POTATO PEEL (*Solanum tuberosum*) AS A NATURAL ANTIOXIDANT IN PORK MEAT DURING CHILLED STORAGE

Daniela A. Espinoza-García[1], Livier Zavala-Cárdenas[1], Rey D. Vargas-Sánchez[1], Gastón R. Torrescano-Urrutia[1] and Armida Sánchez-Escalante[1]

[1]Centro de Investigación en Alimentación y Desarrollo, A.C. Research Laboratory in Meat and Meat Products. Carretera a La Victoria km 0.6, 83304, Hermosillo, Sonora, México

Abstract – The present work was undertaken to examine the utilization of potato peel as a source of natural antioxidants to reduce color changes and lipid oxidation in pork meat during chilled storage (2°C/9 days). Pork meat with three different concentrations (2, 5 and 10%) of potato peel flour (PPF) and a control with no added flour were prepared. Antioxidant activity (total phenolic content, TPC, DPPH radical scavenging assay), color variation (L*, a*, b*, C*, h*), lipid oxidation (thiobarbituric acid reactive substances, TBARS) and physicochemical characteristics (pH; water holding capacity, WHC; cooking lost weight, CLW; texture; proximate chemical analysis; sensory analysis) were analyzed. The pork meat with the highest amount of PPF was correlated with high TPC and DPPH activity and was more effective in retarding color deterioration and TBARS formation (95%) compared with the control treatment. The results indicated that PPF has great potential as a natural antioxidant additive to extend the shelf life of pork meat during chilled storage.

Key Words – Lipid oxidation, Meat color, Natural antioxidants.

I. INTRODUCTION

The oxidation of lipids is one of the major causes of meat deterioration. Lipid oxidation (Lox) is a deteriorative process in which unsaturated fatty acids react with oxygen or other free radicals by a typical chain reaction mechanism, which promotes meat discoloration and leads to the formation of low molecular weight compounds that impart rancid odors and off-flavors [1,2]. Among meat products, pork meat is highly prone to Lox due to the large amount of polyunsaturated fatty acid (PUFA) [2]. Synthetic antioxidants, such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), tert-butylhydroquinone (TBHQ) and propyl gallate (PG) can control oxidation in foods, but the use of such compounds has been related to health risks [3]. The use of natural antioxidant compounds is an alternative means of minimizing or preventing color changes and lipid oxidation, thereby maintaining nutritional and sensory quality and extending the shelf life of meat products [4].

Potatoes (*Solanum tuberosum*) are one of the most commonly consumed vegetables throughout the world (French fries, chips and mashed). Peels are a major by-product of potato processing industries and also represent a major waste disposal problem for the industry [5]. Numerous researchers have reported on the effectiveness of potato peel extracts and flour (PPE and PPF) in reducing free radicals [6], as such have been shown to be a rich source of phenolic acids, including chlorogenic, gallic, protocatechuic and caffeic acids [7]. Taking advantage of the beneficial effects of PPF in meat products may lead to additional economical outputs for the potato industry and would allow for the development of novel and enhanced products. Nevertheless, the effect of PPF from potato by-products on the oxidative stability of meat and meat products remains unknown.

The objective of this work was to determine the effectiveness of potato peel flour as an inhibitor of color change and lipid oxidation in pork meat subjected to chilled storage.

II. MATERIALS AND METHODS

Potato peel was obtained from potato processor (La Costeña, S.A. de C.V.). The peels were dried at room temperature for 8 days and powdered in a mill (Tomas Willey Model 4), equipped with a 0.5 mm orifice plate. The in vitro antioxidant activity was determined by assessing the total phenolic content (TPC) via the Folin-Ciocalteu method and a DPPH radical scavenging assay [6,7]. Pork meat was purchased from a local processor and mixed with 1.5% salt (NaCl, w/w) and 10% fat (w/w, in final formulation). In each replication (twice), pork patties were assessed in four different treatments: 1) control (no antioxidant, C); 2-4) pork patties with a potato peel flour content of 2, 5 and 10% (F2%, F5%, F10%). Each of the pork patties (90 g) was placed on a styrofoam tray, wrapped with polyvinyl chloride film (17,400 cm^3 $O_2/m^2/24$ h at 23 °C), stored at 2 °C in the dark and assessed at day 0, 3, 6 and 9. Two packs were opened for the following analyses: pH, TBARS, color (L*, a*, b*, C*, h*), WHC, CLW, texture, proximate chemical composition and sensory analysis. Data were analyzed using the NCCSS07 statistical package with ANOVA followed by Tukey post-hoc test (P<0.05).

