



Watermelon Peels and Rinds as a Food Preservative and Additive in Pork *Longganisa* (Sausage)

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Abstract Food products in the Philippines mostly use synthetic preservatives, including the curing powder for pork *longganisa* (sausages) (PL), a widely consumed cured meat. Currently, there is an emerging trend to look for natural alternatives to increase the nutritional value of food while ensuring its stability during storage. In Sibalom, Antique, 41.9% or 11,250pcs. of watermelons are surveyed to be rejected and left on the field to rot after harvest. The development of these rejects as food preservatives and additives from the rinds and peels of red-fleshed “Sweet 16” (RF16) and yellow-fleshed “Sweet Gold” (YFSG) watermelons was conducted. The peels and rinds were oven-dried at 60°C were powdered and added at 6% to the PL. A positive control using Prague powder (PRP) and a negative control (NC) were used alongside the treatments. The sensory evaluation results showed a significant difference in odor among the PRP, RF16, and YFSG samples on day 16. Meanwhile, no significant differences were found between the color, texture, and flavor of all samples. The free fatty acid content of PRP and NC increased on day 27, whereas it decreased for RF16 and YFSG, suggesting better shelf-life stability. When analyzing the nutritional content, no significant differences were observed in the moisture content of all samples, whereas the crude fat content did not differ between YFSG and PRP. Crude protein was highest in PRP, whereas the crude fiber content of YFSG and RF16 was significantly higher and even increased on day 27. The use of watermelon peels and rind powders from the rejects was comparable to that of the commercial preservative, as it further improved the nutritional content and shelf-life stability of pork *longganisa*, promoting a circular food system that can also be introduced to a wide variety of food products.

Keywords food preservative, food additive, watermelon rejects, peels and rinds, food losses

INTRODUCTION

In the Philippines, synthetic preservatives are used in a wide variety of food products to increase shelf-life stability, prevent microbial spoilage, reduce lipid oxidation, and maintain sensory properties. Despite its popular use, there is growing concern regarding the use of synthetic preservatives, such as curing powder, locally referred to as *Prague powder*, as it contains nitrates and nitrites that can be converted to carcinogenic nitrosamines, causing adverse health effects to consumers (Shi et al., 2024). Due to this concern, natural preservatives are being explored from plant extracts that can potentially replace the synthetic preservatives in the market. One of these is the use of watermelon waste. Kumar et al. (2018) assessed the lipid peroxidation of pork patties with watermelon rinds (WMR) and found results comparable to those of the positive control (treated with 0.02% butylated hydroxytoluene). The results also showed a significant reduction in lipid peroxidation compared to that in the untreated samples, indicating its effectiveness as a preservative. Currently, there are no studies in the Philippines applying watermelon waste in food products or its

use as a natural preservative and additive, as most studies are geared toward the extraction of its pectin, candying rinds, and its use as a rejuvenating agent (Lo et al., 2019; Back et al., 2016).

The annual production of watermelon in 2021 was estimated at 135, 845.60 tons in the Philippines (FAO, 2024), with Western Visayas being the highest producer in the country at 51, 781 tons, comprising 41.5% of the total watermelon production (Philippine Statistics Authority, 2023). Due to higher watermelon production, great watermelon waste is also generated, as observed in a surveyed site in Cubay-Napultan, Sibalom, Antique, wherein almost half of the watermelons are considered waste (41.9% or 11,250 pcs), and are left in the field to rot (Aposaga et al., 2025). The use of watermelon waste in the form of its peels and rinds as a natural food preservative and value additive has potential, especially in Western Visayas, the highest watermelon producer in the Philippines. In this study, the use of watermelon powder (WamPow) from the top two grown cultivars of the red-fleshed Sweet 16 (RF16) and yellow-fleshed Sweet Gold (YFSG) watermelons as a potential replacement for synthetic preservatives was evaluated in pork longganisa (sausage).

OBJECTIVE

This study aimed to determine the potential of watermelon peel and rind from watermelon rejects left on the field after harvest in Cubay-Napultan, Sibalom, Antique, Philippines, to be used as a natural food preservative and additive when added to pork *longganisa*.

