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ARTICLE

Effect of Goldenrod (*Solidago virgaurea*) Leaf and Stem Powder on Physical and Sensory Characteristics of Emulsion-type Sausages

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Abstract

The effects of adding goldenrod leaf (GL) and stem powder (GS) (1 and 2%) to sausage meat were evaluated for quality characteristics. The compositional properties, pH, cooking yield, instrumental color, emulsion stability, viscosity, texture, and sensory properties were investigated. Adding GL and GS increased the moisture and ash concentration in sausages. Furthermore, increasing the amount of added GL and GS helped to develop ($p<0.05$) cooking yield, emulsion stability, and viscosity in the meat batters. Sausages with 2% GL and GS had significantly higher springiness and hardness than those of the control. No significant differences in cohesiveness were observed among the treatments. CIE L^* and CIE a^* values were highest ($p<0.05$) in the control sausage. Treatment with 2% GL resulted in the highest CIE b^* values ($p<0.05$) in batter and sausages. No significant difference was observed between the control and other treatments for the overall acceptability. Overall, this study indicated that GL and GS could be used as dietary fiber in sausages to improve quality characteristics.

Key words: goldenrod leaf, goldenrod stem, quality characteristics, emulsion-type sausage

Introduction

In past decades, westernization of the diet has increased the intake of fat from meat. Consumption of sausages, containing 20-30% fat, occupies 44% of total meat production in 2010 (Korea Meat Industries Association, 2011). These dietary habits have resulted in diseases such as obesity, cancer, and hypertension (Choi and Chin, 2003). In particular, eating meat products may result in various diseases related to obesity and disorders of the gastrointestinal system because of the lack of dietary fiber. Obese people accounted for 31.9% of the Korean population in 2009 (Korea Centers for Disease Control and Prevention, 2011). Consumers demand healthier meat, and dietary fiber could prevent obesity and various adult diseases (Rodriguez *et al*., 2006). Dietary fiber has functional properties, such as fat replacement, oxidative stability, nutritional value, and product stability such as cooking yield, water binding, fat binding, and texture (Álvarez *et al*., 2011). Dietary fiber such as, citrus fiber, wheat fiber, and grape fiber have been used in various meat product types (Fernández-Ginés *et al*., 2003; Mansour and Khalil, 1997).

Plants provide supplements of vitamin A, C, B group, and dietary fiber including celluloses, hemicelluloses, pectin, and inorganic components such as, calcium, magnesium, and iron. Goldenrod (*Solidago virgaurea*) is native to mountains, fields, and sidewalks and is cultivated in greenhouses all over the country. It belongs to the family *Compositae* and has a unique flavor. Traditionally it has been used to treat colds and headache. Goldenrod contains about 168 mg% calcium, 1.69 mg% iron, 483 mg% potassium, and 21 mg% magnesium (Han *et al*., 1999). In recent years, the demand for goldenrod has risen due to its functional food ingredients and studies about its antibacterial and biochemical activities (Courtney *et al*., 2010). However, goldenrod has not been studied in the meat industry.

Accordingly, the purpose of this study was to research quality characteristics of emulsion type pork sausage added goldenrod leaves and stems.

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Materials and Methods

Preparation of goldenrod leaf and stem powder

The goldenrod was washed and cut to separate the leaves and stems. The leaves and stems were cut into small pieces and dried by a hot air dryer (Enex-Co-600, Enex, Korea) at 50°C for 15 h, powdered (35 mesh). The dried goldenrod leaf and stem powder (15 g) was stored at -20°C until use.

Preparation of meat and emulsion type sausages

Fresh pork hams, weighing 6.5-7.0 kg each, were purchased from a pilot plant at Konkuk University, Korea, at 48 h postmortem. The pork back fat was also collected from the slaughter house. All subcutaneous and intramuscular fat and visible connective tissues were removed from the fresh ham muscles. Lean meats were ground 8 mm plate. The pork back fat was also ground through an 8 mm plate.