III. RESULTS AND DISCUSSION

The Folin-Ciocalteu and DPPH methods are widely used to determine the antioxidant activity of natural plant extracts, among other uses [5,6]. The amount of TPC and DPPH activity of PPF were 296 mg of gallic acid equivalent /g of sample and 84%, respectively (at 500 µg/ml). These results indicated that PPF is rich in phenolic compounds, which can act as H-atom donators during lipid oxidation reactions [8].

The efficacy of PPF as an ingredient to inhibit lipid oxidation in pork patties and to affect water-holding capacity, cooking lost weight and texture were assessed (Table 1). In this study, lipid oxidation was increased over the course of the storage time, although after 9 days of storage, TBARS production was significantly reduced in patties treated with PPF (95%) when compared with the control (P<0.05). All treatments demonstrated TBARS values of less than 1 mg MDA/kg of sample, which indicated that pork patties did not exhibit rancid flavor [9]. The pH values (5.6-5.8) were considered to be normal [8] during the storage time for all treatments (P<0.05).

Currently, food color is measured in terms of CIE L*, a*, b*, C* and h* [10]. In pork patties, a significant decrease in L*, a*, b* and C* values was noted during storage, while the h* value increased (P<0.05). At day 9, the treatment F2% showed a slight decrease in L* (58.07) and a* (8.74) values over the course of the storage period, indicating a lower loss of the pink color characteristic of pork meat. High levels of PPF increased the b* values of samples (P<0.05). The hue angle (h*), which increased as C* value decreased, is related to the state of pigments in the muscle [8, 10]. At day 9, the lowest h* and highest C* values were obtained for pork patties treated with PPF (P<0.05). These results confirmed that pork patties treated with PPF maintained the color of fresh meat during 9 days when compared with the control samples. The ability of meat to retain moisture, whether fresh or cooked, is arguably one of the most important quality characteristics of raw and processed products. It has been estimated that as much as 50% or more of produced pork has an unacceptably high purge or drip loss [11]. The results indicated that the addition of PPF at the different levels increased the water absorption and reduced water loss during cooking (F10%>F5%>F2%) compared with the control sample (P<0.05). These differences are mainly caused by the greater number of hydroxyl groups that exist in the fiber structure of potato peels, which allow more water interaction through hydrogen binding, as previously reported [12]. In addition, results also indicated that PPF increased the texture values: F10% and F5%>F2% (P<0.05), which can be correlated with high WHC and low CLW, as previously reported [13]. The proximate composition and sensory attributes of pork patties varied significantly among the samples treated with different levels of PPF (Table 2). The addition of high levels of PPF significantly reduced the moisture and protein content, while the ash and carbohydrate content were increased (P<0.05). These results indicated that PPF incorporation affects the chemical composition of raw pork patties, which may be associated with the chemical composition of PPF: moisture (5.27%), fat (2.26%), protein (9.11%), ash (3.11%) and carbohydrate (80.25%). Significant differences (P<0.05) were found in the sensory analysis in pork patties containing different levels of PPF. In fresh pork patties (color and appearance) and cooked pork patties (color, appearance, odor, flavor, juiciness, fat and hardness), PPF incorporation reduced the scores of each attribute compared with the control (F10%>F5%>F2%). However, F2% showed similar values compared with the control (P>0.05), which indicated that low levels of PPF had no effect on the organoleptic characteristics of pork patties. These results were in agreement with those reported by other authors [14].

Table 1 Changes in TBARS, pH, color, WHC, texture and CLW of pork patties under chilled storage.

