Official Journal Issued by Faculty of Veterinary Medicine

Benha Veterinary Medical Journal

Journal homepage: https://bvmj.journals.ekb.eg/

Since 1990

Original Paper

Additives in meat products marketed in Beni-Suef, Egypt "Residual levels and effect of cooking"

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ARTICLE INFO

Keywords

Nitrite
Salt
Phosphate
Meat products
Cooking

Received 13/06/2022
Accepted 26/06/2022
Available On-Line 01/10/2022

ABSTRACT

Meat products are highly popular because they are cheap, rich with many nutritive materials, essential amino acids, minerals and trace elements. Meat products are manufactured by combination of meat, fat and other non-meat ingredients. Despite chemical additives are necessary for meat products manufacturing, higher levels than the permissible may constitute public health hazard and/or technological problems. The main objective of the current study was to estimate the levels of moisture, sodium chloride, nitrites and phosphates in some meat products marketed in Beni-Suef Governorate and to study the effect of cooking on their level in fresh sausage. The highest mean value for moisture was detected in burger (63.90±2.57), while the lowest one was in sausage (54.34±2.71**).** Similarly, luncheon and frankfurter had the highest and lowest mean values for salt, which were 4.33±0.05and 3.90±0.27, respectively. Moreover, 3 (15%) of both sausage and frankfurter exceeded the permissible limits recommended by EOS for nitrite, while 1 (5%) and 4(20%) of beef burger and luncheon exceeded this level, respectively. Nitrites was significantly ($P\leq 0.05$) decreased by both frying and steaming, however, the reduction in water, salt and phosphates contents were not significant. Because of some samples exceeded the permissible limits of EOS, therefore a national large scale prescheduled surveys for the proximate chemical analysis and for detection of the levels of chemical additives in various meat products is always required.

1. INTRODUCTION

Meat is one of the most widely consumed sources of nutrient all over the world. Its widely consumption is attributed to its taste, flavor, juiciness, palatability, and ability to provide high biological values in human diet (Decker and Park, 2010; MacAfee et al., 2010; Chikwanda, 2016; Suleman et al., 2020). Combination of meat items with other ingredients can be used to make processed meat products. Meat products are rich with many nutritive materials, essential amino acids, minerals and trace elements. The nutrient contents of meat products usually differ from one meat product to another according to the beef cuts, preparing methods and food additives (Lyng et al., 2002)

The quality of food additives and raw materials used during meat products manufacturing reflects on the quality of the final product quality as well as the public health (Pearson and Gillett, 1996). Food additives provide natural, nutritious, fresh appearance to the product, it also enhances flavor, taste and extend the shelf life of the final meat products (Aymerich et al., 2008).

Water addition in meat products permits a uniform distribution throughout the meat products and acts as a carrier for salts and other ingredients. Using of ice or chilled water is very important during chopping, so that the temperature of sausages does not rise above 7.2^{0}C. Water also enhances the tenderness, juiciness and palatability of the processed meat products (Rabii et al., 2018).

Salt (Sodium chloride) has a preservative effect in meat products by lowering the water activity, it also improves texture flavor and mouth feel (Desmond, 2006). Moreover, salt is extremely important for solubilization and extraction of the myofibrillar proteins, which stabilizes fat in emulsion products resulting in stable emulsion (Ruusunen and Puolanne, 2005). Consumption of sodium chloride varies between individuals and populations worldwide, but it is generally higher than the recommended intake. High intake of sodium in human diet is related to hypertension which may lead to heart attack and stroke.

Sodium nitrite is one of food additives generally used in meat product manufacturing acts mainly as a coloring agent and preservative. Therefore, it extends the durability of the product and improve its appearance, flavor and structure without reducing its nutritional value giving it a pinkish-reddish characteristic feature (Grossi et al., 2014). Moreover, nitrites play role as antioxidant by production of

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nitrosyl-hemochromogen that declined catalytic activity through the immobilization of the iron complex and restricted the initiation of lipid oxidation (Sindelar and Milkowski, 2011). On the other hand, excessive addition of nitrite than the permissible limits has a carcinogenic risk due to the formation of N-nitrosamine compounds that react with the secondary amines in the acidic environment of the stomach. This reaction may cause death due to increasing the risk of colorectal, stomach and pancreatic cancer (Larsson and Wolk, 2012; Rohrmann et al., 2013). As concern in this field, the WHO (2003) established an Acceptable Daily Intake (ADI) of 0 -3.7 mg nitrate /kg body weight.