The emulsion type sausages were prepared by the following formulation and process: 60% lean pork meat, 20% pork back fat, 20% ice, 1.5% sodium chloride, 0.2% sodium tripolyphosphate, 0.3% monosodium L-glutamate, and 0.6% frankfurter spices. Control sample was produced without the addition of goldenrod leaf and stem powder. The hot-air-dried goldenrod leaf and stem powder was added at levels of 1% (GL1 and GS1) and 2% (GL2 and GS2). These percentages were based on the control formula weight.

Three batches (each 2 kg) were prepared for each treatment. For each batch of sausage, meat, fat, water, goldenrod leaf and stem powder, and other ingredients were emulsified using a silent cutter (Nr-963009, Scharfen, Germany). After emulsification, the meat batter was stuffed into collagen casings (approximate 25 mm diameter; #240, NIPPI Inc., Japan) using a stuffer (IS-8, Sirman, Italy), and then were heated at 75±1°C for 30 min in a water bath (VS-1901W, Vision Scientific Co., Ltd., Korea). The cooked sausages were then cooled with cold water and stored at 4°C until testing. Sausages processing was carried out in triplicate for each treatment.

Proximate composition

The proximate properties of the samples were determined using standard AOAC (2000) methods. The moisture contents were determined by weight loss after 12 h of drying at 105°C in a drying oven (SW-90D, Sang Woo Scientific Co., Korea). The fat contents were determined by the Sohxlet method with a solvent extraction system (Soxtec® Avanti 2050 Auto System, Foss Tecator AB, Sweden). The protein contents were determined by the Kjeldahl method with an automatic kjeldahl nitrogen analyzer (Kjeltec® 2300 Analyzer Unit, Foss Analytical AB, Sweden) and the ash contents were determined according to AOAC (2000) method.

pH values

The pH values of samples were determined with a pH meter (Model 340, Mettler-Toledo GmbH, Switzerland). The pH of the batter and sausages was measured after blending 5 g of sample with 20 mL of distilled water for 60 s in a homogenizer (Ultra-Turrax SK15, Janke & Kunkel, Germany).

Instrumental color evaluations

The instrumental color analysis of the batter and sausages were conducted as follows. The color measurements were taken with a colorimeter (Chroma meter CR-210, Minolta, Japan; illuminate C, calibrated with a white standard plate CIE L* = 97.83, CIE a* = -0.43, CIE b* = +1.98), consisting of an 8 mm diameter measuring area and a 50 mm diameter illumination area. The color values (CIE L*, a*, and b*) were measured on the sample surfaces and data were taken in triplicate for each sample.

Cooking yield

The meat batter was weighed (80 g) and stuffed into collagen casings and then heat processed at 75±1°C for 30 min. After cooling 30 min, the cooked sausages were weighed and the percentage cooking yields were calculated from the weights.

$$\text{Cooking yield (\%)} = \frac{\text{weight of sausage after cooking}}{\text{weight of sausage before cooking}} \times 100$$

Emulsion stability

The meat batters were analyzed for emulsion stability using the method of Ensor *et al*. (1987) with the following modifications. At the middle of a 15 mesh sieve (50 mm diameter), pre-weighed graduated glass tubes (Volume 15 mL, Graduated units: 0.2 mL; Pyrex Chojalab Co., Korea) were filled with batter. The glass tubes were closed and heated for 30 min in a boiling water bath to a core temperature of 75±1°C. They were then cooled to approximately 4°C to facilitate the separation of the fat and water layers. The fluid water and fat, which separated well in the bottom of the graduated glass tube, were measured in milliliters and calculated as percentages of the original weight of the batter.

