EFFECT OF TOMATO POWDER DRIED AT DIFFERENT TEMPERATURES ON PHYSICO-CHEMICAL AND TEXTURAL CHARACTERISTICS OF REGULAR-FAT PORK SAUSAGES

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Abstract – This study was performed to evaluate antioxidant activity of water soluble fraction of oven-dried tomato powder (TP) as affected by drying temperatures. As a result of antioxidant model study, water soluble fraction from TP dried at 100℃ oven showed higher activities for 1,1-diphenyl-2-picrylhydrazyl radical scavenging activity and iron chelating ability than those with other temperatures (60 and 80℃). The effects of TP dried at different temperatures on the physico-chemical and textural properties of emulsified pork model sausages were also evaluated. The control (without TP) and three dried temperatures (60, 80 and 100℃ oven) for TP (1%) were used to manufacture the regular-fat sausages. Addition of TP into the pork sausages did not affect physico-chemical properties and expressible moisture (%) (*p*>0.05). pH and Hunter L values of pork sausages were reduced, while Hunter a and b values were increased with the addition of TP. No differences in textural characteristics were observed among all treatments (*p*>0.05). These results indicated that TPs could be used to manufacture regular-fat pork sausages to produce a meat product as a natural color agent. Future study will be performed to evaluate if TP may affect the antioxidant activity of regular-fat pork sausage during refrigerated storage.

Key Words – antioxidant activity, color agent, oven-dried tomato powder, different temperatures, pork sausages

I. INTRODUCTION

Color is the major constituent for consumers to select the meat products [1]. Nitrite (NO_2), which contributes to the development of pink color, is one of the key ingredients in meat products [2]. In addition, it is particularly effective in inhibiting *Clostridium* species [3]. A key role of nitrite in the cured meat sausages is the strong antioxidant activity, retard the lipid oxidation, off-odors and flavors during storage [4]. However, despite its important technological value, the presence of free nitrite in the meat products and other foods is also associated with potential health risks. Under certain circumstances, nitrite can react with amines to form nitrosamines, a compound associated with certain types of cancer [5]. Due to the potential health risk of nitrites, natural colorants seem to be an acceptable alternative to nitrite reduction to improve or maintain the color of processed meat products, since they are considered to be healthy and of good quality. In addition, they have consumer acceptance, antioxidant activity and acceptable sensorial characteristics of color and flavor [6].

Tomato and tomato products are an integral part of the human diet worldwide. Lycopene from tomato and tomato products is the major carotenoid compound that gives the red color to the tomato [7]. In addition, lycopene has been shown to have a strong antioxidant effect and to exhibit the highest quenching rate constant with singlet oxygen [8].

Mach research has been conducted to improve the functional and antioxidant properties of meat products using tomato [9-11]. However, effects of tomato powder as affected by various drying temperatures on the physico-chemical and textural properties in the meat products have not been investigated yet. Therefore, the objectives of this study were to evaluate the antioxidant activity of water soluble extract from tomato powder (TP) as affected by different drying temperature, and the effects of TP at different temperatures (60, 80 and 100℃) on physico-chemical composition, color and textural properties of emulsified pork model sausages.

II. MATERIALS AND METHODS

Experiment I: Antioxidant activity of water soluble extract from tomato powder (TP) as affected by different drying temperatures

A. Preparation of tomato powder

Ripened fresh tomatoes were purchased from a local market. Prior to drying, fresh tomatoes were chopped and homogenized by mixer and then, dried at 60, 80 and 100℃ oven. The obtained powder was used as the dried tomato powder (TP).

B. Extraction of water soluble fraction from TP

Water soluble fraction of tomato was extracted by stirring with deionized water (1:20, w/v). After the aqueous solution was filtered, water soluble tomato powder (WST) was obtained with freeze drying of the aqueous solution.

C. 1,1-Diphenyl-2-picrylhydrazyl (DPPH)-radical scavenging activity

The radical scavenging activity of three types of WST was measured based on their ability to scavenge DPPH-radicals, according to the method described by Huang *et al*. [12].

D. Ferrous iron chelating ability

The ferrous ion chelating abilities of WST were determined by measuring the inhibition of the formation of an Fe^{2+}-ferrozine complex using the method described by Le *et al*. [13].