Phosphates added during meat product manufacturing have several functions, as changing and stabilizing the pH value, increasing water holding capacity, decreasing losses of weight in cooking, improving texture and sensory properties (tenderness, juiciness, color and flavor) and extending shelf life of the product. Phosphate also represents a source of phosphorus through diet, which is an essential mineral for the life of humans (Long et al., 2011). Despite, phosphates improve the technological properties of the meat products, higher levels may result in technological defects (soapy texture and rubbery taste) on meat products and adverse effects on human health, so their use is regulated by law setting the maximum allowable level of phosphates in a meat product (Dimitrovska et al., 2019).

Despite of the previously mentioned food additives have great functions in further processed meat products, uncontrolled high levels may result in technological defects or may lead to public health hazards. Therefore, the current study was planned to investigate the levels of moisture, salt, nitrites and phosphates in sausage, beef burger, luncheon and frankfurter marketed in Beni-Suef Governorate and to compare their levels with the national and international standards, as well as, to study the effect of frying and steaming on the levels of these additives in fresh sausage.

2. MATERIAL AND METHODS

2.1. Samples collection

A total of 80 random samples of some meat products represented by beef burger, luncheon, frankfurter and sausage (20 each) were collected from different supermarkets in Beni-suef Governorate. The collected samples were aseptically transferred in an insulated ice box to the laboratory of Food Hygiene and control, Faculty of Veterinary Medicine, Beni-Suef University without undue delay to determine their chemical profiles. Samples of sausage, burger, and frankfurter were purchased in their packages (about 400 g each), while luncheon samples were purchased sliced (about 250g). The collected samples were kept frozen at -18°C and analyzed for their moisture, salt, nitrite and phosphate contents in not more than 5 days of collection. All chemicals used in the current study were purchased from Sigma and El-Gomhouria Company, Egypt.

2.2. Detection of moisture (AOAC, 2002)

The sample was minced by passing it through food blender (Moulinex Dpa241 France) then thoroughly mixed (the casing of fresh sausage was removed before mincing). Ten grams of the sample were placed in covered aluminum dish and dried in the oven (Heraeus, Germany) for 16 – 18 hours at 101 $\pm$ 2 °C, then cooled in desiccator and weighed. The loss in weight was reported as moisture content.

2. 3. Detection of sodium chloride content

The titration method of **AOAC (2002)** was applied, the sample was digested using 0.1N AgNO3 solution and 15 ml of conc. HNO3. The excess of 0.1N AgNO3 was titrated against 0.1N ammonium thiocyanate using ferric alum as indicator.

2.4. Detection of nitrite

Residual nitrites were determined using the spectrophotometric method prescribed by **AOAC (2002):** Briefly, ten grams of finely comminuted, thoroughly mixed sample were deproteinized using saturated borax solution. A series of nitrites standard solution were prepared. For colour development, sulphanilamide ($NH_2C_6H_4SO_2NH_2$) and N-1-naphthylethylenediaminedihydrochloride ($C_{10}HNHCH_2.2HCl$) solutions were added to tested, standard nitrite solution and blank samples. The absorbance of the solutions (standard and tested samples) was measured spectrophotometrically (Unico-UV-2100 spectrophotometer, USA) at 538 nm against the blank. The nitrite content of the sample expressed as milligrams of sodium nitrite per kilogram (ppm).

2.5. Detection of phosphate (AOAC, 20002)

Five grams of the thoroughly mixed minced sample was burned in muffle furnace then 10 ml of HNO_3 (1:2 in water) was added. Then coloring reagent consists ofHNO_3 + Ammonium monovandate solution +Ammonium heptamolybdate were added and allowed 2 be stand for 15 minutes. The absorbance of the solution is measured spectrophotometrically against the blank at wave length of 540nm. A series of Standard solutions containing different phosphate concentrations were prepared and treated as the tested sample. The calibration curve was drawn by plotting the measured absorbencies against the concentrations in micrograms per milliliter of the standard solutions.

