USE OF SWISS CHARD EXTRACTS AND STARTER CULTURE AS A NATURAL NITRITE IN COOKED PORK PATTY

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Abstract – The natural nitrite formed Swiss chard evaluated in cooked pork patties with 120 ppm sodium nitrite (CON), no sodium nitrite added (NSP), 0.4% pre-converted nitrite from celery power (CP), 4% pre-converted nitrite from Swiss chard extracts (SC). Results showed that the pork patty containing SC was effective for delaying lipid oxidation when compared to the CP added. Also, the redness values did not differ significantly between SC and CP during storage. These findings demonstrate natural nitrite formed Swiss chard can be used more effectively as an alternative not only for reddish-pink color expression, but also for natural preservative of meat product.

Key Words – natural nitrite, celery, Swiss chard

I. INTRODUCTION

Nitrite, is one of the main additives in meat product manufacturing, has four main functions: contribution of notable reddish-pink color, characteristic flavor of meat products, inhibition of lipid oxidation, and control of several pathogenic and spoilage organisms [1]. However, the use of nitrite in meat products has become controversial due to potential nitrosamine formation from nitrite, which are suspected of being carcinogens. Currently nitrite approved levels in meat products are deemed safe, there is nevertheless pressure coming from the con-sumer side to further reduce or eliminate the use of nitrite. Because of this potential health risk, nitrite alternatives from natural sources which are considered healthier have been developed steadily [2].

One method to avoid the direct addition of nitrite to meat is the addition of ingredients that have a natural high nitrate content and starter culture transforming nitrate into nitrite. Previous studies have demonstrated pre-converted nitrite from celery juice powder should be similar to the synthetic nitrite. However, concerns have grown over the allergens of celery [1, 2]. For this reason, meat processing industries are actively searching new natural nitrite to increase its shelf stability.

Recently Swiss chard (*Beta vulgaris* var. cicla) is being developed as sources of nitrate and nitrite for use in cured meat products. The spray-dried Swiss chard powder contains 3.0%–3.5% nitrate and is recommended to be used at a concentration of 0.15%-0.3%, which is essentially same as celery powder. One of the advantages claimed for the pre-converted nitrite from Swiss chard is that it contains no allergens [1, 2]. Therefore, the aim of this study was to evaluate the effect of Swiss chard as a natural nitrite on the color stability, residual nitrite contents, lipid oxidation of cooked pork patty during 6 weeks at 4°C.

II. MATERIALS AND METHODS

Pre-converted nitrite from Swiss chard extracts

Commercial samples of Swiss chard powders (Hangaram gf Co. Ltd., Seoul, South Korea) were purchased from local market. Ten grams of Swiss chard powders were mixed with 100 mL of distilled water for 30 min, then 0.025 % nitrate reductase-active culture containing *Staphylococcus carnosus* (S-B-61, Bactoferm™, Chr. Hansen Inc., Gainesville, Fla., U.S.A) was added. The mixture was shaken well and incubated for 24 h at 30°C using shaking incubator (VS-8480, Vision Scientific Co., Ltd, Seoul, South Korea). After fermentation, the extracts were heat treated for 30 min at 75°C to ensure the absence of starter culture and then stored in flasks in the dark at 4°C until utilization, no more than 24 h later.

Preparation of pork patties

Fresh pork hams and back fats were purchased from a local processor at 48 h postmortem. The pork hams and pork back fat were initially ground through an 8-mm plate, and then secondly ground through a 3-mm plate. The Swiss chard extracts were prepared according to the formulations: CON (sodium nitrite 120 ppm added), NSN (no sodium nitrite added), CP (pre-converted nitrite from celery juice powder 0.4%) and SC (pre-converted nitrite from Swiss chard extract 4%). For each batch of pork patties, pork meat (60%), back fat (20%), and ice (20%), salt (NaCl, 1.5%), and natural nitrite were mixed using a mixer for 15 min and then, formed into patties (80 g each) using sterile 15 × 90 mm Petri dishes. After forming, the pork patties were heated at 75±1°C (central temperature) for 30 min in a water bath (Model 10-101, Dae Han Co., Seoul, South Korea). The cooked pork patties were vacuum packaged in PE/nylon film bags and, stored at 4±1°C for 6 weeks.

