products under Different Cooking and Freezing Methods. *Korean J. Food Sci. Anim. Resour.* **2018**, *38*, 180–188. [PubMed]
5. Lee, J.; Choi, J.; Ha, J. Physicochemical and Storage Characteristics of Pork Tteokgalbi Treated with *Boesenbergia pandurata* (Roxb.) Powder. *Appl. Sci.* **2022**, *12*, 2425. [CrossRef]
6. Son, H.K.; Xiang, H.; Park, S.; Lee, J.; Lee, J.J.; Jung, S.; Ha, J.H. Partial Replacement of Dietary Fat with Polyunsaturated Fatty Acids Attenuates the Lipopolysaccharide-Induced Hepatic Inflammation in Sprague-Dawley Rats Fed a High-Fat Diet. *Int. J. Environ. Res. Public Health* **2021**, *18*, 10986. [CrossRef]
7. Son, H.K.; Kim, B.H.; Lee, J.; Park, S.; Oh, C.B.; Jung, S.; Lee, J.K.; Ha, J.H. Partial Replacement of Dietary Fat with Krill Oil or Coconut Oil Alleviates Dyslipidemia by Partly Modulating Lipid Metabolism in Lipopolysaccharide-Injected Rats on a High-Fat Diet. *Int. J. Environ. Res. Public Health* **2022**, *19*, 843. [CrossRef]
8. Lee, J.; Lee, J.K.; Lee, J.J.; Park, S.; Jung, S.; Lee, H.J.; Ha, J.H. Partial Replacement of High-Fat Diet with Beef Tallow Attenuates Dyslipidemia and Endoplasmic Reticulum Stress In db/db Mice. *J. Med. Food.* **2022**, *25*, 660–674. [CrossRef]
9. Park, S.; Lee, J.J.; Lee, J.; Lee, J.K.; Byun, J.; Kim, I.; Ha, J.H. Lowering n-6/n-3 Ratio as an Important Dietary Intervention to Prevent LPS-Inducible Dyslipidemia and Hepatic Abnormalities in Ob/Ob Mice. *Int. J. Mol. Sci.* **2022**, *23*, 6384. [CrossRef] [PubMed]
10. Raederstorff, D.; Wyss, A.; Calder, P.C.; Weber, P.; Eggersdorfer, M. Vitamin E Function and Requirements in Relation to PUFA. *Br. J. Nutr.* **2015**, *114*, 1113–1122. [CrossRef]
11. Ha, J.H.; Shil, P.K.; Zhu, P.; Gu, L.; Li, Q.; Chung, S. Ocular Inflammation and Endoplasmic Reticulum Stress Are Attenuated by Supplementation with Grape Polyphenols in Human Retinal Pigmented Epithelium Cells and in C57BL/6 Mice. *J. Nutr.* **2014**, *144*, 799–806. [CrossRef]
12. Hong, S.C.; Ha, J.H.; Lee, J.K.; Jung, S.H.; Kim, J.C. In Vivo Anti-Inflammation Potential of Aster Koraiensis Extract for Dry Eye Syndrome by the Protection of Ocular Surface. *Nutrients* **2020**, *12*, 3245. [CrossRef] [PubMed]
13. Ha, J.H.; Lee, J.H.; Lee, J.J.; Choi, Y.I.; Lee, H.J. Effects of Whey Protein Injection as a Curing Solution on Chicken Breast Meat. *Food Sci. Anim. Resour.* **2019**, *39*, 494–502. [CrossRef] [PubMed]
14. Bae, I.K.; Kim, K.J.; Choi, J.S.; Choi, Y.I.; Ha, J.H. Quality Properties and Storage Characteristics of Pyeonyuk with Different Additional Levels of Turmeric Powder. *Food Sci. Anim. Resour.* **2019**, *39*, 35–44. [CrossRef] [PubMed]
15. Jae-Joon, L.; Eun, J.; Yeon-Jin, P. Quality Characteristics and Antioxidant Activity of Yanggaeng Added with Watermelon Radish Flesh Powder. *Korean J. Food Nutr.* **2021**, *34*, 631–640.
16. Song, Y.-B.; Choi, J.-S.; Lee, J.-E.; Noh, J.-S.; Kim, M.-J.; Cho, E.-J.; Song, Y.-O. The Antioxidant Effect of Hot Water Extract from the Dried Radish (*Raphanus sativus* L.) with Pressurized Roasting. *J. Korean Soc. Food Sci. Nutr.* **2010**, *39*, 1179–1186. [CrossRef]
17. Jeon, H.; Kim, H.; Song, Y. Effect of Kimchi Solvent Fractions on Anti-oxidative Enzyme Activities of Heart, Kidney and Lung of Rabbit Fed a High Cholesterol Diet. *J. Korean Soceity Food Sci. Nutr.* **2003**, *32*, 250–255.
18. Kim, H.-K. The Effects of Reducing Skin Wrinkles and Improving Skin Elasticity from Korean Radish Extract. *Int. J. Adv. Smart Converg.* **2019**, *8*, 113–125.
