ORIGINAL ARTICLES

Effect of Nitrite Level and Tea Catechins on Residual Nitrite and Quality Indices of Raw-Cured Sausages

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ABSTRACT

Cured-sausages were prepared with different concentration of NaNO₂ (75, 100 and 125 ppm), combined or not with 300 mg kg⁻¹ tea catechins. Proximate composition, TBARS, TVBN, pH values, color measurements (L*, a* and b* values) and residual nitrite level of samples were evaluated one day after processing and after 10, 20 and 30 days of chilling storage at 3-5°C. Results indicated that nitrite is very effective to enhance the formation of typical red color, delay the oxidative rancidity and prevent microbial decomposition in cured sausages during chilling study as shown by consistently lower and acceptable values of TBARS, TVBN and pH values. The originally added nitrite seems to have little influence on proximate composition and the acidity (pH values) of meat sausages. However, the higher its value, the higher the level remained as residual with the best color values and reversely were the lower TVBN and TBARS values. Results also indicated that about 50% of the ingoing nitrite can be analyzed in the samples after processing. Moreover, residual nitrite level also declined during chilling storage of sausages. The use of tea catechins in combination with nitrite for dry-cured sausages was more effective in keeping the quality and safety of refrigerated consumer products as indicated by attractive red color and lower residual nitrite levels, TBAR and TVBN values as compared to samples treated with nitrite.

Key words: cured-meat, residual nitrite, quality, tea catechins.

Introduction

Dry-cured meat products either raw (oriental sausages and pastirma) or cooked (luncheon and frankfurter) manufactures is a major industry in Egypt. Nitrite and nitrate play an important role on the safety and quality of cured meat products (Viuda-Martos et al., 2009). Sodium or potassium nitrite is widely used as a curing agent in cured meat products because it inhibits outgrowth and neurotoxin formation by Clostridium botulinum, delays the development of oxidative rancidity, develops the characteristics flavor of cured meats, and reacts with myoglobin and stabilizes the red meat color (Yetim et al., 2006 and Gotterup et al., 2008).

Although the preservatives which are permitted in foods are considered to be without potential adverse effects there have been concerns about the safety of nitrates. Nitrite in high concentrations, is undoubtedly toxic to human (Van Loon, 1998). Nitrite, also can react with secondary and tertiary amines to form carcinogenic compounds called nitrosamines (Choi et al., 2007). Furthermore, a relation has been suggested between the ingestion of N-nitroso compounds and the occurrence of childhood leukemia, brain tumors, and colorectal cancer (Demeyer et al., 2008).

Nitrite is consumed in the diet, through vegetables, drinking water and cured-meat products (raw or cooked), the potential risks of this practice are balanced against the unique protective against toxin-forming bacteria. Although some alternatives to the use of nitrite and nitrate in meat processing have been proposed, they are hard to replace the antibotulinal effects of them (Cammack et al., 1999, Viuda-Martos et al., 2009).

On the other hand, nitrite added to meat for the purpose of curing, can be partially recovered in the finished products as residual nitrite. As soon as nitrite is added in the meat formulations it starts to combine with pigments or undergo other reactions. The amount detectable diminishes rapidly. In general, 50-70% of the ingoing nitrite can be analyzed in the product immediately after its is formulated. In addition, residual nitrite is greatly reduced by heating process and continues to decline during subsequent storage of cured meat products (Cassens, 1997). However, the rate of residual nitrite depletion is dependent upon various factors, such as pH, initial nitrite level, processing and storage temperatures, and the presence of reductants (Tanwisuit and Peuchkamut, 2011).

Health concerns relating to the use of nitrates and nitrites in cured-meats (raw and cooked), trend towards decreased usage to alleviate the potential risk to the consumers from formation of carcinogenic compounds. Recently, some new ingredients principally agro-industrial co-products, particularly from the citrus industry are
seem as good source of bio-compounds that may help to reduce the residual nitrite level in meat products (Fernandez-Lopez et al., 2007; Viuda-Martos et al., 2009).

In view of the possible risk of toxicity and carcinogenesis, the amount of nitrates added to meat products is progressively being restricted. Nitrite rather than nitrates tends to be added to foods, and in the lowest concentrations consistent with food safety (EFSA, 2010). However, it has been observed that the incorporation of sodium ascorbate (SA) and water plant extracts from red pepper, rosemary, thyme and green tea, can prevent lipid oxidation, improve color and flavor, reduce biogenic amines (BAs) and can also prolong the shelf life of foods (Mitsumoto et al., 2005; Lui et al., 2010; Abu-Salem et al., 2011 and Vuong et al., 2011).

Therefore, our objective in this article is to study the effect of ingoing nitrite concentration (75, 100 and 125 mgkg$^{-1}$ meat) combined or not with 300 mg kg$^{-1}$ tea catechins (TC) on residual nitrite level and some quality attributes (TBARS, TVBN, pH and color measurements), of raw dry cured beef sausages, one day after processing and after 10, 20 and 30 days of chilling storage at 3-5°C.

Materials and Methods

Frozen beef, cattle fat, mutton casings, salt, spices, garlic, and potato starch were purchased from a local markets at Giza. Tea Catechins (T.C) purity of >80%, were extracted from green tea (Camellia sinensis L.), using 30% ethanol solution and supplied by king Long Natural Plant Products Industry Ltd. Changsha, Hunan, China. The tea catechins contained epigallocatechin gallate (EGCG-40%), epigallocatechin (EGC-24%), epicatechin gallate (ECG/12%) and epicatechin (EC/10%), according to the analytical results by HPLC (Wang et al., 1991).