Fat released (%)
= [the fat layer (mL)/weight of raw meat batter (g)] × 100

Water released (%) = [the water layer (mL)/
weight of raw meat batter (g)] × 100

Viscosity analysis

The flow behavior and time dependency of the batters were measured in triplicate with a rotational viscometer (HAKKE Viscotester® 550, Thermo Electron Corporation, Karlsruhe, Germany) set at 10 rpm. The tests were performed by a standard cylinder sensor (SV-2) at 20±1ºC. The time dependency of the meat batter was evaluated by measuring the viscosity under a constant share rate of 10 s^{-1} for 40 s.

Texture profile analysis (TPA)

Texture profile analyses were performed in duplicate on each sausage. The samples were cooked as previously described. The cooked sausages were cooled at room temperature for 1 h to determine the texture properties. The textural properties of each sausage were measured by a spherical probe (5 diameter), attached to a Texture Analyzer (TA-XSK1*i*, Stable Micro System Ltd., UK). The test conditions were as follow: stroke, 20 g; test speed, 2.0 mm/s; and distance, 10.0 mm. The data were collected and analyzed in terms of hardness (kg), springiness, cohesiveness, gumminess (kg), and chewiness (kg) values.

Sensory evaluations

The sausages were evaluated for color, flavor, juiciness, tenderness, and overall acceptability. The cooked samples as previously described were cooled to room temperature at 25±1ºC and cut and served to the panelists in random order. The sensory evaluations were performed by the panelists under fluorescent lighting. The panelists were instructed to cleanse their palates between samples using water. The color, flavor, and overall acceptability (1=extremely undesirable, 10=extremely desirable); tenderness (1=extremely tough, 10=extremely tender); and juiciness (1=extremely dry, 10=extremely juicy) of the sausage samples were evaluated using a 10-point descriptive scale. The panel consisted of 12 members from the Department of Food Science and Biotechnology of Animal Resources at Konkuk University, Korea.

Statistical analysis

Analysis of variance was performed on all the variables measured using the General Linear Model (GLM) procedure of the SAS statistical package (SAS Institute, Inc., 1999). Duncan's multiple range test (p<0.05) was used to determine the differences between treatment means. T-test (p<0.001) was used to determine the differences between pH values of batter and sausages means.

Results and Discussion

Proximate composition

The physicochemical properties of goldenrod leaf (GL) and stem powder (GS) are shown in Table 1. Protein and fat content of GL were higher (p<0.05) than that of GS. The dietary fiber contents of GL and GS were 6.84 and 12.47. Moisture content of sausages with GL and GS was higher (p<0.05) than that of the control (Table 2). This may be due to adding GL and GS, which have water-binding capacity. Similar results were obtained when hazelnut pellicle was added, resulting in a significant increase in moisture content in ground beef, and adding raw and cooked albedo increases moisture content in bologna sausages (Fernández-Ginés *et al*., 2004; Turhan *et al*., 2005). Control had the highest fat content and GS2 had the highest ash content in all treatments. In this study, we did not find any significant differences in protein content of the emulsion-type sausages among treatments.

pH values

Meat batters had pH values between 6.04 and 6.25 (Table 3). After cooking, pH values of the sausages were higher (p<0.001) than those of the batter for all samples, which could be explained by exposure of some basic amino acid residue chains due to protein denaturation (Tanford, 1968). These results are in agreement with those of Tsai *et al*. (1998) and Morin *et al*. (2002). The pH values of control samples had higher (p<0.05) than those of samples with GS and lower than those of sam-

Table 1. Physico-chemical properties of goldenrod leaf and stem powder

	Goldendrod leaf powder	Goldendrod stem powder
Moisture (%)	5.98±0.02	9.76±0.24
Protein (%)	23.47±0.93	11.88±0.36
Fat (%)	5.69±0.14	2.19±0.08
Ash (%)	15.52±0.05	19.51±0.03
Dietary fiber (%)	6.84±0.05	12.47±0.03
pH	6.30±0.03	5.96±0.02

ples with GL in batter and sausages. Pork sausage samples with 2% GL had higher (p<0.05) pH values than sausage samples with 1% GL. The pH of GS2 was lower (p<0.05) than GS1. This could be due to the high pH value of GL and the basic mineral content and low pH value of GS (Table 3). The increase in pH of pork patties with added ginseng and rosemary causes markedly high pH values compared to that in a control (McCarthy *et al*., 2001). Kang *et al* (2010) noted that the low pH of tomato powder (pH 3.48) affects the decrease of pH values in pork patties.