19. Banihani, S.A. Radish (*Raphanus sativus*) and Diabetes. *Nutrients* **2017**, *9*, 1014. [CrossRef]
20. Sim, W.-S.; Choi, S.-I.; Cho, B.-Y.; Choi, S.-H.; Han, X.; Cho, H.-D.; Kim, S.-H.; Lee, B.-Y.; Kang, I.-J.; Cho, J.-H.; et al. Anti-obesity Effect of Extract from *Nelumbo nucifera* L., *Morus Alba* L., and *Raphanus sativus* Mixture in 3T3-L1 Adipocytes and C57BL/6J Obese Mice. *Foods* **2019**, *8*, 170. [CrossRef]
21. Ahn, Y.-H.; Yoo, J.-S.; Kim, S.-H. An Antioxidant Capacity Assay Using a Polyvinyl Alcohol-Based DPPH Pellet. *Bull. Korean Chem. Soc.* **2010**, *31*, 2557–2560. [CrossRef]
22. Song, H.S.; Bae, J.K.; Park, I. Effect of Heating on DPPH Radical Scavenging Activity of Meat Substitute. *Prev. Nutr. Food Sci.* **2013**, *18*, 80–84. [CrossRef]
23. Kang, J.; Lee, J.; Choi, M.; Jin, Y.; Chang, D.; Chang, Y.H.; Kim, M.; Jeong, Y.; Lee, Y. Physicochemical and Textural Properties of Noodles Prepared from Different Potato Varieties. *Prev. Nutr. Food Sci.* **2017**, *22*, 246–250. [CrossRef]

24. Romans, J.R.; Johnson, R.C.; Wulf, D.M.; Libal, G.W.; Costello, W.J. Effects of ground flaxseed in swine diets on pig performance and on physical and sensory characteristics and omega-3 fatty acid content of pork: I. Dietary level of flaxseed. *J. Anim. Sci.* **1995**, *73*, 1982–1986. [CrossRef]
25. Wang, P.; Xu, X.-L.; Zhou, G.-H. Effects of Meat and Phosphate Level on Water-Holding Capacity and Texture of Emulsion-Type Sausage during Storage. *Agric. Sci. China* **2009**, *8*, 1475–1481. [CrossRef]
26. Huttunen, M.M.; Pietilä, P.E.; Viljakainen, H.T.; Lamberg-Allardt, C.J. Prolonged Increase in Dietary Phosphate Intake Alters Bone Mineralization in Adult Male Rats. *J. Nutr. Biochem.* **2006**, *17*, 479–484. [CrossRef] [PubMed]
27. Meng, Y.; Sun, J.; Yu, J.; Wang, C.; Su, J. Dietary Intakes of Calcium, Iron, Magnesium, and Potassium Elements and the Risk of Colorectal Cancer: A Meta-analysis. *Biol. Trace Elem. Res.* **2019**, *189*, 325–335. [CrossRef]
28. St-Jules, D.E.; Woolf, K.; Pompeii, M.L.; Kalantar-Zadeh, K.; Sevick, M.A. Reexamining the Phosphorus–Protein Dilemma: Does Phosphorus Restriction Compromise Protein Status? *J. Ren. Nutr.* **2016**, *26*, 136–140. [CrossRef] [PubMed]
29. Ruusunen, M.; Vainionpää, J.; Puolanne, E.; Lyly, M.; Lähteenmäki, L.; Niemistö, M.; Ahvenainen, R. Physical and Sensory Properties of Low-Salt Phosphate-Free Frankfurters Composed with Various Ingredients. *Meat Sci.* **2003**, *63*, 9–16. [CrossRef]
30. Zhu, Y.; Yan, Y.; Yu, Z.; Wu, T.; Bennett, L.E. Effects of High Pressure Processing on Microbial, Textural and Sensory Properties of Low-Salt Emulsified Beef Sausage. *Food Control* **2022**, *133*, 108596. [CrossRef]
31. Jeon, M.-R.; Choi, S.-H. Quality Characteristics of Pork Patties Added with Seaweed Powder. *Food Sci. Anim. Resour.* **2012**, *32*, 77–83. [CrossRef]
32. Choi, Y.-S.; Jeong, J.-Y.; Choi, J.-H.; Lee, M.; Lee, E.-S.; Kim, H.-Y.; Han, D.-J.; Kim, J.-M.; Kim, C.-J. Effects of Immersion Period after Tumbling Processing on the Quality Properties of Boiled Pork Loin with Soy Sauce. *Korean J. Food Cook. Sci.* **2006**, *22*, 379–385.
