Control of oxidation of cooked nitrite-free meats with novel ingredients

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Abstract

Lipid oxidation is a major cause for meat quality deterioration and formation of warmed over flavour. While nitrite cured meats do not suffer from this problem, cooked uncured products generally have compromised quality unless appropriate preventive measures, such as use of antioxidants, are considered. In this work, we used a number of plant-based ingredients and their extracts to extend the shelf-life of cooked ground pork. A number of cereals and/or their phenolic extracts were employed for this purpose. In another set of experiments, canola protein hydrolysates or fruit vinegars were employed in order to examine their efficacy in preventing lipid oxidation in products. Using thiobarbituric acid (TBA) test, we found that these novel ingredients were effective in controlling lipid oxidation and quality deterioration of cooked pork. Thus, non-meat ingredients in nitrite-free systems may render the desired oxidative stability to cooked products.

Background

The role of non-meat ingredients in rendering functionality to meat products is a well known. Research has also indicated that whole grains and plant foods are rich sources of bioactive phytochemicals that may provide beneficial health effects beyond their general nutritional value (Shahidi, 2000; Slavin, 2000; Liu, 2007). Lipid oxidation is a major deteriorative process in muscle foods which affects the overall quality of products. Antioxidants derived from non-meat ingredients can be used to prevent oxidative deterioration of polyunsaturated fatty acids and hence generation of off-flavours in cooked nitrite-free meat products (Shahidi & Rubin, 1987).

At present, there is a growing interest in the use of natural antioxidants and ingredients from plant sources to replace chemicals perceived as being un-natural and possibly unhealthy (Liyana-Pathirana, & Shahidi, 2005, 2006; Liyana-Pathirana *et al*., 2006; Que *et al*., 2006; Madhujith & Shahidi, 2007). The objective of the present study was to determine the effect of wheat, barley, millets and fruit vinegar and canola protein hydrolysate on the oxidative stability of cooked comminuted lean pork.

Materials and methods

Barley grains (Peregrine and AC Metcalfe varieties) were obtained from the Field Crop Development Centre, Lacombe, AB, Canada. Wheat grains (Canadian Western Red Spring) were procured from milling suppliers of Robin Hood Multifoods Inc. (Markham, ON) in Saskatchewan. Millet grains (Kodo and Proso millets) were obtained from the Field Crop Research and Development Center, Mahaillupplama, Sri Lanaka. Balsamic vinegar was purchased from Costco, (St. John's, NL, Canada). Protein hydrolysates were prepared according to Cumby *et al.* (2007). All chemicals used were purchased from Fisher Scientific Co. (Nepean, ON, Canada) or Sigma-Aldrich Canada Ltd. (Oakville, ON, Canada). Lean picnic shoulder pork was purchased from a butchery shop in St. John's, NL, Canada.

Preparation of wheat, barley, millet and vinegar samples. Whole grains and bran were ground in a coffee grinder (Black & Decker Canada Inc., Brockville, ON, Canada) for 5 min. Vinegar was used directly. Canola protein hydrolysates were prepared using Alcalase, Flavourzyme, and combination of Alcalase and Flavourzyme, respectively, as described by Cumby *et al.* (2008).

Preparation of crude phenolic extracts of barley and millet samples. Ground whole grain samples were defatted blending with hexane (1:5 w/v, 5 min x 3) in a Waring blender (Model 33BL73; Dynamics Corp. of America, New Hartford, CT) at room temperature. Phenolic compounds of barley samples were extracted as reported by Madhujith and Shahidi (2007) and those in Phenolic compounds in defatted millet samples were extracted using 70% acetone (5 g /100 mL) at 60 ^{0} C by sonication for 25 min.

Cooked comminuted pork. Fresh pork trimmed to remove most of the surface fat was purchased from a local supplier and ground twice (plate sizes 7.2 and 4.0 mm, respectively) using a meat grinder (Omega, CEG Cardano al Campo (VA), Italy). Ground pork was mixed with 20% (w/w) distilled water in Mason jars. Whole grain and bran samples (1 and 2%), extracts as well as hydrolysates (0.1 and 0.2%), and vinegar (1 and 2%) were added separately to meat samples (100g) and were homogenized thoroughly using a Polytron Homoginizer. A control sample was prepared without any additives. Samples were cooked in a

thermostated water bath to an internal temperature of 80 ± 2 ^{0} C for 40 min while stirring every 5 min with a glass rod. After cooling to room temperature, meat samples were homogenized for 30s and transferred into plastic bags and stored at 4^{0}C. Samples were removed for determination of thiobarbituric acid reactive substances (TBARS) on days 0, 7, and 14.