Instrumental color evaluation

The color of meat products is a very important for choice by consumers and is affected by pH, additives, and pigments through cooking (Osburn and Keeton, 1994). The instrumental color of the batter and sausages samples is presented in Table 4. Control samples had the highest CIE a^* values and the lowest CIE b^* values in both batter and sausage. Adding GL and GS resulted in a decrease of CIE L^* and CIE a^* values and an increase of CIE b^* values in the batter and sausage. These observation could be due to the color of GL (CIE L^*: 33.16, CIE a^*: -12.51, CIE b^*: 21.66) and GS (CIE L^*: 61.30, CIE a^*: -14.32, CIE b^*: 29.00). Lee *et al*. (2004) found that mugwort affects the color of emulsion-type sausages. The color of apple pulp results in significantly higher CIE a^* and CIE b^* values in chicken nuggets, compared with those of a control (Verma *et al*., 2010). This result was in agreement with the findings of Fernandez-Gine *et al*. (2004) in bologna sausages with added lemon albedo. A contrary view was reported by Turhan *et al.* (2005) who found that that adding hazelnut pellicle decreases the CIE L^*, CIE a^*, and CIE b^* values. The color (CIE L^*, CIE a^*, and CIE b^*) of batter samples had lower values in all treatments during cooking. Hutchings (1999) reported that CIE L^* values may be relevant to moisture content in food. However, in this study, CIE L^* values were not affected by the moisture content of the sausages.

Cooking yield and emulsion stability

Significant differences were found in cooking yield among the samples (Table 3). The control samples had the lowest cooking yield, because they lost fat and water during cooking (Turhan *et al*., 2005). Treatments with 2% GL and GS resulted in the highest cooking yields for all treatments. Furthermore, samples with GS had higher cooking yields than samples with GL, which may have been

Table 2. Compositional properties of emulsion-type sausages with goldenrod leaf and stem powder

Treatment[1)]	Control	GL1	GL2	GS1	GS2
Moisture (%)	60.48±0.73^{C}	61.20±0.19^{BC}	61.58±0.82^{B}	62.16±0.32^{B}	64.09±0.13^{A}
Protein (%)	15.58±0.76	16.09±0.14	15.52±0.60	15.60±0.34	16.09±0.24
Fat (%)	20.15±0.98^{A}	19.71±0.25^{AB}	18.27±0.71^{B}	17.43±0.29^{B}	17.91±0.56^{B}
Ash (%)	2.60±0.00^{B}	2.66±0.07^{AB}	2.70±0.14^{AB}	2.69±0.11^{AB}	2.77±0.11^{A}

All values are mean±SD of three replicates.
$^{A-C}$ Means in a row with different superscript letters are significantly different (p<0.05).
[1)]Control, pork sausages without goldenrod leaf and stem powder; GL1, pork sausages with 1% goldenrod leaf powder; GL2, pork sausages with 2% goldenrod leaf powder; GS1, pork sausages with 1% goldenrod stem powder; GS2, pork sausages with 2% goldenrod stem powder

Table 3. pH, cooking yield, and emulsion stability of emulsion-type sausages with goldenrod leaf and stem powder