Color instrument

Color changes in the pork patties during storage were monitored with a colorimeter (Chroma meter CR-210, Minolta, Japan) using an 8-mm diameter measuring area and a 50-mm diameter illumination area. The total color differences between the CON (days 0) and treatments with different natural nitrite at each storage time were calculated by: $\Delta E = [(L^*-L_0^*)^2 + (a^*-a_0^*)^2 + (b^*-b_0^*)^2]^{½}$.

Additionally, the hue (H°) values were determined using the formula, $Tan^{-1}(b^*/a^*)$. Color readings were measured on ten randomly chosen spots on the pork patties and were utilized as an estimate of meat discoloration.

Residual nitrite contents

Residual nitrite content was determined according to the Diazo coupling method [3] and is expressed as ppm per kilogram of patty. The residual nitrite content was calculated by a standard curve using nitrite solution.

Thiobarbituric acid reactive substances (TBARS) values

Lipid oxidation was assessed in triplicate using the TBARS method of Tarladgis *et al.* [4] with minor modifications and was expressed as milligrams of malondialdehyde (MA) per kilogram of pork patty.

Statistical analysis

All data were subjected to the analysis of variance (ANOVA) using general linear model (GLM) procedure of SPSS 18.0 software (SPSS Inc., Chicago, IL, USA), with three replications, which was used as the storage periods and treatment type. When significant (p<0.05) treatment effects were shown, Duncan's multiple range test was used to compare the mean values. Mean values and standard error of the means (SEM) were reported.

III. RESULTS AND DISCUSSION

The changes in redness, ⊿E, and H° values were analyzed during storage and are depicted in Table 1. The pork patties with CON (sodium nitrite 120 ppm) had significantly (p<0.05) higher a* values than either the CP or SC treatments, which were not different from each other. As expected, CON had a more intense cured color at the end of the storage period (6 weeks) than other samples. Significantly lower CIE-a* values were observed in NSN (salt only) compared to CON and other treatment. Also, the CIE-a* values of the SC treatment were almost the same as those of the treatment with added celery powder (CP) (p>0.05).

Table 1. Effects of natural nitrite formed Swiss chard on redness (CIE-a), color difference (⊿E), and hue (H°) values of pork patties during storage

Storage period (weeks)		CON[1]	NSN	CP	SC
CIE-a*	0	15.09±0.42^{Cb}	7.78±0.29^{Ab}	14.10±0.30^{Bc}	14.28±0.45^{Bc}
	2	15.14±0.16^{Cb}	7.41±0.37^{Ab}	13.44±0.51^{Bc}	13.29±0.37^{Bb}
	4	14.39±0.58^{Da}	6.18±0.27^{Aa}	12.27±0.49^{Bb}	12.42±0.51^{Ba}
	6	14.37±0.47^{Ca}	5.36±0.18^{Aa}	12.29±0.27^{Ba}	12.48±0.59^{Ba}
⊿E	0	-	9.15±0.28^{Ba}	2.07±0.28^{Aa}	2.13±0.16^{Aa}
	2	1.01±0.29^{Aa}	8.88±0.37^{Ca}	2.80±0.28^{Bb}	2.90±0.20^{Bb}
	4	2.12±0.45^{Ab}	10.38±0.80^{Cb}	3.75±0.83^{Bc}	3.63±0.61^{Bc}
	6	2.40±0.28^{Ab}	11.59±0.59^{Cb}	3.73±0.57^{Bc}	3.92±0.63^{Bc}
H°	0	30.41±0.76^{Aa}	60.27±0.59^{Ca}	32.91±0.93^{Ba}	34.33±1.41^{Ba}
	2	30.35±0.53^{Aa}	61.46±0.79^{Db}	33.44±0.51^{Ba}	35.80±0.66^{Cb}
	4	31.70±0.54^{Ab}	64.28±0.71^{Cc}	35.79±0.97^{Bb}	37.19±0.67^{Bb}
	6	31.54±0.91^{Ab}	64.03±0.43^{Dc}	35.74±0.83^{Bb}	37.06±1.07^{Cb}

[1] CON, sodium nitrite 120 ppm; NSN, no sodium nitrite added; CP, pre-converted nitrite from celery juice powder 0.4%; SC, pre-converted nitrite from Swiss chard extract 4%.
All values are mean ± standard deviation of three replicate.
Means with different superscripts are significantly different (p<0.05). A-D: nitrite effects, a-c: storage day effects.