Analysis	Day	Control	F2%	F5%	F10%
TBARS	0	0.07^{a}	0.05^{a}	0.07^{a}	0.13^{b}
	3	0.73^{c}	0.12^{a}	0.12^{a}	0.17^{b}
	6	0.91^{c}	0.13^{a}	0.12^{a}	0.16^{b}
	9	1.46^{c}	0.14^{a}	0.14^{a}	0.20^{a}
pH	0	5.80^{a}	5.77^{a}	5.82^{a}	5.86^{a}
	3	5.78^{a}	5.76^{a}	5.74^{a}	5.71^{a}
	6	5.73^{ab}	5.79^{b}	5.77^{ab}	5.72^{a}
	9	5.65^{a}	5.77^{b}	5.62^{a}	5.63^{a}
L*	0	59.18^{b}	57.23^{b}	54.17^{ab}	50.80^{a}
	3	57.04^{b}	55.84^{b}	51.79^{ab}	48.32^{a}
	6	63.03^{c}	53.43^{b}	49.05^{b}	47.90^{a}
	9	62.00^{c}	58.07^{c}	50.25^{b}	47.37^{a}
a*	0	18.69^{c}	16.41^{b}	14.89^{b}	12.81^{a}
	3	16.43^{c}	14.71^{c}	12.84^{b}	10.44^{a}
	6	13.12^{b}	11.38^{b}	11.04^{b}	9.06^{a}
	9	7.78^{a}	8.74^{c}	8.71^{b}	8.70^{b}
b*	0	18.20^{a}	18.49^{a}	19.63^{a}	20.08^{a}
	3	17.35^{a}	18.25^{a}	18.04^{a}	18.25^{a}
	6	16.17^{a}	15.98^{a}	16.86^{a}	18.12^{b}
	9	13.56^{a}	14.71^{a}	16.60a^{b}	17.48^{b}
C*	0	26.09^{a}	24.72^{a}	24.64^{a}	23.82^{a}
	3	23.90^{a}	23.81^{a}	22.15^{a}	21.02^{a}
	6	20.61^{a}	19.07^{a}	19.92^{a}	20.30^{a}
	9	16.47^{a}	16.77^{a}	18.96^{ab}	19.61^{b}
h*	0	44.20^{a}	48.41^{b}	52.81^{c}	57.47^{d}
	3	46.60^{a}	51.32^{b}	54.55^{c}	60.23^{d}
	6	56.90^{a}	57.48^{ab}	60.24^{bc}	63.23^{c}
	9	61.97^{a}	61.22^{a}	61.97^{a}	63.08^{a}
WHC	0	91.27^{a}	95.45^{b}	94.57^{b}	96.07^{b}
	3	93.78^{a}	95.50^{b}	96.00^{b}	98.51^{c}
	6	96.10^{a}	96.38^{a}	97.10^{a}	98.20^{b}
	9	95.38^{a}	95.70^{a}	97.64^{b}	98.53^{b}
CLW	0	18.56^{c}	11.96^{b}	8.49^{a}	7.34^{a}
	3	14.29^{d}	9.68^{c}	7.54^{b}	6.50^{a}
	6	13.00^{c}	10.44^{b}	6.97^{a}	6.58^{a}
	9	15.53^{c}	8.94^{b}	7.38^{a}	6.37^{a}
Texture	0	2.80^{a}	3.31^{b}	3.65^{bc}	4.15^{c}
	3	2.76^{a}	3.37^{a}	4.08^{b}	4.77^{c}
	6	2.88^{a}	3.94^{b}	4.29^{bc}	5.11^{c}
	9	3.29^{a}	3.14^{a}	4.41^{b}	4.14^{b}

WHC: water holding capacity; CLW: cooking loss weight. Different superscripts (a-c) within the same sampling day differ significantly (P<0.05).

Table 2 Proximate chemical composition and sensory analysis of pork patties under chilled storage.

