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Effect of Replacing Sodium Nitrite with Celery on Sensory and Chemical Quality of Popular Dry Sausage

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Abstract

The global economic crisis led to the tendency of consumers to search for cheap food sources of animal origin, including dry sausage, regardless of the quality or safety factor. Nitrite is an important meat additive responsible for the distinctive color and flavor of meat products, inhibits the development of microbial spores, and delays lipid oxidation. At the same time, it has adverse health risks for meat consumers. Celery, *Apium graveolens*, as a plant rich in nitrate was used in this study for replacing the synesthetic chemical nitrite used in sausage manufacture. Dry sausage samples were divided into three equal groups, the first group without adding sodium nitrite and kept as a control group. The second group was treated with 100 mg/kg of sodium nitrite while the third group was treated with 0.3% celery powder. All groups were periodically examined for sensory and chemical quality parameters. Generally, there are no significant differences (P>0.05) found between sausage groups attributes to appearance. The results of color, flavor, smell, nitrite content, TVN, and TBA of control sausage samples were statistically lower (P<0.05) than those of treated sausage groups. No differences (P>0.05) were found for the attribute color, flavor, smell, nitrite content, TVN, and TBA between those treated with 100 ppm sodium nitrite and 0.3% celery sausages groups. The obtained results concluded that safe dry sausage could be produced with high quality without the addition of synthetic sodium nitrite, by replacing it with 0.3% celery powder. Celery offers a high potential nitrite as natural substitutes improve both the sensory and chemical quality of the dry sausage. However, further research is needed to irrefutably determine all potential benefits content of the celery.

KEYWORDS
Sodium Nitrite, Celery, Dry Sausage, Sensory, Chemical, Quality.

INTRODUCTION

Nowadays, there is a global economic crisis engulfing the world coming on top of high food prices, as a result, consumers seek low prices meat products regardless of their safety or quality. Generally, meat products are considered one animal protein source of high biological value, in addition, it contains some soluble vitamins, minerals, and essential fats (Biswas *et al*., 2011; Eze *et al*., 2017). Sausage is minced meat in combination with salt, seasoning, and other materials replete in a casing that can be natural or artificial (FAO, 2010). Dry sausage has a pH range between 5.2 – 5.8, water activity value range is 0.85–0.91, and moisture: protein ratio lower than 2.3: 1 (Vignolo *et al*., 2010).

One of the essential chemical synthetic meat additives used in dry sausage manufacture is sodium nitrite, which has a positive effect on final products by improving their color, taste, and shelf-life. Another important function of sodium nitrite as a meat additive is inhibiting some meat poisoning pathogens such as *Clostridium botulinum*, and delaying the development of oxidative rancidity (Rahman, 2007; Goswami *et al*., 2014; Nader *et al*., 2021). So, it was noted down that dry sausage is a shelf-stable food, which means that it does not sustain the growth of pathogens and refrigeration is not necessary to maintain the organoleptic properties of the product (Serra-Castelló *et al*., 2021).

One of the challenges facing food safety scientists is the impact is the rapid reaction of nitrite as it is a volatile substance, so, it rapidly reacts with several meat components such as myoglobin and fat (Govari and Pexara, 2015). Nitrite residues in meat products are reactive substance that is more toxic and represent a health risk (Munekata *et al*., 2020). Nitrite in meat products may be decomposed into nitric acid and reacts with the secondary amines to form nitrosamine compounds (Bahadoran *et al*., 2016). N-nitrosamines are incriminating in various human risks like colorectal cancer (Santarelli *et al*., 2008), pancreatic cancer (Larsson and Wolk, 2012), mutagenicity (Azad and Hoseyni, 2013), methemoglobinemia (Javan *et al*., 2013), gastric cancers (Butler, 2015) and general carcinogenic (Ziarati *et al*., 2018).

As more people demand the preparation of natural safe meat products due to their concerns about the health risk of synthetic chemicals, the meat industry is focusing on producing formulated products that are natural, functional, and nutritional. The replacement of synthetic food additives appears to be the most promising method to achieve the so-called 'clean label' product with high quality and prolonged shelf-life (Prusa and Tarte, 2019). The induction of certain nitrite-rich plants into the formula

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of meat products proved to decrease residual nitrite levels and could prevent nitrosamines formation and hence improving the safety and quality of meat products (Shahat *et al*., 2016).