Experiment II: Effects of various TP on physico-chemical and textural properties of emulsified pork sausages

E. Preparation of regular-fat pork model sausages

Regular-fat pork sausages were produced with TPs dried at different temperatures. For pork model sausage formulation, pork ham, pork back fat, non-meat ingredients, ice water and TPs were homogenized (Table 1). After mixing, batters (~30 g) were placed into 50 mL plastic tubes and cooked in a water bath at 75℃ for 30 min. After cooking, samples were cooled with ice for 15 min and stored at 4℃ until analyzed.

F. Proximate analysis

Moisture, fat, protein, and ash contents (%) of regular-fat pork sausages were measured by using AOAC methods [14].

G. Expressible moisture (EM, %)

Approximately 1.5 g of sausage samples was weighed and wrapped with filter paper, and then centrifuged at 3,000 rpm for 15 min, according to the method of Jauregui et al. [15]. Expressible moisture contents were calculated as below:

Expressible moisture (EM, %) = (weight of expressed water in filter paper / weight of sample) × 100

Table 1. Formulation of pork model sausages with TPs dried at different drying temperatures (Unit: %)

Ingredients	Treatments			
	CTL	TRT1	TRT2	TRT3
Raw meat	60.0	60.0	60.0	60.0
Fat	20.0	20.0	20.0	20.0
Water	18.0	18.0	18.0	18.0
Non meat ingredients	2.00	2.00	2.00	2.00
Salt	1.30	1.30	1.30	1.30
STPP[1)]	0.40	0.40	0.40	0.40
Cure blend[2)]	0.25	0.25	0.25	0.25
Sodium erythorbate	0.05	0.05	0.05	0.05
Tomato powder (60℃)	-	1.00	-	-
Tomato powder (80℃)	-	-	1.00	-
Tomato powder(100℃)	-	-	-	1.00
Total (%)	100	101	101	101

[1)] STPP= sodium tripolyphosphate.

[2)] Cure blend: containing 93.75% NaCl and 6.25% $NaNO_2$

H. pH and Hunter color measurement

pH values were measured using a digital pH-meter (MP 120, Mettler-Toledo, Schwarzen-bach, Switzerland) at five times and then expressed as average values. Hunter L (lightness), a (redness) and b (yellowness) values were measured five times on sausage samples using a Color Reader (CR-10, Minolta Corp., LTD, Japan). The colorimeter was calibrated against a white board (L = 91.0, a = 1.60, b = 1.00) before used.

I. Texture profile analysis

Inston Universal Testing Machine (Model 3344, Canton, MA, USA) was used to measure textural properties of sausage samples. Hardness (gf), springiness (cm), gumminess, chewiness and cohesiveness were determined according to the method of Bourne [16]. Two cycles of compression test were performed with 75% of sample height with a 500N load cell at a cross speed of 300 mm/min.

J. Statistical analysis

The experiment was replicated twice, and the data were analyzed by one-way analysis of variance (ANOVA) using SPSS 19.0 for Windows [17].

Significant differences among means were analyzed by Duncan's multiple range test (p<0.05).

III. RESULTS AND DISCUSSION

Experiment I: Antioxidant activity of TP dried at different drying temperatures

DPPH radical scavenging activity and ferrous iron chelating ability of WSTs were affected by drying temperatures of tomato. WST from TP dried at 100℃ showed higher radical scavenging activity (Figure 1) and iron chelating ability (Figure 2) than other drying temperatures (p<0.05).

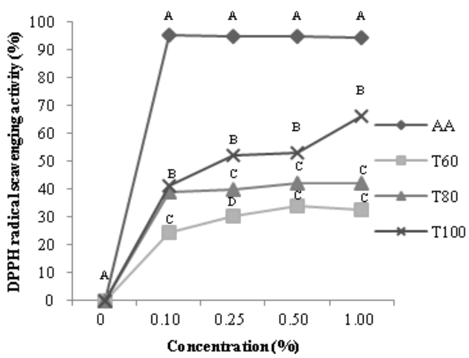

Figure 1. DPPH radical scavenging activity (%) of SWTs as affected by drying temperature.
Treatments: AA= ascorbic acid; T60= SWT from TP dried at 60℃ oven; T80= SWT from TP dried at 80℃ oven; T100= SWT from TP dried at 100℃ oven.
[A-D] Means with different superscripts in a same concentration are different (p<0.05).