	Proximate chemical composition			
Parameter (%)	Control	F2%	F5%	F10%
Moisture	70.62^{d}	69.61^{c}	67.28^{b}	63.44^{a}
Fat	7.02^{a}	6.81^{a}	7.16^{a}	7.12^{a}
Protein	17.74^{c}	17.56^{bc}	16.84^{ab}	16.01^{a}
Ash	2.30^{a}	2.32^{a}	2.41^{b}	2.62^{c}
Carbohydrates	2.42^{a}	3.69^{b}	6.32^{c}	10.81^{d}
Sensory	Sensory analysis			
attribute	Control	F2%	F5%	F10%
Fresh color	6.87^{c}	6.00^{bc}	5.07^{ab}	4.40^{a}
Fresh appear.	6.73^{c}	5.87^{bc}	4.87^{ab}	4.20^{a}
Cooked color	5.33^{a}	5.13^{a}	5.53^{a}	5.07^{a}
Cooked appear.	5.87^{a}	5.33^{a}	5.93^{a}	5.20a
Odor	5.27^{a}	5.33^{a}	4.73^{a}	4.40^{a}
Flavor	6.13^{b}	5.73^{b}	5.33^{b}	4.20^{a}
Juiciness	6.47^{c}	6.07^{bc}	5.00^{ab}	4.07^{a}
Feeling fat	5.80^{b}	5.60^{ab}	5.13^{ab}	4.47^{a}
Hardness	6.60^{b}	6.40^{b}	5.80^{b}	4.93^{a}
General accept.	6.03^{b}	6.10^{b}	5.53^{b}	4.6^{7a}

Appear.: appearance; Accept.: acceptance. Different superscripts (a-c) differ significantly (P<0.05).

IV. CONCLUSION

In conclusion, the addition of potato peel flour as a functional ingredient during meat product preparation improved the antioxidant effect when stored at a chilled temperature for 9 days. In future studies, it would be useful to test the effect of such natural antioxidant sources on animal models to analyze in vivo protection against subsequent meat quality and oxidation.

ACKNOWLEDGEMENTS

The author thanks La Costeña, S.A. de C.V. for providing potato peels for the development of this research. The authors also thank Gerardo Reyna-Cañez for his academic and bibliographic assistance during research.

REFERENCES

1. Ladikos, D., & Lougovois, V. (1990). Lipid oxidation in muscle foods: A reviwe. Food Chemistry 35: 295-314.
2. Shahidi, F., & Zhong, Y. (2010). Lipid oxidation and improving the oxidative stability. Chemical Society Reviews 39: 4067-4079.
3. Amarowicz, R., Naczk, M., & Shahidi, F. (2000). Antioxidant activity of various fractions of non-

tannin phenols of canola hulls. Journal of Agricultural and Food Chemistry 48: 2755-2759.

4. Pokorný, J., Yanishlieva, N., & Gordon, M. (2001). Antioxidants in foods. Cambridge: CRC Press.
5. Farvin, K. S., Grejsen, H. D., & Jacobsen, C. (2012). Potato peel extract as a natural antioxidant in chilled storage of minced horse mackerel (*Trachurus trachurus*): Effect on lipid and protein oxidation. Food Chemistry 131: 843-851.
6. Singh, N., & Rajini, P. S. (2004). Free radical scavenging activity of an aqueous extract of potato peel. Food Chemistry 85: 611-616.
7. Habeebullah, S. F. K., Nielsen, N. S., & Jacobsen, C. (2010). Antioxidant activity of potato peel extracts in a fish-rapeseed oil mixture and in oil-in-water emulsions. Journal of American Oil Chemist's Society 87: 1319-1332.
8. 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: 46-53.
9. Ockerman, H. W. (1985). Quality control of post-mortem muscle and tissue. *Department of Animal Science*, Ohio State University. Columbus, OH USA. Vol. 1. p91.
10. Girolami, A., Napolitano, F., Faraone, D., & Braghieri, A. (2013). Measurement of meat color using a computer vision system. Meat Science 93:111-118.
11. Huff-Lonergan, E., & Lonergan, S. M. (2005). Mechanisms of water-holding capacity of meat: The role of postmortem biochemical and structural changes. Meat Science 71: 194-204.
12. Rosell, C. M., Rojas, J. A., & De Barber, C. B. (2001). Influence of hydrocolloids on dough rheology and bread quality. Food Hydrocolloids 15: 75-81.
13. Bouton, P. E., Harris, P. T., & Shorthose, W. R. (1971). Effect of ultimate pH upon the water-holding capacity and tenderness of mutton. Journal of Food Science 36: 435-439.
14. Nassar, A. G., AbdEl-Hamied, A. A., & El-Naggar, E. A. (2008). Effect of citrus by-products flour incorporation on chemical, rheological and organolepic characteristics of biscuits. World Journal of Agricultural Sciences 4: 612-616.