Celery, *Apium graveolens*, as a plant from the apiaceous family is a flavour tasty vegetable much appreciated for its nutritive and therapeutic values (Gauri *et al*., 2015). Celery contains a high level of nitrate in its leaves (Ziarati and Bidgoli, 2012). Celery also contains betalains, which have free radical scavenging and antioxidant activities (Georgiev *et al*., 2010). Recent issues of meat technology, focus on the replacement of synthetic nitrite with celery leaves powder because it doesn't change the flavor or appearance of the finished product (Sindelar *et al*., 2007), and prevents sporulation of *Clostridium botulinum* (Baseler, 2009), has antimicrobials action (Terns *et al*., 2011; Mahdi, 2011), proved that not allergen (Sebranek *et al*., 2012), has many human medical benefits (Sowbhagya, 2014), slow down lipid oxidation and inhibits meat spoilage (Jin *et al*., 2018a), decrease the residual nitrate or nitrite (Eisinaitė *et al*., 2020) and improve color development (Jeong, 2020).

Therefore, this study was conducted to evaluate the effect of celery replacement in dry sausage on the sensory and chemical quality to enhance the safety and quality of the final products.

MATERIALS AND METHODS

Samples manufacture

The sausage in this study was manufactured according to the criteria stipulated by the Egyptian Organization for Standardization and Quality Control; ESS 4177 (2005) and Heinz and Hautzinger (2007).

Preparation of celery powders

Celery powders were prepared according to the methods described by El-Nashi *et al*. (2015). Plant leaves were cleaned from irrelevant matter, dead leaves, and non-edible parts (roots). Slice celery crossways at about 1/4-inch-thickness then evenly placed in a hot air oven at 100°C for 2 h, then at 60°C for an additional 4 h. Grind to a fine powder then package in polyethylene bags until used.

Experimental design

The sausage formula was divided into three equal groups, the first group without adding sodium nitrite and kept as a control group. The second group was treated with 100 mg/kg of sodium nitrite while the third group was treated with 0.3% celery powder which is equal to 100 ppm nitrite according to Alahakoon *et al*. (2015) and Salehi (2021). All sausage groups were filled in dry sausage collagen casing tube (LKXHarleya, China), then kept for slow fermentation without using external starter cultures for two days at 20±2 ºC and relative humidity of 82-98%. The drying and ripening were carried out by using an incubator (Incucell model B080660), with relative humidity at 92-94% on the first day then decreased to 82-84% with store temperature at 20±2 ºC for 4 weeks tell ripening (Ritter *et al*., 2020; Public Health England, 2020). Dry sausage samples were collected after 1, 15, 30, 45, 60, 75, and 90 days for sensory and chemical evaluation whereas stored at 10±2 ºC all over the experiment.

Sensory evaluation

A panel consisting of 9 trained members of the same ages performed the sensory evaluation of dry sausage samples. Panelists were asked to score samples for appearance, color, flavor, and smell based on a 1–9 scale points start 1: dislike extremely to 9: like extremely (Wichchukit and O'Mahony, 2014).

Sensory evaluation

After complete ripening, a panel consisting of 10 trained members of the same ages performed the sensory evaluation of dry sausage samples. Panelists were asked to score samples for appearance, color, flavor, and smell based on a 1–9 scale points start 1: dislike extremely to 9: like extremely (Wichchukit and O'Mahony, 2014).