Traits		Control	GL1	GL2	GS1	GS2
pH	batter	6.15±0.02^{E**}	6.20±0.02^{B**}	6.25±0.03^{A**}	6.09±0.05^{C**}	6.04±0.04^{D**}
	sausages	6.26±0.03^{B**}	6.33±0.02^{A**}	6.34±0.06^{A**}	6.22±0.04^{C**}	6.21±0.02^{C**}
Cooking yield (%)		85.28±0.43^{C}	90.34±0.75^{B}	95.07±0.60^{A}	91.76±0.48^{B}	95.08±0.82^{A}
Emulsion stability						
Fat released (%)		2.11±0.38^{A}	0.91±0.29^{B}	0.62±0.12^{BC}	0.92±0.15^{B}	0.50±0.12^{C}
Water released (%)		12.18±0.88^{A}	7.29±0.97^{B}	4.84±0.28^{BC}	8.84±0.99^{B}	4.66±0.94^{C}

All values are mean±SD of three replicates.
$^{A-E}$Means in a row with different superscript letters are significantly different (p<0.05).
Significant differences between pH values of batter and sausages are denoted by asterisks: ** p<0.001.
Control, pork sausages without goldenrod leaf and stem powder; GL1, pork sausages with 1% goldenrod leaf powder; GL2, pork sausages with 2% goldenrod leaf powder; GS1, pork sausages with 1% goldenrod stem powder; GS2, pork sausages with 2% goldenrod stem powder.

due to the high water holding capacity. Other authors have also reported an increase in cooking yield of restructured beef steak with 10% walnuts, meatballs with rye bran, low-fat beef burgers containing hazelnut pellicle, and pork patties with tomato powder (Jiménez Colmenero, 2003; Kang *et al*., 2010; Turhan *et al*., 2005).

Emulsion stability of the meat batter indicates the fat and water binding contents by the meat protein. The stability of the meat emulsion was significantly affected by adding GL and GS (Table 3). The control treatment was the highest in both fat released and water released from meat batter, indicating instability. Increasing the amount of added GL and GS decreased exudation of fat and water. The GS2 treatments had the lowest fat and water released from meat batter. According to Elleuch *et al*. (2011), dietary fiber contributes to improving emulsion stability of meat. Dehydrated lemon albedo affects emulsion stability (Sariçoban, *et al*., 2008), and adding collagen fiber promotes water-binding properties (Prabhu *et al*., 2004). However, Son *et al*. (2009) did not report any differences in the fat and water content of a low-fat sausage emulsion with added *Lentinus edodes* powder.

Viscosity analysis

Viscosity of a meat emulsion is the most effective factor for absorbing additives (Dogan *et al*., 2005). Fig. 1 shows the viscosity data for all meat batters under a steady speed. Batter samples without added GL and GS were 52.67 Pas. Batter samples with added GS had higher viscosity than samples with added GL. Adding GL and GS influenced (p<0.05) the increase in viscosity. This result was supported by a study indicating that dietary fiber content and retained fat and water content affects the increase of viscosity in a meat emulsion (Nuria *et al*., 1999). Furthermore, viscosity in a meat emulsion is highly correlated with increases in fat and water retention (Zorba

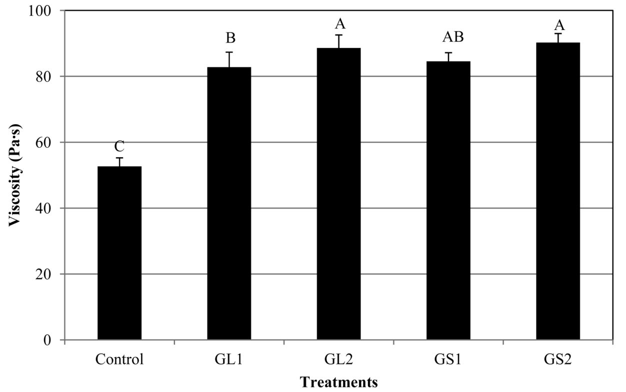

Fig. 1. Viscosity of emulsion-type batter with goldenrod leaf and stem powder. All values are mean ± SD of three replicates. A-CMeans within treatments with different superscript letters are significantly different (p<0.05). 1)Control, pork sausages without goldenrod leaf and stem powder; GL1, pork sausages with 1% goldenrod leaf powder; GL2, pork sausages with 2% goldenrod leaf powder; GS1, pork sausages with 1% goldenrod stem powder; GS2, pork sausages with 2% goldenrod stem powder

et al., 1993). Because of this, the meat emulsion was not destroyed. Claus and Hunt (1991) found that batter containing Duofiber and oat fiber were highly viscous, compared with that of a control.

