

USE OF ALBEDO AND FLAVEDO GRAPEFRUIT POWDERS AS OXIDATIVE STABILISERS OF PORK PATTIES DURING CHILLED STORAGE

Sandra G. López-Santiz¹, Gastón R. Torrescano-Urrutia², Rey D. Vargas-Sánchez³, Livier Zavala-Cárdenas², and Armida Sánchez-Escalante^{3*}

¹Universidad Tecnológica de la Selva, Chiapas, México; ²Centro de Investigación en Alimentación y Desarrollo, A.C. Hermosillo, México.

³Universidad Autónoma de Sinaloa, Culiacán, México.

*Corresponding author email: armida-sanchez@ciad.mx

Abstract – This work evaluates the ability of albedo (AGP) and flavedo (FGP) grapefruit powders (2% and 5%) to improve the quality of raw pork patties during chilled storage (2 °C/9 days/under darkness). First, AGP and FGP were analysed for their *in vitro* antioxidant activity (AOX) (total phenolic content, TPC; antiradical DPPH• activity; reducing power ability, RP). Then, pork patties treated with AGP and FGP (0%, 2% and 5%) were evaluated for pH, lipid oxidation (thiobarbituric acid reactive substances, TBARS), metmyoglobin formation (MetMb), colour (a*) and water holding capacity (WHC) during chilled storage (2–4 °C/9 days/without illumination). The results indicate that AGP and FGP were an important source of phenolic compounds and exerted good antiradical DPPH• and RP properties ($P<0.05$). No significant differences were found in pH or WHC of pork patties treated with grapefruit powder ($P>0.05$). Also, the pork patties treated with AGP and FGP at 2% showed the lowest TBARS and MetMb values in comparison to the control group ($P<0.05$). These results indicate that albedo and flavedo grapefruit powders have great potential for preventing oxidation in pork patties and could be used as a natural ingredient for preserving the shelf life of meat and meat products during refrigerated storage.

Key Words – Lipid oxidation, albedo and flavedo grapefruit, porcine meat, natural antioxidant.

I. INTRODUCTION

Synthetic Antioxidants (SAx) such as BHT (butylated hydroxytoluene), BHA (butylated hydroxyanisole), TBHQ (tertiary butyl hydroquinone) and PG (propyl gallate) have been widely used in the food industry. However, SAx are suspected carcinogens, and consumer acceptance of these has decreased in recent years [1]. In the meat and meat products industry, natural sources of antioxidants, such as plant extracts (grape seed, lycopene, onion, oregano, pine bark and rosemary, among others), can be used to reduce lipid oxidation (LOX) in meat [2]. Grapefruit is known to have high levels of flavonoids and ascorbic acid, which both have nutritional and antioxidant properties [3]. The albedo and flavedo of some citrus fruits have been reported to possess significant antioxidant properties resulting from the presence of phenolic compounds [4]. However, to the best of our knowledge, no investigation has examined the use of these components of grapefruit as antioxidants in meat and meat products. Thus, the objective of this study was to assess the antioxidant activity of albedo and flavedo grapefruit powder in raw pork patties during chilled storage.

II. MATERIALS AND METHODS

Antioxidant *in vitro* properties were evaluated through determining the total phenolic content (TPC) using Folin-Ciocalteu's method in addition to antiradical activity (DPPH•, 1,1-diphenyl-2-picrylhydrazyl) following the ferricyanide/prussian blue method (RP). Minced pork meat (90:10 ratio of meat:fat) was obtained from a local processor and homogenised with 1.5% salt (NaCl, w/w). Polystyrene trays containing the samples were wrapped with polyvinyl chloride film (17,400 cm³ O₂/m², 24 h at 23 °C). Five treatments of pork patties with two replicates were assessed: 1) Control (without additives), 2) AGP (2% and 5%) and 3) FGP (2% and 5%). The pork patties were subjected to refrigerated storage at 2–4 °C in the dark during 9 d, and 2 packs were opened for subsequent analysis of the following characteristics: pH, TBARS, MetMb, colour (a*) and WHC. Data were subjected to an ANOVA and a post-hoc test (Tukey-Kramer) at $\alpha = 0.05$ (SPSS v. 21 statistical package) [1, 5].

III. RESULTS AND DISCUSSION

Phytochemicals are compounds characterised for exerting anticancer, antifungal, antimicrobial and antioxidant properties. An antioxidant is defined as any substance that, when present at low concentrations in comparison with an oxidisable substrate (i.e. lipids, proteins, carbohydrates and DNA, among other compounds found in cells), significantly delays or prevents the oxidation of the substrate. The most important phytochemical obtained from fruits include phenolic compounds such as phenolic acids and flavonoids [1, 2, 3, 5]. Hence, the TPC and AOX properties of AGP and FGP were analysed. The results indicate that grapefruit powder (FGP > AGP; at 500 µg/mL) had high TPC (>90 mg gallic acid equivalents/g) and good antioxidant properties (~50% DPPH• inhibition and ~0.3 abs RP) ($P<0.05$). These results confirm that grapefruit is an important source of natural antioxidants.