2.6. Effects of frying and steaming on the chemical composition of fresh sausage

A total of 30 fresh sausage samples were analyzed for their moisture, sodium chloride, nitrite and phosphate contents. Before analysis every sausage finger is cut into 3 equal parts (about 20 mm long). Each sample was divided into 3 parts; the first is analyzed raw, while the second and third were cooked by both frying and steaming then analyzed again for the same chemical parameters. Frying was done in a shallow frying pan using sunflower oil till well done (about 6 min; 3 min on each side). Steaming also was carried out till well done (about 24 – 28 min.).

2.6. Statistical analysis

Means were compared at significance level of 0.05 by Analysis of variance (ANOVA) using SPSS 17.0 for windows (SPSS Inc, Chicago, IL, USA)

3. RESULTS

The mean values of moisture % in the examined meat product samples were 63.90±2.57 for beef burger, 60.76±2.98 for beef luncheon, 54.34±2.71 for sausage and 58.14±2.99 for frankfurter (Table 1). Also, results in Table (2) showed that the mean values of sodium chloride% in the examined samples were 3.95±0.21**,** 4.21±0.08, 4.33±0.05 and 3.9±0.27 for fresh sausage, beef burger, luncheon and frankfurter, respectively.

Table 1 Moisture (%) in examined meat products (n=20).

Meat product	Min	Max	Mean± S.E	Un acceptable samples (EOS)*	
				No	%
sausage	35.4	64.4	54.34±2.71[a]	3	15
burger	56.4	76.0	63.90±2.57[b]	16	80
luncheon	55.1	68.9	60.76±2.98[b]	8	40
frankfurter	53.6	63.1	58.14±2.99[ab]	8	40

Results expressed as mean± S.E. Means with different superscript are significantly different at $p\leq 0.05$. *EOS (2005) recommended 60% moisture in meat products.

Table 2 Sodium chloride (%) in examined meat products (n-20).

Meat product	Min	Max	Mean± S.E	Un acceptable Samples (EOS)		Un acceptable Samples (WHO)	
				No	%	No	%
sausage	1.8	5.57	3.95±0.21[a]	2	10	2	10
burger	3.8	4.73	4.21±0.08[a]	0	0	0	0
luncheon	4	4.6	4.33±0.05[a]	0	0	0	0
frankfurter	1.8	5.57	3.90±0.27[a]	2	10	2	10

Results expressed as mean± S.E. Similar superscript indicates no significant at $p \leq 0.05$. OS (2005) and FAO/ WHO (1991) recommended 5% salt in meat product

Moreover, the mean values of residual nitrite (ppm) in the examined meat product samples were 82±14.51 for sausage, 45±6.44 for beef burger, 69±15.4 for luncheon, and 114±29.99for frankfurter (Table 3). Additionally, the mean values of phosphate in the examined meat products samples of fresh sausage, beef burger, luncheon and frankfurter were 1821±307, 1638±209, 1451±142 and 2221±215ppm, respectively (Table 4). It is important to point out that there was significant difference ($P\leq 0.05$) between the examined meat products (sausage, luncheon, frankfurter and burger) in relation to moisture content, however, salt, nitrite and phosphate contents were not significantly different at $P\leq 0.05$.

Table 3 Nitrite (ppm) in examined meat products (n=20).

Meat product	Min	Max	Mean± S.E	Un acceptable Samples (ESS)		Un acceptable Samples (WHO)	
				No	%	No	%
sausage	20	363	82±14.51[a]	3	15	3	15
burger	16	100	45±6.44[a]	1	5	0	0
luncheon	4	150	69±15.4[a]	4	20	3	15
frankfurter	40	430	114±29.99[a]	3	15	3	15

Results expressed as mean± S.E. Similar superscript indicates no significant at $p \leq 0.05$. EOS (2005) recommended nitrite content not more than 100 ppm.FAO/WHO (1991) recommended nitrite content not more than 125 ppm.

Table 4 Phosphates (ppm) in examined meat products (n=20).