Texture profile analysis

Texture properties of meat are affected by fat and water content, species and type of additive, cooking temperature, and degree of protein denaturation (Moon *et al*., 2001). A texture evaluation is an estimation method that measures the quality characteristics of finished products and selects functional ingredients available for adding to meat products (Herrero *et al*., 2007). The texture profile properties of the sausage samples without or with added GL and GS analysed in this study are presented in Table 5. Significant differences in hardness, springiness, gumminess, and chewiness were observed between the con-

Table 4. Instrumental color evaluation of emulsion-type sausages with goldenrod leaf and stem powder

Traits		Control	GL1	GL2	GS1	GS2
batter	CIE L^*	75.56±0.99^A	67.52±0.98^C	61.11±0.97^D	74.57±0.98^{AB}	73.65±0.99^B
	CIE a^*	12.44±0.79^A	-4.91±0.52^D	-9.55±0.36^E	7.17±0.80^B	2.83±0.84^C
	CIE b^*	19.36±0.64^D	24.95±0.35^A	25.43±0.73^A	20.78±0.61^C	21.95±0.92^B
sausages	CIE L^*	75.34±0.88^A	62.21±0.97^D	57.61±0.84^E	71.63±0.58^B	68.65±0.92^C
	CIE a^*	4.87±0.49^A	-5.35±0.40^D	-9.85±0.40^E	1.47±0.28^B	-1.05±0.30^C
	CIE b^*	15.82±0.80^D	19.93±0.96^B	22.42±0.53^A	16.14±0.76^D	18.31±0.87^C

All values are mean±SD of three replicates.

A-EMeans in a row with different superscript letters are significantly different (p<0.05).

Control, pork sausages without goldenrod leaf and stem powder; GL1, pork sausages with 1% goldenrod leaf powder; GL2, pork sausages with 2% goldenrod leaf powder; GS1, pork sausages with 1% goldenrod stem powder; GS2, pork sausages with 2% goldenrod stem powder trol and samples with added GL and GS. The control had the lowest hardness (0.32 kg), possibly because the control had the highest cooking loss among treatments. Sausage containing 2% added GL and GS had significantly higher hardness. The increase in the hardness by adding GL and GS resulted in positive effects in the sensory evaluation. These results agree with those of Cho and Chung (2010) who reported that increased hardness is affected by both adding and increasing the added level of steam-dried green tea powder. Park *et al*. (2002) added green tea powder and increased the hardness of beef jerky. The increase in the hardness of the samples containing GL and GS might be due to protein coagulation by tannic acid, which is produced by reacting tannin and oxygen in air (Scalbert, 1991). García *et al*. (2007) found that adding cereal and fruit fiber resulted in harder dry and cooked sausages. Verma *et al*. (2010) reported that adding apple pulp results in lower hardness of low-fat chicken nuggets, and Tsoukalas *et al.* (2011) found that adding freeze-dried leek powder resulted in no differences in hardness of fermented sausages. Adding GL and GS increased springiness, gumminess, and chewiness. Pork sausages containing konjac and seaweed have increased springiness (Jiménez-Colmenero *et al*., 2010). Cohesiveness was not affected by adding GL and GS to the sausages. Similar trends were observed in sausages with added mugwort powder and frankfurter with added peach dietary fiber (Grigelmo-Miguel *et al*., 1999; Lee *et al*., 2004). Lin *et al*. (1988) observed that a decrease in gel strength of the final product is influenced by peach dietary fiber because it interrupts the network of protein-water or protein-protein binding gel.