33. Flores, M.; Moya, V.-J.; Aristoy, M.-C.; Toldrá, F. Nitrogen Compounds as Potential Biochemical Markers of Pork Meat Quality. *Food Chem.* **2000**, *69*, 371–377. [CrossRef]
34. Winger, R.J.; Fennema, O. Tenderness and Water Holding Properties of Beef Muscle as Influenced by Freezing and Subsequent Storage at −3 or 15 °C. *J. Food Sci.* **1976**, *41*, 1433–1438. [CrossRef]
35. Cheng, J.H.; Chen, Y.Q.; Sun, D.W. Effects of Plasma Activated Solution on the Colour and Structure of Metmyoglobin and Oxymyoglobin. *Food Chem.* **2021**, *353*, 129433. [CrossRef]
36. Wang, X.; Wang, Z.; Zhuang, H.; Nasiru, M.M.; Yuan, Y.; Zhang, J.; Yan, W. Changes in Color, Myoglobin, and Lipid Oxidation in Beef Patties Treated by Dielectric Barrier Discharge Cold Plasma during Storage. *Meat Sci.* **2021**, *176*, 108456. [CrossRef]
37. Asami, H.; Kawabata, R.; Kawauchi, N.; Kohno, J.-y. Photodissociation Spectroscopy of Hydrated Myoglobin Ions Isolated by IR-Laser Ablation of a Droplet Beam: Recovery from pH-Denatured Structure by Gas-Phase Isolation. *Chem. Lett.* **2019**, *48*, 140–143. [CrossRef]
38. Krycki, M.M.; Lin, S.Y.; Loglio, G.; Michailov, A.V.; Miller, R.; Noskov, B.A. Impact of Denaturing Agents on Surface Properties of Myoglobin Solutions. *Colloids Surf. B Biointerfaces* **2021**, *202*, 111657. [CrossRef]
39. Munsu, E.; Mohd Zaini, H.; Matanjun, P.; Ab Wahab, N.; Sulaiman, N.S.; Pindi, W. Physicochemical, Sensory Properties and Lipid Oxidation of Chicken Sausages Supplemented with Three Types of Seaweed. *Appl. Sci.* **2021**, *11*, 11347. [CrossRef]
40. Gullón, B.; Gagaoua, M.; Barba, F.J.; Gullón, P.; Zhang, W.; Lorenzo, J.M. Seaweeds as Promising Resource of Bioactive Compounds: Overview of Novel Extraction Strategies and Design of Tailored Meat Products. *Trends Food Sci. Technol.* **2020**, *100*, 1–18. [CrossRef]
41. Younis, K.; Yousuf, O.; Qadri, O.S.; Jahan, K.; Osama, K.; Islam, R.U. Incorporation of Soluble Dietary Fiber in Comminuted Meat Products: Special Emphasis on Changes in Textural Properties. *Bioact. Carbohydr. Diet. Fibre* **2022**, *27*, 100288. [CrossRef]
42. Zhao, D.; Guo, C.; Liu, X.; Xiao, C. Effects of Insoluble Dietary Fiber from Kiwi Fruit Pomace on the Physicochemical Properties and Sensory Characteristics of Low-Fat Pork Meatballs. *J. Food Sci. Technol.* **2021**, *58*, 1524–1537. [CrossRef] [PubMed]
43. Moghtadaei, M.; Soltanizadeh, N.; Goli, S.A.H. Production of Sesame Oil Oleogels Based on Beeswax and Application as Partial Substitutes of Animal Fat in Beef Burger. *Food Res. Int.* **2018**, *108*, 368–377. [CrossRef] [PubMed]
44. Gómez-Estaca, J.; Pintado, T.; Jiménez-Colmenero, F.; Cofrades, S. Assessment of a Healthy Oil Combination Structured in Ethyl Cellulose and Beeswax Oleogels as Animal Fat Replacers in Low-Fat, PUFA-Enriched Pork Burgers. *Food Bioprocess Technol.* **2019**, *12*, 1068–1081. [CrossRef]
45. Nahed, L.; Nasra, Z.; Hanaa, A.A.-E.; Abd El-Rahman, S. The Utilization of Yellow and Red Onion Peels and Their Extracts as Antioxidant and Antimicrobial in Preservation of Beef Burger during Storage. *Am. J. Food Sci. Technol.* **2022**, *10*, 1–9.
46. Wang, T.; Jin, Y.; Yang, N.; Xu, D.; Yang, Z.; Tan, Y.; Xu, X.; Jin, Z.; Cui, B. Effect of Magnetic Field with Different Dimensions on Quality of Avocado Puree during Frozen Storage. *Int. J. Food Sci. Technol.* **2022**, *57*, 1698–1707. [CrossRef]
47. Rahmasari, Y.; Yemiş, G.P. Characterization of Ginger Starch-Based Edible Films Incorporated with Coconut Shell Liquid Smoke by Ultrasound Treatment and Application for Ground Beef. *Meat Sci.* **2022**, *188*, 108799. [CrossRef]
48. Ministry of Food and Drug Safety. *Food Sanitation Act*; Ministry of Food and Drug Safety: Cheongju, Korea, 2014.
49. Swanson, K.M.J.; Buchanan, R.L.; Cole, M.B.; Cordier, J.L.; Flowers, R.S.; Gorris, L.G.M.; Taniwaki, M.H.; Tompkin, R.B.; Zwietering, M.H. *Microorganisms in Foods: Use of Data for Assessing Process Control and Product Acceptance*; Springer Science: Berlin/Heidelberg, Germany, 2011.
50. MFDS. *The Guideline of Processing and Composition Standard of Animal Resourced Food Products*; Korean Food Drug Administration Notification No. 2014-135; MFDS: Cheongju, Korea, 2014.