Determination of nitrite content

The nitrite content of dry sausage samples was determined according to the Association of Official Analytical Chemists (AOAC, 2016). Five grams of each sample were weighed in a 50 mL beaker, then 40 mL of distilled water and heated to 80°C were added to the sample. The samples were thoroughly mixed and transferred to a 500 mL volumetric flask. Further, enough hot water was added to bring volume to 300 mL, and then let to stand in the water bath for 2 h with shaking. The mixture was cooled to room temperature, diluted to 500 mL with distilled water, remixed, and then filtered. After that, 2.5 mL sulfanilamide reagent was added to 10 ml of the filtrate, and mixed. After 5 min, 2.5 mL N-1-naphthyl ethylenediamine reagent was added, diluted to 50 mL, and mixed. Accordingly, the developed color within 15 min. was determined at 540 nm against a blank of 45 mL water, 2.5 mL sulfanilamide reagent, and 2.5 mL N-1-naphthyl ethylenediamine reagent using a spectrophotometer. Nitrite present was determined by comparison with the standard curve prepared as follows: 10, 20, 30, and 40 mL nitrite working standard solutions were separately added to 50 ml volumetric flasks and 2.5 mL sulfanilamide reagent were added, mixed, and preceded as the first step. The standard curve is a straight line to 1µg/ml $NaNO2$ in the final solution.

Chemical quality criteria

Total Volatile Bases Nitrogen (TVB-N) and thiobarbituric acid (TBA) values were determined on schedule experimental design during sausage storage. The Total Volatile Base Nitrogen (mg/100 g) was measured based on the method described by Kearsley *et al*. (1983). The thiobarbituric acid (mg/Kg) value was measured by the method outlined by Du and Ahn (2002).

Statistical analysis

The chi-square test was used to test the significant differences between results obtained from control, $NaNO2$ and celery treatments. p-values less than 0.05 were considered statistically significant. The chi-square test for the results was performed with Microsoft excel 2019.

RESULTS AND DISCUSSION

Sensory evaluation

The sausage curing and fermentation process mainly comprises the addition of salt and nitrite to sensory modifies the consumer perception. The mean sensory values of treated dry sausage stored at 10ºC were shown in Table 1. The mean appearance values for control (group 1), treated with sodium nitrite (group 2), and treated with 0.3% celery (group 3) at one-day storage after ripening were 7.3, 7.9, and 8.0 respectively, while at 90-day storage were 6.9, 7.0 and 7.1 respectively. Generally, there are no significant differences (P>0.05) found between sausage groups attributes to appearance. Like the current study, meat products manufactured under adequate hygienic measures and from high-quality ingredients should has a great appearance. Whatever, the overall appearance of commercial sausages was the least preferred by consumers (Venturini and Cavenaghi, 2010). These results concerning dry sausage appearance agreed with those obtained by Olivares *et al.* (2010) and Bowser *et al.* (2014).

Color is considered the most crucial attribute of food quality and has a great influence on consumer impressions. As a result, a product's color may be the primary criterion for rejection before any other factors are evaluated. The mean color values for group 1, group 2, and group 3 at one-day storage after ripening were 4.5, 8.1, and 7.2 respectively, while at 90-day storage were 2.5, 7.8, and 7.7 respectively. The color results of control sausage samples (group 1) were statistically different (P<0.05) than those of treated sausage groups (like). No differences (P>0.05) were found for the attribute color between sodium nitrite and celery-treated sausages groups. Celery powder doesn't affect sausage color, it plays an important role as synthetic nitrite to improve sausage color (Jin *et al.*, 2018; Pennisi *et al.*, 2020).

Sausage flavor originated due to its constitution of volatile and non-volatile compounds. The mean flavor values for group 1, group 2, and group 3 at one-day storage after ripening were 5.5, 8.6, and 8.5 respectively, while at 90-day storage were 3.4, 7.6, and 7.6 respectively. The flavone results of control sausage samples (group 1) were statistically neither like nor dislike (P<0.05) than those of treated sausage groups (like moderately). No differences (P>0.05) were found for the attribute color between sodium nitrite and celery-treated sausages groups. Results obtained came with agree with those obtained by Pennisi *et al.*, (2020).

The mean smell values for group 1, group 2, and group 3 at one-day storage after ripening were 4.9, 7.7, and 7.8 respectively, while at 90-day storage were 3.3, 7.1, and 7.1 respectively. it is observed that there is a highly significant difference between the control group (dislike slightly) on one side versus NaNO2 and celery groups (like moderately). These results are inconsistent with that obtained by Kamenik *et al.* (2012) and Bowser *et al.* (2014).