METHODOLOGY

Around 100 pcs. of RF16 and YFSG were collected in Cubay-Napultan, Sibalom, Antique, in February 2023. Only the watermelons that were considered rejects and left in the field but were still in good condition were collected as samples. The watermelons were washed with potable water, dipped in 100ppm ppm chlorine solution for 5 min, rinsed with potable water, air-dried, and stored in a well-ventilated area before preparation. The peels and rinds were thoroughly separated from the flesh and cut into 1x1cm³. The two cultivars of YFSG and RF16, labeled YFSG 60°C and RF16 60°C, respectively, were dried at 60°C and powdered.

In formulating the pork *longganisa* with WamPow, the percentage of WamPow added to pork *longganisa* was examined through a preliminary test ranging from 3%, 6%, and 9%, wherein the most acceptable result came from pork *longganisa* treated with 6% WamPow and was used in the final formulation. Controls were also prepared alongside the treatments using Prague powder and one without any preservatives or additives. The samples were then analyzed for *Escherichia coli*, *Staphylococcus aureus*, and Aerobic Plate Count for microbial quality, sensory evaluation using the 7-point hedonic scale from seven trained panelists, free fatty acid content based on the modified method from the AOAC 41.121 for crude and refined oils, and proximate nutrient content (AOAC International, 2019). In analyzing the results, the two-way analysis of variance (ANOVA) was performed, with Fisher's least significant difference (LSD) as the post-hoc using the StatPlus software (Build 8.0.3/Core v7.8.11). The level of significance was set at P<0.05.

RESULTS AND DISCUSSION

Microbiological Analysis

Over 27 days, the APC test was conducted to monitor the progress of bacterial growth in the cooked *longganisa*, as shown in Fig. 1. Analysis on Day 0 showed a high count for RF16 60°C samples; however, it was still within the set limit for ready-to-eat (RTE) food. The sudden drop in count in all samples on Day 7 was mainly due to the longer storage period at -2°C to -5°C, which affected the metabolic activity and nutrient uptake of the microorganisms, leading to a partial reduction in the microbial population. From days 14 to 27, the increase in APC may be associated with the increased resistance of the remaining bacterial population to the frozen conditions and may have multiplied

once heated due to its longer storage period. Despite the increase in microbial count, all samples passed the microbiological test during the 27-day storage period and were within the limit. This indicates the safety of watermelon rejects when added to food.

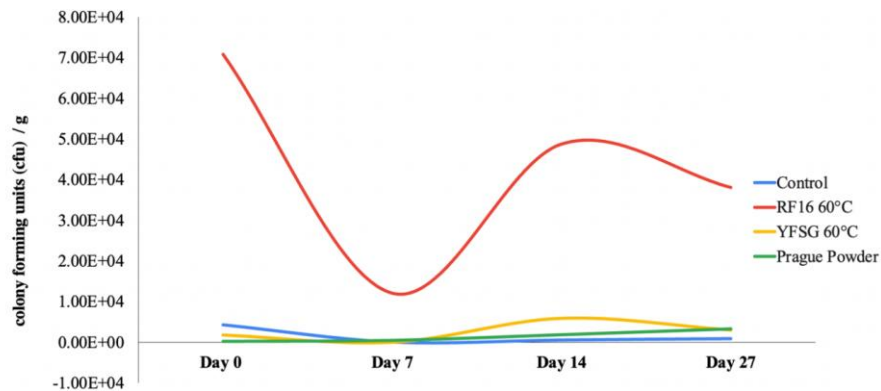


Fig. 1 APC monitoring of cooked pork Longganisa

Further microbiological tests were conducted through the assessment of the indicator organisms, *E.coli* and *S. aureus*. All samples tested showed negative growth for *E.coli*, while monitoring for *S. aureus* showed growth, but all within the acceptable limit, with the lowest recorded at ≤ 25 cfu/g for pork longganisa mixed with RF16 60°C and the highest at 9×10^1 cfu/g from the Prague powder. The maximum limits of the indicator organisms were based on the Food Standards Australia New Zealand (2025). The results indicate how WamPow was able to reduce the growth of *S. aureus* compared to the synthetic preservative.

Sensory Evaluation

The sensory characteristics of the pork longganisa with WamPow, Prague powder, and those without any preservatives or additives did not significantly vary in terms of its color, texture, odor, and flavor during the storage at days 1, 7, and 16.

Effect of the Treatments on the Color of the Pork Longganisa

The color, as seen in Table 1 of the samples remained stable throughout the storage period, with Prague powder exhibiting the highest acceptability due to its distinct red color in the pork longganisa. The color of the sample treated with RF16 at 60°C had the highest acceptability the longer it was stored. On the 7th and 16th days of storage, the pork longganisa with WamPow did not significantly differ from that with Prague powder. The green color in the pork longganisa from the WamPow was still considered new, and uncommon for pork products by the panelists. Green is mostly associated with non-meat products, which still serves as an area for improvement during product development.