Meat product	Min	Max	Mean± S.E	Un acceptable Samples (EOS)		Un acceptable Samples (C.A)	
				No	%	No	%
sausage	440	4695	1821±307	2	10	0	0
burger	530	3556	1638±209	4	20	0	0
luncheon	450	2282	1451±142	0	0	0	0
frankfurter	580	3350	2221±215	3	15	3	15

Results expressed as mean± S.E. Similar superscript indicates no significant at $p \leq 0.05$. EOS (2005) recommended phosphate content not more than 3000 ppm. FAO/WHO (1991) recommended phosphate content not more than 5000 ppm in burger and sausage, and not more than 3000ppm in luncheon and frankfurter.

On the other hand, the effect of cooking on chemical composition of fresh sausage showed in Table (5), where, nitrite contents significantly ($P\leq 0.05$) decreased from 24.7±2.2 in raw sausage to 18.3±1.4 and 17.1±1.5ppm in fried and steamed sausage, respectively. Similarly, Frying and steaming reduce moisture, salt and phosphate contents, but this reduction was not significant at ($P\leq 0.05$).

Table 5 Effect frying and steaming on chemical composition of sausage (n= 30).

Items	Sausage		
	Raw	Fried	Steamed
Nitrite (ppm)	24.7±2.2[a]	18.3±1.4[b]	17.1±1.5[b]
Phosphate(ppm)	1752±121[a]	1521±128[a]	1627±79[a]
Moisture%	55.23±0.6[a]	49.26±0.8[a]	51.8±3.1[a]
Salt%	3.9±1.4[a]	3.5±2.2[a]	3.6±0.9[a]

Results expressed as mean± S.E. Means with different superscript are significantly different at $p\leq 0.05$.

4. DISCUSSION

Water constitutes about 75% of muscle meat. It is a constant ingredient in meat processing with multifunctional properties. Results in table (2) showed that 3 (15%), 16 (80%), 9 (40%) and 8(40%) of sausage, burger, luncheon and frankfurter samples exceeded the permissible limits (60%) for moisture recommended by EOS (2005).

The moisture contents of meat products investigated by many authors. In this respect, Selim et al (2015) recoded mean values of about 55%, and 60% for moisture in luncheon and sausage marketed in Mansoura, Egypt. Moreover, Elbazidy et al. (2017) investigated 800 types of traditional Egyptian beef luncheon produced by eight different meat processing plants in which the mean values of moisture content ranged from 47.77±1.28 to 57.72±0.43. However, Ahmed et al (2020) recorded slightly higher results in sausage and luncheon marketed in Ismalia, Egypt, with mean values of 62.66 and 61.02%, respectively. On the other hand, Liguori et al. (2015) recorded lower results (27 - 41.2%) for three types of fermented sausage produced by Calabria region, Italy. Furthermore, variable results in 3 classes of luncheon (according to their prices) marketed in Qena, Egypt were detected by Maky et al. (2020), who found that the average moisture percentage was 64.52% ± 0.31%, 56.97% ± 0.69%, and 59.58% ± 0.66% for classes A, B, and C, respectively.

The variation in the moisture content of the examined samples is related to the amount of lean meat, and fat percentage used in meat processing. It is also mainly attributed to the amount of added water, sodium chloride, pH of meat. Moreover, levels of moisture in meat products also affected by the temperature, duration and method of cooking (Serrano et al., 2007; Gerber et al., 2009).

Data in Table (2) showed that 10%of sausage and frankfurter samples exceeded the permissible limits (5%) of EOS (2005) and FAO/ WHO/ (1991) for sodium chloride, while none of luncheon and burger samples exceeded this limit. Lower results in sausages were detected by Gab-Allah and Shalaby (2001) and Abdel-Atty (2005). However, Saad et al. (2018) detected salt contents of 3.07 ± 0.37, 1.91 ± 0.28, 3.30 ± 0.39, 2.75 ± 0.32 in sausage, beef burger, luncheon and frankfurter, respectively.

Salt is incorporated during meat processing either as dry powder or dissolved in water with other indigents (pickle or marinade). Salt contributes to flavor and acts as preservatives for processed meat. It also solubilizes and extracts myofibril proteins (Xiong, 2012). However, salt is a pro-oxidant that enhances rancidity. Also, higher daily intake of sodium is related to hypertension and heart diseases (Aburto et al., 2013). Mostly, 77% of salt intake by human comes from processed foods (Ruusunen and Puolanne, 2005). Therefore, the WHO (2012) recommended 5g/day salt as the maximum daily intake by adult human.