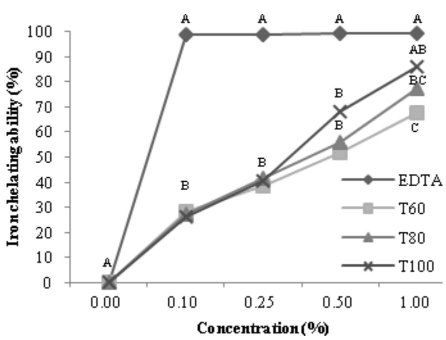

Figure 2. Iron chelating ability (%) of SWTs as affected by drying temperature.
Treatments: As shown in Figure 1.
[A-C] Means with different superscripts in a same concentration are different (p<0.05).

Experiment II: Effect of various TP on the quality of regular-fat pork sausage

As shown in Table 2, the addition of TP did not show any differences in moisture, crude fat, protein, ash contents and expressible moisture.

Table 2. Proximate analysis (%) and expressible moisture (EM, %) of pork sausages with TPs

Parameters	Treatments[1)]			
	CTL	REF	TRT1	TRT2
Moisture (%)	62.7^{a}	62.7^{a}	62.7^{a}	62.8^{a}
Fat (%)	20.7^{a}	20.4^{a}	21.1^{a}	20.9^{a}
Protein (%)	11.4^{a}	12.4^{a}	12.5^{a}	12.7^{a}
Ash (%)	2.12^{a}	2.38^{a}	2.03^{a}	2.05^{a}
EM (%)	21.2^{a}	22.1^{a}	24.0^{a}	22.0^{a}

[a] Means with same superscript within same row are not different (p>0.05).
[1)] Treatments: As shown in Table 1.

pH and color values of regular-fat model sausage were affected by drying temperatures of TPs added (Table 3) (p<0.05). pH values were reduced when TPs was added. Especially, the addition of TP dried at 100℃ oven (TRT3), resulted in the highest reduction of pH values. A decrease in the pH value of meat product containing TP has been reported by Kang *et al.* [18]. This might be partially due to the low pH value of tomato powder itself (pH 4.26 for 60℃, 4.16 for 80℃ and 4.03 for 100℃). Hunter L values were decreased when TPs added, and TRT3 showed the highest reduction of lightness value. Incorporation of TPs dried at 60 (TRT1) and 80℃ (TRT2) oven-drying increased redness, as compared to the control, while TRT3 did not affect. Hunter b value also increased when TP was added, and TRT3 showed higher yellowness value than those of others. Candogan [9] and Deda *et al*. [6] observed that higher tomato paste level, lower values for lightness and higher

Table 3. pH and Hunter color values of pork sausages with TPs dried at different drying temperatures

Parameters	Treatments[1)]			
	CTL	TRT1	TRT2	TRT3
pH	6.16^{a}	5.95^{b}	5.95^{b}	5.88^{c}
Hunter L	73.7^{a}	71.0^{b}	69.8^{c}	66.0^{d}
Hunter a	13.1^{b}	14.8^{a}	15.1^{a}	13.2^{b}
Hunter b	3.65^{d}	6.42^{c}	9.85^{b}	12.9^{a}

[ad] Means with same letter into same row are not different (p>0.05).
[1)] Treatments: As shown in Table 1.

values for redness and yellowness. Carotenoids in tomato products, like lycopene and β-carotene, are responsible for the red coloration.
As shown in Table 4, no differences in textural parameters, such as hardness, springiness, gumminess, chewiness and cohesiveness, were observed with the addition of various TPs.

Table 4. Textural properties of regular-fat pork sausages with various TPs

Parameters	Treatments[1)]			
	CTL	REF	TRT1	TRT2
Hardness (gf)	2181 [a]	2291 [a]	2094 [a]	2013 [a]
Springiness (mm)	4.32 [a]	5.12 [a]	5.02 [a]	4.35 [a]
Gumminess	19.7 [a]	15.6 [a]	16.6 [a]	12.6 [a]
Chewiness	78.0 [a]	93.1 [a]	84.6 [a]	54.3 [a]
Cohesiveness	0.008 [a]	0.007 [a]	0.008 [a]	0.007 [a]

[a] Means with same superscript within same row is not different (p>0.05).
[1)] Treatments: As shown in Table 1.

IV. CONCLUSION

Water soluble fraction from TP dried at 100℃ oven showed higher activities for 1,1-diphenyl-2-picrylhydrazyl radical (DPPH) scavenging activity and iron chelating ability than those with other temperatures (60 and 80℃). Addition of various TP into pork sausages reduced pH and Hunter L values, however it increased Hunter a and b values. Thus, tomato powder could be used as a natural color agent in regular-fat pork sausages.

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