Effect of the Treatments on the Texture of the Pork Longganisa

The texture of each sample during the whole storage period from day 1, 7, and 16 did not significantly differ. However, for the control, its texture was found to be highly acceptable at the end of its storage period, as seen in Table 1. Based on the comments of the panelists, the texture of the RF16 60°C pork longganisa on day 1 was quite dry but improved the longer its storage period, similar to YFSG 60°C. The texture of the WamPow-treated pork longganisa on day 1 was less juicy and moist due to the observed high absorbency of the WamPow, which soaked up the water, oils, and juices in the pork longganisa, resulting in lower scores for its texture. Over time, the texture of the WamPow improved when stored longer and became comparable with the control and Prague powder on days 7 and 16.

Effect of the Treatments on the Odor of the Pork *Longganisa*

The odor, as shown in Table 1 of the samples, did not significantly differ during the whole storage period, with the highest rating given to the control and the Prague powder. YFSG 60°C had the most acceptable score among the WamPow-treated samples on days 7 and 16. The odor of the WamPow-treated pork *longganisa* was generally similar to one other, having leafy and grassy notes described as having an interesting odor when incorporated into the meat. Since the addition of WamPow has not yet been previously explored in the Philippines, the combination of its odor with meat was considered new and predominantly different. However, higher acceptability values were noted as the duration of storage increased, as the smell became less distinct compared to day 1.

Table 1 Sensory evaluation results of the cooked pork *Longganisa*

Sample	Color attribute during storage		
	Day 1	Day 7	Day 16
Control	6.67±1.94 ^{a,A,B}	5.00±2.52 ^{a,A}	4.43±2.07 ^{a,B}
RF16 60°C	5.22±1.30 ^{a,B}	5.86±1.21 ^{a,A}	6.86±1.07 ^{a,A}
YFSG 60°C	4.89±1.05 ^{a,B}	5.43±2.07 ^{a,A}	5.29±1.50 ^{a,A,B}
Prague powder	7.11±1.9 ^{a,A}	6.57±2.64 ^{a,A}	7.29±1.60 ^{a,A}
Sample	Texture attribute during storage		
	Day 1	Day 7	Day 16
Control	7.44±1.67 ^{a,A}	6.86±2.19 ^{b,A}	7.14±1.21 ^{a,b,A}
RF16 60°C	4.67±1.00 ^{a,C}	6.57±1.13 ^{a,A}	5.71±2.06 ^{a,A}
YFSG 60°C	5.44±1.42 ^{a,B,C}	6.14±1.77 ^{a,A}	5.71±1.89 ^{a,A}
Prague powder	7.33±1.58 ^{a,A}	5.14±2.41 ^{a,A}	7.00±1.91 ^{a,A}
Sample	Odor attribute during storage		
	Day 1	Day 7	Day 16
Control	5.78±1.92 ^{a,A}	4.86±2.12 ^{a,A}	6.29±1.60 ^{a,A,B}
RF16 60°C	4.33±1.66 ^{a,A}	4.14±2.04 ^{a,A}	5.29±1.70 ^{a,B}
YFSG 60°C	4.33±1.58 ^{a,A}	5.43±1.62 ^{a,A}	5.57±1.5 ^{a,A,B}
Prague powder	6.11±1.83 ^{a,A}	5.57±2.44 ^{a,A}	7.71±1.60 ^{a,A}
Sample	Flavor attribute during storage		
	Day 1	Day 7	Day 16
Control	6.67±2.24 ^{a,A}	7.14±2.40 ^{a,A}	6.00±2.52 ^{a,A}
RF16 60°C	4.56±1.24 ^{a,A}	4.86±1.95 ^{a,A}	6.00±2.08 ^{a,A}
YFSG 60°C	6.11±1.96 ^{a,A}	6.14±2.34 ^{a,A}	5.71±2.14 ^{a,A}
Prague powder	5.89±2.76 ^{a,A}	5.57±2.88 ^{a,A}	6.71±2.81 ^{a,A}

Data are presented as mean ± standard deviation (n=9 for day 1, and n=7 for days 7 and 16). Mean values in the same row per attribute, with similar superscript small letters (a-b), are not significantly different at $p < 0.05$. Mean values in the same column per attribute, with similar superscript capital letters (A-D), are significantly different at $p < 0.05$.