Determination of TBARS in meat. Samples were analyzed for TBARS according to the method of Siu and Draper (1978) as described by Wijeratne *et al*. (2006). A standard curve was constructed using 1,1,3,3-tetramethoxypropane as a precursor of malonaldehyde and a factor (5.437) was derived. TBARS values were calculated by multiplying absorbance readings by the factor so obtained.

Results and discussion

In this study, all non-meat ingredients tested exhibited antioxidant activity, albeit to different extent. Balsamic vinegar, was however least effective in rendering beneficial effect in quenching oxidation, despite the presence of phenolics at low levels in it. Therefore, its role may only be limited to imparting desirable flavour effects (Table 1).

Table 1. Inhibition (%) of formation of oxidative products (TBARS) in cooked ground pork as affected by different additives

Additives	Level (%)	Day 0	Day 7	Day 14
Whole wheat	1	15.89	3.94	3.83
	2	30.91	12.72	19.12
Wheat bran	1	61.88	46.70	51.28
	2	74.59	57.95	50.31
Whole Peregrine	1	34.12	9.40	8.94
	2	55.71	34.17	19.07
Peregrine extract	0.1	22.25	25.51	17.28
	0.2	41.80	20.46	18.63
Whole Metcalfe	1	20.06	31.28	23.09
	2	39.70	16.80	21.99
Metcalfe extract	0.1	26.10	26.96	31.16
	0.2	26.90	8.61	10.78
Whole Kodo	1	39.66	42.87	38.54
	2	87.26	72.25	64.61
Kodo extract	0.1	89.14	79.34	74.38
	0.2	88.16	86.38	82.57
Whole Proso	1	12.06	4.03	1.21
	2	35.26	20.13	2.93
Proso extract	0.1	10.61	10.69	1.06
	0.2	15.02	12.30	3.36
CPH (AL)	0.1	32.41	23.48	4.41
	0.2	55.67	41.50	16.49
CPH (FL)	0.1	20.74	25.79	21.00
	0.2	50.16	45.90	37.5
CPH (COMB)	0.1	22.24	21.83	7.99
	0.2	29.65	39.58	11.59
Balsamic vinegar	1	33.85	0.68	12.16
	2	27.57	28.61	2.80

CPH: Canola protein hydrolysates; AL: Alcalase; FL: Flavourzyme; COMB: Combination of Alcalase and Flavourzyme

The TBA values found for ground cooked pork (control) are in agreement with those reported by Siu and Draper (1978). There was a gradual increase of TBARS values and the results were similar to those obtained by Shahidi and Rubin (1986). It is well known that disruption of the muscle membrane by homogenization allows oxygen to penetrate inside the tissue and, in turn, accelerate lipid peroxidation (Pikul, 1992). Similarly, cooking causes breakdown of haem constituents and the release of iron. Non-haem iron is an active catalyst responsible for rapid oxidation of lipids in heated meat (Stodolak *et al*., 2007).

Addition of wheat, barley and millet (whole and extracts) to the pork resulted in a reduction in the TBARS value as compared to the control samples. This may be due to the wide array of phenolic compounds that are present in these grains (Shahidi & Naczk, 1995). Natural antioxidants in cereal grains may act as free radical scavengers, reducing agents and potential complexers of metal ions. Kodo millet extract had the highest antioxidant activity among all plant ingredients tested in this work. However, whole grains of Proso millet and its extracts were anot as effective as Kodo millet. The antioxidant properties of wheat and barley cultivars were clearly established in earlier studies conducted in our laboratories (Liyana-Pathirana & Shahidi, 2005; Madhujith & Shahidi, 2007). The potency of the wheat bran and barley extracts in inhibiting the formation of TBARS in pork was stronger than the whole wheat and barley grains (Table 1). The outer layers of cereal grains (pericarp, testa and aleurone layer) contain the highest concentration of phenolics whereas the starchy endosperm contains a considerably lesser amount (Shahidi & Naczk, 1995). This is clearly the reason why the wheat bran and the phenolic extracts of the wheat and barley samples had a better antioxidant activity, thus inhibiting TBARS formation to a greater extent. The strongest TBARS inhibitory effect was observed for samples containing wheat bran and the least inhibitory effect for samples containing 1g whole wheat. However, it was also observed that an increase in the concentration of whole wheat and barley (from 1 to 2 g) in the pork system resulted in a lower TBARS values, while an increase in the bran and extract concentration did not show much change in the formation of TBARS. The hydrolysates from canola were also found to inhibit oxidation of meat lipids as reflected in their TBARS values (Table 1). Cumby *et al.* (2008) have previously reported the radical scavenging activity of canola protein hydrolysates. In the meat system, inhibition of TBARS formation was concentration dependent and was somewhat higher for samples prepared using Flavourzyme; thus lending support to previous findings (Cumby *et al*., 2008).

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