Nitrite Content

The mean nitrite values of treated dry sausage stored at 10ºC were shown in Table 2 the mean nitrite content values for group 1, group 2, and group 3 at one-day storage after ripening were 9.7, 49.1, and 32.3 respectively, while at 90-day storage were 3.6, 29.7 and 10.9 respectively. The lower nitrite values are interpreted as 50 to 70% of the nitrite added either synthetic or natural to sausages mainly degraded to NO and binding to myoglobin by forming nitrosomyoglobin which is responsible for the characteristic color of cured meat (Li *et al.*, 2013 and Eisinaitė *et al.*, 2020). The residual nitrite values at the end of the ripening step in control and both treatments groups were significantly lower (P<0.05) and conform to the standard legislation which stated the level of residual nitrite to be not more than 100 mg/kg sample (ESS/3598, 2005). The addition of proper concentration of nitrite in treated groups is reflected by the normal cured color of the end product. Celery, natural curing substance, can be used as an effective al-

Table 1. Mean sensory values of treated dry sausage stored at 10ºC.

	Groups	Storage Time/ Day						
		Day one	Day 15	Day 30	Day 45	Day 60	Day 75	Day 90
Appearance	Group 1	#7.3±1.10	7.9 ±0.80	7.7 ±1.81	7.9 ±1.55	6.9 ±2.2	6.8 ±1.92	6.9 ±1.62
	Group 2	7.9 ±0.94	8.2 ±1.41	8.3 ±1.30	8.2 ±1.23	7.2 ±1.54	7.1 ±1.74	7.0 ±0.90
	Group 3	8.0 ±0.97	8.4 ±2.01	8.5 ±1.44	8.1 ±1.31	7.3 ±1.37	7.2 ±1.49	7.1 ±1.42
Color	Group 1	4.5 ±0.43*	4.4 ±1.02*	4.2 ±0.98*	4.1 ±1.36*	4.1 ±0.94*	3.4 ±1.1*	2.5 ±0.90*
	Group 2	8.1 ±1.22	8.6 ±1.40	8.6 ±1.92	8.52 ±2.05	8.3 ±1.70	8.1 ±2.42	7.8 ±1.08
	Group 3	7.2 ±0.95	7.9 ±1.45	8.2 ±1.22	8.2 ±1.55	8.1 ±1.42	7.9 ±1.94	7.7 ±1.32
Flavour	Group 1	5.5 ±0.66*	5.8 ±0.85*	5.5 ±1.40*	5.3 ±0.98*	4.2 ±0.94*	3.9 ±0.92*	3.4 ±1.11*
	Group 2	8.6 ±1.35	8.4 ±1.14	8.1 ±1.22	7.9 ±1.60	7.9 ±1.70	7.8 ±1.24	7.6 ±1.20
	Group 3	8.5 ±1.12*	8.5 ±1.52	8.2 ±1.18	7.88 ±10	7.8 ±1.14	7.8 ±0.99	7.8 ±0.96
Smell	Group 1	4.9 ±1.36*	5.4 ±0.95*	5.3 ±1.41*	4.1 ±0.99*	3.9 ±1.37*	3.6 ±1.13*	3.3 ±0.58*
	Group 2	7.7 ±1.22	8.2 ±1.78	8.1 ±2.30	7.8 ±1.35	7.8 ±1.53	7.2 ±0.91	7.1 ±1.21
	Group 3	7.8 ±1.05*	8.3 ±1.34	8.2 ±1.84	7.9 ±1.30	7.7 ±0.92	7.4 ±1.17	7.3 ±0.91

Scale point start for sensory evaluation start from 1: Dislike extremely to 9: Like extremely
#means ± Standard Error; Means followed by (*) on the column are significantly different (p<0.05).

Table 2. Mean nitrite values for treated dry sausage stored at 10ºC.

	Groups	Storage Time/ Day						
		Day one	Day 15	Day 30	Day 45	Day 60	Day 75	Day 90
Nitrite content	Group 1	9.7±3.20*	5.6±1.20*	5.5±1.00*	5.3±0.08*	5.1±1.62*	4.6±0.93*	3.6±0.87*
	Group 2	39.1±7.10	32.4±6.50	30.4±5.20	30.2±4.40	18.9±9.40	16.2±6.20	12.7±8.33*
	Group 3	35.3±8.33	31.3±6.10	29.2±2.11	28.8±3.70	17.8±8.70	14.7±5.48	10.9±7.58*

Means followed by (*) on the column are significantly different (p<0.05).