Effect of the Treatments on the Flavor of the Pork *Longganisa*

Flavor is considered an important sensory characteristic of a food product, as it is a major determinant factor in terms of food preference. The sensory evaluation results showed the flavor profile of the samples during the storage period, and when compared with one another, did not generally significantly differ at days 7 and 16, indicating that the taste of WamPow-treated pork *longganisa* can be compared with that of Prague powder-treated samples. The WamPow samples were noted to have an improved flavor, from a strong leafy taste that became faint the longer its storage, which was noted by the panelists as the reason for its higher rating at day 7. This indicates that a longer storage period aids in enhancing the overall flavor profile of pork *longganisa* treated with WamPow, as it was able to compete with the controls, as detailed in Table 1.

Free Fatty Acid (FFA)

FFA are prone to oxidation and are indicators of rancidity. The %FFA from Day 0 to Day 27, as shown in Table 2, increased for the control and Prague powder-treated samples, while the FFA of RF16 60°C and YFSG 60°C decreased over time. The lower %FFA value of WamPow-treated pork *longganisa* indicates the pork is less rancid, and implies a slower degradation process, making the samples shelf-stable. Based on the results, WamPow can act as a natural preservative and enables the reduction of %FFA values during its storage period, indicating the influence of the WamPow on lowering lipid oxidation. The RF16 60°C contributed to a much lower FFA.

Table 2 Free fatty acid (FFA) values of cooked pork *Longganisa* samples

Sample	Day of storage (FFA (%), cooked samples)			
	0	7	16	27
Control	0.33±0.1 ^{a,B}	0.50±0.06 ^{a,C}	0.59±0.15 ^{a,B}	0.70±0.10 ^{a,A,B}
RF16 60°C	0.86±0.21 ^{a,A}	0.72±0.15 ^{a,A,B,C}	0.77±0.08 ^{a,A,B}	0.61±0.05 ^{a,B}
YFSG 60°C	0.71±0.28 ^{a,A,B}	1.05±0.10 ^{a,A}	0.93±0.17 ^{a,A,B}	0.70±0.02 ^{a,A,B}
Prague powder	0.42±0.31 ^{a,A,B}	0.55±0.14 ^{a,B,C}	0.65±0.09 ^{a,B}	0.84±0.31 ^{a,A,B}

Data are presented as mean ± standard deviation (n=3). Mean values in the same row with similar superscript small letters (a-b) are not significantly different at $p < 0.05$. Mean values in the same column with similar superscript capital letters (A-B) are significantly different at $p < 0.05$.

Nutritional Composition of Cooked Pork *Longganisa*

The proximate nutrients of the cooked pork *longganisa* were evaluated on days 0 and 27.

Moisture Content (MC)

The %MC of the pork *longganisa* samples, as shown in Table 3, did not significantly vary among the treatments and between the storage times (Day 0 and 27). This indicates that WamPow does not significantly affect the %MC of pork *longganisa*.

Ash Content

The %Ash of pork *longganisa* for all treatments decreased by day 27. The highest value of ash was reported to be RF16 at 60°C, with a value of 8.68% on day 0. The lowest ash value was recorded for the control at 5.51% on day 27. The higher ash values of pork *longganisa* with WamPow may be due to the number of inorganic compounds, such as minerals, present in the dried watermelon peels and rinds, as detailed in Table 3.

Crude Protein (CP)

The %CP of pork *longganisa* decreased with storage period, except for YFSG 60°C, which increased on day 27 (Table 3). On day 0, the highest %CP was recorded for Prague powder at 32.62%, and the lowest %CP was recorded for YFSG 60°C at 24.44%. The %CP of Prague powder was significantly higher than that of the WamPow-treated pork *longganisa* at days 0 and 27 due to the presence of nitrates and nitrites. For the control, the %CP by day 27 was not significantly different from that of the Prague powder-treated samples and YFSG 60°C. The results show that the RF16 cultivar at 60 °C may have affected the %CP of the pork *longganisa* samples during the storage period.

Crude Fat (CFt)

The %CFt of pork *longganisa* did not significantly differ over the storage period from day 0 to day 27, except for the control, which significantly decreased by day 27, as shown in Table 3. As preservatives were not added to the control, the fat may have oxidized, resulting in a much lower value. No significant differences were found in the reduced %CFt of the other samples by day 27,

indicating the effect of minimizing fat oxidation through the addition of Prague powder and WamPow to pork *longganisa*.