The ⊿E measures the total color distance by accounting for combined changes in L*, a*, and b* values. Therefore, ⊿E values estimated between the days 0 measurement and each subsequent measurement can provide a measure of the overall color variation of meat with time. Amongst all treatments, the formulations with NSN had higher ⊿E values compared to that of the CON. Higher ⊿E results indicated a greater relative change in color compared to the meat's cured color.

H° value, which means that 0/360° is red, 90° is yellow, 180° is green and 270° is blue, describes the vividness of the color and the overall color change. As the storage period progressed, H° value tends to increase (ranged from red to yellow), resulting from the oxidize nitrosohemochrome pigment in cured meat products. Samples treated with SC displayed significantly higher H° values compared to the CP, however SC effectively prevented lipid oxidation compared to the CP throughout the whole storage time (except for day 0) (Table 2). This could be due to the specific color of Swiss chard extracts (brownish) which were likely transferred to the pork patties, causing a littles modification of the patty color.

Table 2. Effects of natural nitrite formed Swiss chard on TBARS values (mg MA/kg) and residual nitrite contents (ppm) of pork patties during storage

Storage period (weeks)		CON[1]	NSN	CP	SC
Residual nitrite (ppm)	0	50.93±0.27^{Ad}	0.10±0.05^{Da}	19.81±0.72^{Bd}	21.69±0.68^{Cd}
	2	46.95±0.62^{Ac}	0.10±0.02^{Da}	16.39±0.75^{Bc}	18.32±0.22^{Cc}
	4	42.65±0.47^{Ab}	0.08±0.03 ^{Da}	12.95±0.07^{Bb}	15.16±0.09^{Cb}
	6	37.40±0.68^{Aa}	0.08±0.04^{Da}	8.70±0.15^{Ba}	9.70±0.25^{Ca}
TBARS (mg MA/kg)	0	0.17±0.02^{Aa}	1.16±0.02^{Ba}	0.32±0.01^{Ca}	0.31±0.01^{Ca}
	2	0.18±0.01^{Aa}	3.18±0.06^{Dd}	0.40±0.02^{Cb}	0.36±0.01^{Bb}
	4	0.21±0.02^{Ab}	2.55±0.04^{Dc}	0.49±0.03^{Cc}	0.41±0.02^{Bc}
	6	0.22±0.02^{Ab}	2.45±0.03^{Db}	0.52±0.02^{Cd}	0.47±0.01^{Bd}

[1] Treatments are the same as in Table 1.
All values are mean ± standard deviation of three replicates.
Means with different superscripts are significantly different (p<0.05). A-D: nitrite effects, a-c: storage day effects.

Table 2 show contents of residual nitrite in pork patties during storage at 4°C. There were significant (p<0.05) differences in the amount of nitrite measured at day 0. The residual nitrite contents were 50.93, 19.81, and 21.69 ppm for the CON, CP, and SC treatments, respectively. Also, the residual nitrite contents declined over time for all treatments but the patty with CON had signify-cantly more residual nitrite than the patties with CP and SC. The residual nitrite contents can be detected approximately 50-70% of the added nitrite in the meat product immediately after manufac-turing process because when nitrite is added in the meat product, it reacts with myoglobin, sulfhydryl groups, lipids and proteins.

Addition of natural nitrite formed Swiss chard retarded lipid oxidation significantly (p<0.05) as measured by TBARS (Table 2). As expected, the CON appeared to effectively retard MA concent-rations of cooked pork patties during the entire storage period, whereas lipid oxidation in the NSN was more intense compared to other treatments; the maximum values for TBARS were sharply increased on week 2, after which a decline was observed. At the final storage day, significant difference was found between the patties with CP and SC. This could be due to initial nitrite contents of samples with CP (19.81 ppm) or SC (21.69 ppm) which may affect the oxidative stability of pork patties.

IV. CONCLUSION

Effect of natural nitrite from Swiss chard on color stability, residual nitrite content, lipid oxidation of cooked pork patties was investigated. The CIE a* (redness) values of pork patty prepared with Swiss chard extracts was similar to that of sample with celery powder. Also, Swiss chard extract was much more useful for preventing lipid oxidation in pork patties than celery powder. Therefore, Swiss chard extract is more effective as a natural preservative compared to commercial celery powder, which is currently used to make natural meat product and it can be used as another natural nitrite source for making processed meat products.

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