Table 3. The mean TVB-N and TBA values of treated dry sausage stored at 10ºC.

	Groups	Storage Time/ Day						
		Day one	Day 15	Day 30	Day 45	Day 60	Day 75	Day 90
TVB-N	Group 1	8.4 ±1.66	10.6 ±1.30*	14.8 ±1.36*	16.3 ±2.30*	21.1 ±2.20*	22.4 ±2.10*	28.4 ±3.41*
	Group 2	7.4 ±0.95	7.9 ±1.22	10.8 ±1.80	12.3 ±1.22	15.1 ±1.71	16.3 ±1.72	18.4 ±2.60
	Group 3	7.2 ±1.00	8.3 ±0.87	11.9 ±0.94	13.2 ±1.36	16.5 ±1.33	16.6 ±1.63	17.1 ±1.80
TBA	Group 1	0.2 ±0.02	0.3 ±0.03	0.6 ±0.11*	0.7 ±0.22*	0.9 ±0.19*	1.4 ±0.32*	2.3 ±0.84*
	Group 2	0.1 ±0.03	0.2 ±0.06	0.3 ±0.02	0.4 ±0.07	0.6 ±0.14	0.8 ±0.12	1.2 ±0.26
	Group 3	0.2 ±0.01	0.2 ±0.01	0.4 ±0.054	0.5 ±0.03	0.7 ±0.08	0.9 ±0.24	1.3 ±0.18*

Means followed by (*) on the column are significantly different ($p<0.05$).

ternative for commercial NaNO2.

Chemical quality criteria

The mean TVB-N and TBA values of treated dry sausage stored at 10ºC were shown in Table 3. The mean TVB-N values for group 1, group 2, and group 3 at one-day storage after ripening were 8.4, 7.4, and 7.2 respectively, while at 90-day storage were 28.4, 18.4, and 17.1 respectively. TVB-N values for the treated groups were within the acceptable level range reported by Egyptian Standards Specification (2005) which indicated that the TVB-N content should not exceed 20 mg/100 g. TVB-N content is usually used to assess the freshness and shelf-life of processed meats (Ba *et al*., 2018). The results cleared that there is a significant difference (P<0.05) between the control group and treated groups for TVB-N. In addition, no significant difference was observed between treated groups (P> 0.05). The addition of celery powder inhibits the growth of spoilage microorganisms and prolongs the shelf-life of sausage (Jin *et al*., 2018), and is directly related to the markable delayed changes in color and flavor of the end product (Wang *et al*., 2020).

Rancidity can alter the nutritive values, colors, and flavors of meat products and may pose health risks to consumers. The mean TBA values for group 1, group 2, and group 3 at one-day storage after ripening were 0.2, 0.1, and 0.2 respectively, while at 90-day storage were 2.3, 1.2, and 1.3 respectively. The results cleared that there is a significant difference (P<0.05) between the control group and treated groups for TBA values. No significant difference was observed between the treated groups (P> 0.05). The TBA value increases in a positive correlation with the duration of storage especially for the control samples in which the rate of rancidity is faster than the other two treated groups. Comparing the obtained results with the acceptable limit mentioned in the ESS (2005) as 0.9 mg malonaldehyde/kg, it was found that only the treated groups showed acceptable levels till the day 75th. The presence of betalains in celery extract composition demonstrates antioxidant activity and elimination of free radicals that make it follow in the same footsteps of traditional sodium nitrite in rancidity control. Recent studies confirmed that TBA values have shown no significant difference between treated sausage samples with sodium nitrite or celery (Wang *et al*., 2018; Ritter *et al*., 2020).

CONCLUSION

The obtained results concluded that safe dry sausage could be produced with high quality without the addition of synthetic sodium nitrite, by replacing it with 0.3% celery powder. Celery offers a high potential nitrite as natural substitutes improve both the sensory and chemical quality of the dry sausage. However, further research is needed to irrefutably determine all potential benefits content of the celery.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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