Crude Fiber

Higher crude fiber values were found in the YFSG treated at 60°C. The WamPow-treated pork *longganisa* was significantly higher and even increased by day 27 compared to Prague powder and control. This indicates the ability of WamPow to add value to pork *longganisa* and other food products. The significant increase in the crude fiber at day 27 for YFSG 60°C by 1.33% shows the positive interaction of WamPow with the nutrient matrix of the pork *longganisa*. No significant increase in the crude fiber of the Prague powder and control by the end of its 27-day storage period was observed as presented in Table 3. The results show that the addition of WamPow can further increase the marketability of pork products, which were previously low in fiber.

Table 3 Proximate nutrient results of the cooked pork *Longganisa*

Sample	Moisture content (%) during storage, cooked samples	
	Day 0	Day 27
Control	3.86±0.01 ^{a,A}	3.84±0.03 ^{a,A}
RF16 60°C	3.85±0.02 ^{a,A}	3.87±0.01 ^{a,A}
YFSG 60°C	3.87±0.01 ^{a,A}	3.83±0.02 ^{a,A}
Prague powder	3.83±0.05 ^{a,A}	3.84±0.01 ^{a,A}
Sample	Ash content (%) during storage, cooked samples	
	Day 0	Day 27
Control	5.67±0.09 ^{a,E}	5.51±0.16 ^{a,E}
RF16 60°C	8.68±0.08 ^{a,A}	8.63±0.11 ^{a,A}
YFSG 60°C	6.88±0.05 ^{a,C}	6.71±0.01 ^{a,C}
Prague powder	6.54±0.05 ^{a,D}	6.35±0.10 ^{a,D}
Sample	Crude protein (%) during storage, cooked samples	
	Day 0	Day 27
Control	29.78±0.85 ^{a,B}	29.33±2.17 ^{a,A,B}
RF16 60°C	30.36±2.80 ^{a,B}	26.76±0.59 ^{b,B,C}
YFSG 60°C	24.44±0.20 ^{a,B}	25.14±1.69 ^{a,C}
Prague powder	32.62±3.01 ^{a,A}	32.55±1.13 ^{a,A}
Sample	Crude fat (%) during storage, cooked samples	
	Day 0	Day 27
Control	45.44±1.44 ^{a,A}	39.50±2.93 ^{b,A,B}
RF16 60°C	37.95±2.80 ^{a,B}	36.58±5.5 ^{a,B}
YFSG 60°C	43.71±2.21 ^{a,A}	41.80±2.30 ^{a,A}
Prague powder	42.48±0.23 ^{a,A,B}	42.33±1.21 ^{a,A}
Sample	Crude fiber (%) during storage, cooked samples	
	Day 0	Day 27
Control	0.30±0.08 ^{a,B}	0.51±0.07 ^{a,B}
RF16 60°C	3.52±0.13 ^{a,A}	3.78±0.04 ^{a,A}
YFSG 60°C	3.32±0.16 ^{b,A}	4.65±0.16 ^{a,A}
Prague powder	0.39±0.01 ^{a,B}	0.58±0.04 ^{a,B}

Data are presented as mean ± standard deviation (n=3). Mean values in the same row per test, with similar superscript small letters (a), are not significantly different at p<0.05. Mean values in the same column per test, with similar superscript capital letters (A), are significantly different at p<0.05.

CONCLUSION

The production of watermelon powders (WamPow) from the red-fleshed *Sweet 16* and yellow-fleshed *Sweet Gold* in the province of Antique, Philippines, has great potential for commercialization and use in a wide variety of food products as a natural food preservative and value additive, as it performs similarly to synthetic preservatives in reducing the production of free fatty acids during

storage and even adding fiber to pork *longganisa*. In comparing the WamPow powders, RF16 60°C had higher values of color, crude ash, and crude protein, and lower FFA, while YFSG 60°C had higher results for odor, flavor, crude fat, and crude fiber.

This study addresses the research gaps in utilizing watermelon peels and rinds as natural preservatives and value additives for potential use in a wide variety of food products. Overall, the results of the study produced a technology that adds economic value and addresses the problems of watermelon losses and waste during watermelon harvests in the Philippines, while simultaneously increasing the marketability of pork *longganisa*.

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