Several investigations have reported the preservation of fresh meat following the inclusion of natural antioxidant as ingredients [2]. Therefore, in this study, the effect of AGP and FGP in pork patties was evaluated during storage time (Table 1). The results showed no significant effect of AGP and FGP on pH (5.5) and WHC (~90%) values, which are characteristic values for fresh pork meat ($P>0.05$) [1]. Lipid and myoglobin oxidation in meat leads to the development of off-flavours and discolouration, respectively [2, 5]. On day 9, TBARS and MetMb formation significantly reduced in pork patties treated with grapefruit albedo and flavedo (at 2%; 62.5% and 33.3% inhibition, respectively) in comparison with the control group. Currently, colour is one of the most important organoleptic attributes that influences consumer acceptance and the decision to purchase meat and meat products [2]. The red index (a^* value) significantly reduced throughout storage time, and this value can be associated with environmental oxygen consumption and MetMb formation [2]. However, on the last sampling day, AGP and FGP at 2% showed the highest a^* values (>14.0) in comparison to the control group, which showed a^* values <10.0 ($P<0.05$). These results reveal that incorporation of AGP and FGP can maintain to a certain extent the red colour of fresh pork samples during storage time.

Table 1. Meat quality characteristics of pork patties treated with albedo and flavedo grapefruit powder.

Analysis	Day	Control	AGP2%	AGP5%	FGP2%	FGP5%
pH	0	5.6 ± 0.1aB	5.5 ± 0.1aA	5.4 ± 0.1aA	5.5 ± 0.2aA	5.4 ± 0.1aA
	9	5.3 ± 0.1aA	5.3 ± 0.2aA	5.3 ± 0.1aA	5.5 ± 0.1aA	5.3 ± 0.1aA
TBARS (mg MDA/kg)	0	0.04 ± 0.0aA	0.10 ± 0.01bA	0.12 ± 0.02cA	0.10 ± 0.01bA	0.28 ± 0.01dA
	9	0.40 ± 0.1cB	0.15 ± 0.01aB	0.30 ± 0.01bB	0.16 ± 0.01aB	0.29 ± 0.01bB
MetMb (%)	0	1.0 ± 0.1aA	1.0 ± 0.3aA	0.9 ± 0.2aA	1.1 ± 0.1aA	1.3 ± 0.5aA
	9	59.1 ± 4.3cB	42.3 ± 1.0aB	86.0 ± 0.4dB	40.2 ± 1.7aB	50.9 ± 1.2bB
Colour a^*	0	18.8 ± 2.3aB	20.8 ± 0.5aB	23.5 ± 2.1aB	21.9 ± 1.1aB	22.0 ± 1.0aB
	9	10.7 ± 1.0aA	14.8 ± 0.9cA	12.1 ± 0.5bA	15.8 ± 0.6cA	14.9 ± 0.9cA
WHC (%)	0	93.3 ± 0.9aA	90.3 ± 1.6aA	92.8 ± 2.6aA	93.9 ± 2.1aA	93.3 ± 2.1aA
	9	91.5 ± 1.0aA	89.2 ± 1.7aA	91.8 ± 1.0aA	91.2 ± 2.9aA	93.3 ± 1.3aA

MDA, malondialdehyde; MetMb, metmyoglobin; WHC, water holding capacity. AGP, albedo grapefruit powder; FGP, flavedo grapefruit powder. Different superscripts (a-d) for the same sampling day and (A-B) storage time indicate significant differences ($P<0.05$).

IV. CONCLUSION

In this study, the results demonstrated the effectiveness of albedo and flavedo grapefruit powder (2%) as antioxidants in raw pork patties stored at 2 °C without illumination. These substances led to reductions in LOX, MetMb formation and colour changes during the storage period (9 days).

ACKNOWLEDGEMENTS

We are grateful for Daniela Espinoza-García and her technical support of this research.

REFERENCES

1. Huang, B., He, J., Ban, X., Zeng, H., Yao, X., & Wang, Y. (2011). Antioxidant activity of bovine and porcine meat treated with extracts from edible lotus (*Nelumbo nucifera*) rhizome knot and leaf. *Meat Science* 87(1): 46-53.
2. Faustman, C., Sun, Q., Mancini, R., & Suman, S. P. (2010). Myoglobin and lipid oxidation interactions: Mechanistic bases and control. *Meat Science* 86(1): 86-94.
3. Wu, T., Guan, Y., & Ye, J. (2007). Determination of flavonoids and ascorbic acid in grapefruit peel and juice by capillary electrophoresis with electrochemical detection. *Food Chemistry* 100(4): 1573-1579.
4. Liu, Y., Shi, J., & Langrish, T. A. G. (2006). Water-based extraction of pectin from flavedo and albedo of orange peels. *Chemical Engineering Journal* 120(3): 203-209.
5. Vargas-Sánchez, R. D., Torrescano-Urrutia, G. R., Acedo-Félix, E., Carvajal-Millán, E., González-Córdova, A. F., Vallejo-Galland, B., Torres-Llanez, M. J. & Sánchez-Escalante, A. (2014). Antioxidant and antimicrobial activity of commercial propolis extract in beef patties. *Journal of Food Science* 79(8): C1499-C1504.