Sensory evaluation

The sensory evaluation is the most important method to investigate consumer food preferences. Sensory scores for pork sausages without/with added GL and GS are presented in Table 6. No significant difference was observed between the control and other treatments for the sensory evaluation, except for color and juiciness. The control and GL2 had the highest (p<0.05) scores (8.89 and 8.33) in color. The control had the general sausage color, whereas GL2 had a strong green color due to the added GL. Nevertheless, the panelists preferred GL2. This might be related to a trend for well-being, which was contributed by the green color in the sausages. Sausages with different levels of added GL and GS did not have significant differences in flavor, tenderness, overall acceptability from the control. Treatments containing 2% GL was the juiciest (p< 0.05) in all samples. A significantly higher juiciness was

Table 5. Texture profile analysis (TPA) of emulsion-type sausages with goldenrod leaf and stem powder

Traits	Control	GL1	GL2	GS1	GS2
Hardness (kg)	0.32±0.12^{B}	0.35±0.02^{AB}	0.39±0.05^{A}	0.34±0.03^{AB}	0.38±0.04^{A}
Springiness	1.09±0.04^{B}	0.96±0.02^{AB}	0.96±0.02^{A}	0.94±0.11^{AB}	0.99±0.14^{A}
Cohesiveness	0.58±0.09	0.61±0.05	0.60±0.07	0.58±0.04	0.57±0.07
Gumminess (kg)	0.18±0.02^{B}	0.21±0.03^{A}	0.22±0.03^{A}	0.19±0.03^{AB}	0.22±0.06^{A}
Chewiness (kg)	0.18±0.02^{B}	0.20±0.03^{AB}	0.21±0.03^{AB}	0.19±0.03^{B}	0.22±0.06^{A}

All values are mean ± SD of three replicates.
^{A,B}Means in a row with different superscript letters are significantly different (p<0.05).
Control, pork sausages without goldenrod leaf and stem powder; GL1, pork sausages with 1% goldenrod leaf powder; GL2, pork sausages with 2% goldenrod leaf powder; GS1, pork sausages with 1% goldenrod stem powder; GS2, pork sausages with 2% goldenrod stem powder

Table 6. Sensory evaluation of emulsion-type sausages with goldenrod leaf and stem powder

Traits	Control	GL1	GL2	GS1	GS2
Color	8.89±0.33^{A}	7.44±0.88^{B}	8.33±0.87^{A}	7.56±0.88^{B}	7.11±0.93^{B}
Flavor	8.33±0.71	8.44±0.88	8.33±0.71	8.44±0.88	8.33±0.87
Tenderness	8.56±0.73^{B}	8.77±0.78^{AB}	9.00±0.50^{A}	8.78±0.44^{AB}	8.86±0.71^{AB}
Juiciness	8.33±0.71^{B}	8.67±0.71^{AB}	9.11±0.60^{A}	9.00±0.50^{AB}	9.00±0.71^{AB}
Overall acceptability	8.44±0.88	8.67±0.87	8.44±0.88	8.78±0.83	8.33±0.71

All values are mean ± SD of three replicates.
^{A,B}Means in a row with different superscript letters are significantly different (p<0.05).
Control, pork sausages without goldenrod leaf and stem powder; GL1, pork sausages with 1% goldenrod leaf powder; GL2, pork sausages with 2% goldenrod leaf powder; GS1, pork sausages with 1% goldenrod stem powder; GS2, pork sausages with 2% goldenrod stem powder

observed in low-fat beef burgers incorporated with oat fiber (Desmond *et al*., 1998). Fernández-Ginés *et al*. (2004) reported that bologna sausages were not significantly different in juiciness from control and treatments with added lemon albedo. A significant difference was not found among the treatments for overall acceptability; GS1 was higher (p>0.05) than the other samples in overall acceptability scores. In conclusion, adding GL and GS did not negatively affect the sensory evaluation of the sausages.

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