Data in Table (3) showed that 3(15%) of sausage, luncheon and frankfurter exceeded the permissible limits (125ppm) of nitrite recommended by FAO/WHO / (1991), while, all burger samples had nitrite content within the permissible values. In this respect, Jackson et al. (2011) concluded that nitrites levels in frankfurters ranged from 1 ppm to 65 ppm. However, Rezaeia et al. (2013) found that the residual nitrite in hamburgers sold in Arak city, Iran, ranged from 30 to 100 mg/kg. Additionally, Saad et al. (2018) found that the mean levels of nitrite in sausage, beef burger, luncheon and frankfurter were 67.73 ± 3.48, 46.75 ± 2.33, 79.40 ± 3.52 and 59.29 ± 3.10ppm, respectively.

Phosphates are not considered as direct preservatives, they only can enhance some desirable properties when used as acidulates or in combination with other food ingredients (Long et al., 2011).

Data in Table (4) showed that all the examined samples of meat products did not exceed 5000ppm phosphate, while 2 (10%),4 (20%) and 3 (15%) of sausage, burger and frankfurter exceeded3000ppm, respectively.

Phosphates in meat products had been assessed by many researchers. In this respect, Salim and Abou El-Roos (2013) in Minufia, Egypt recorded 0.4 ± 0.019 and 0.53 ± 0.020 as mean values of phosphate in burger and canned sausage, Moreover, Dimitrovska et al. (2019) in north Macedonian market found that about 64% of raw beef and pork products exceeded 5000ppm (0.5%). Furthermore, Koricanac et al. (2015) measured phosphates in 701 samples of different cooked sausages in Serbia and found that the most common range (33.38%) was 4.01-5.00 g/kg.

Sodium chloride content of cooked sausage could be reduced by 1.4% through addition of phosphates without affecting the water holding capacity of higher salt concentration (Ruusunen and Puolanne, 2005). Phosphates also reduce the pro-oxidant activity of NaCl, therefore their addition is important to reduce rancidity and warmed-over flavor in processed meat products (Vasavada et al., 2006).

Results in Table (5) indicated that frying and steaming had significantly reduced nitrite content in fresh sausage at $P<0.05$. Similar findings for traditional dry fermented sausage (sucuk) in Turkey were reported by Kurt and Zorba (2010) and Toptanci and Ercoşkun (2017). Moreover, Paudel et al. (2021) in Dharan city, Nepal concluded that frying and boiling reduce the residual nitrite level in sausages with greater reduction by boiling at 100°C for 15 min. The reduction of nitrite residual levels due to cooking may be attributed to the reaction of sodium nitrite with various constituents in the complex biological systems of meat which is probably accelerated by further heat treatment (Ercoşkun, 2006). Moreover, cooking may result in higher levels of N-nitrosamines due to reaction of nitrite with secondary amines in meat (Li et al., 2012).

Also, frying and steaming reduced moisture, sodium chloride and phosphate content of sausage, but this reduction was not significantly different at $P\leq 0.05$. The reduction in water content obtained in the current study were in good agreement with Liao at al. (2010) in chicken and duck breast and Li et al. (2012) in dry cured sausage. The reduction in sodium chloride and phosphate obtained in this study may be follow the loss of moisture due to cooking. In this respect, Serrano et al. (2007) concluded that cooking results in water evaporation from the sausage surface and the amount of water losses depends up on cooking temperature, amount of added water, pH, and amount of red meat in the formula.

5. CONCLUSION

Results of the current study demonstrated that nitrites residual level in sausage was significantly increased by frying and steaming, while moisture and sodium chloride significantly reduced. Additionally, 10% of both sausage and frankfurter exceeded the permissible limits of EOS in relation to salt content, while 15, 5, 20 and 15% of sausage, burger, luncheon and frankfurter exceeded the limits of nitrite, respectively. Therefore, a national large scale prescheduled surveys for the proximate chemical analysis and for detection of the levels of chemical additives in various meat products is always required.

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