Sausage Manufacture:

Samples were prepared according to a traditional formulation, starts by cutting beef and cattle fat (after thawing), to small pieces (2-3 cm$^3$), then minced individually through a 8-mm plates (coarse), minced meat and fat portions needed to formulate 2 kg sausage from each group were mixed together with ice flakes (10%) reground through a 6-mm plate for 1 min to insure uniform meat (68.5%) with fat level (15%), after formulating process, the original mixture was split into 5 batches (explained in detail later in experimental design) to which curing mixture (salt, 2.2%, black pepper 0.5%, red pepper 0.25%, sodium ascorbate 0.05%, sodium nitrite at different concentration (75, 100 and 125 ppm), and tea catechins 300 ppm) was added separately. After curing samples from different batches were ground again (3 mm plates) to form meat emulsion. By the end of emulsion process potato starch (3%) was added and reground for 3 minutes and stored overnight at 3-5°C. Then each batch was stuffed separately (perfect filling) into previously cleaned and prepared mutton casings. The rounds had been tight into fingers, rinsed in diluted vinegar solution as a decontaminator, packed separately in polyethylene bags, and chilled at 3-5°C for 1, 10, 20 and 30 days.

Experimental Design:

In practice, oriental sausage produced in Egypt were consumed within couple of days after processing or marketed frozen no effective replacment for nitrate addition to cured meat product. However, we conducted experiments in meat system in order to establish the effect of ingoing nitrite concentration, combined or not with tea catechins (TC) on residual nitrite level and some quality attributes, over processing and chilling storage. Generally the different sausage formulas under investigation were:

1) Control (75 mg Na NO$_2$ kg$^{-1}$ meat).
2) $T_1$ (100 mg Na NO$_2$ kg$^{-1}$ meat).
3) $T_2$ (125 mg Na NO$_2$ kg$^{-1}$ meat).
4) $T_3$ (100 mg Na NO$_2$ plus 300 mg TC. kg$^{-1}$ meat).
5) $T_4$ (125 mg Na NO$_2$ plus 300 mg TC. kg$^{-1}$ meat).

Analytical Methods:

Chemical analysis was performed at least in duplicate on finely ground samples, after removal of separated drip, while color measurements was applied three measurements over sausage surface on each side to compute mean scores for $L^*$, $a^*$ and $b^*$ values. The analysis was performed one day after processing and after 10, 20 and 30 days of chilling storage.
Chemical Analysis:

Residual nitrite level of raw sausages was determined as mg NaNO₂ kg⁻¹ meat by a spectrophotometer method at 540 n.m as described in AOAC, (1995). Proximate analysis of meat and sausage samples were measured by the methods of AOAC (1995), results were expressed as moisture %, protein %, fat% and ash% contents. Feder value was calculated as moisture/protein ratio, according to Pearson (1981). Lipid oxidation was assessed by 2-TBA method of Vyncke (1975). Thiobarbituric acid reactive substances (TBARS) values were expressed as mg MA/kg sample. Protein deterioration was studied by determination of total volatile basic nitrogen (TVBN) as mg N/100g flesh, according to Pearson (1981).

Physico-Chemical Analysis:

PH value of sausages was determined according to the method of Fernandez-Lopez et al., (2007), using pH meter (Hanna, HI, 9021).

Color Measurements:

Lightness (L*), redness (a*) and yellowness (b*) values were measured using a Hunter Lab Scan XE Colorimeter (Hunter Laboratory INC. Restonva). An average of three measurements over sausage samples on each side to compute mean scores for each of the color parameter.

Results and Discussion

Frozen Beef Analysis:

Frozen meat used in this study was analyzed before processing for its proximate and freshness tests, the analysis exhibit that moisture, protein, fat and ash contents of frozen beef were 73.4, 20.2, 4.9 and 1.02%; respectively. In addition TBARS (0.318 mg MA/kg meat), TVBN (10.7 mg N/100g flesh), and pH value of 5.86 (Table 1). The results indicated that raw frozen beef was normal meat without defect and had high quality indices, which affect to a great extent the quality of beef sausages under investigation.

Table 1: Frozen meat analysis (on fresh weight basis):

<table>
<thead>
<tr>
<th>Moisture</th>
<th>Protein</th>
<th>Fat</th>
<th>Ash</th>
<th>TBARS</th>
<th>TVRN</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>73.4%</td>
<td>20.2%</td>
<td>4.9%</td>
<td>1.02%</td>
<td>0.318 mg MA.Kg⁻¹ meat</td>
<td>10.7 mgN/100g flesh</td>
<td>5.86</td>
</tr>
</tbody>
</table>

Sausage Composition:

Proximate composition and Feder values of sausages samples are present in table 2, data showed that control sausage samples after one day of processing contained 62.9% moisture, 16.1% protein, 18.1% fat and 1.8% ash. In this concern, Pereira et al., (2000) reported that most sausage formulas fall within the following specification: moisture 50-70%, protein 11-15%, fat 15-30%, and ash contents 1.5-2.8% (on fresh weight basis). However, sausage samples (Table 2) composition are typical for high protein, low ash sausage formulations, moisture and fat fell in the middle of the expected range.

Referring to data in Table 2, it is obvious that all sausage samples exhibit nearly similar composition, the increase in going nitrite concentration and the inclusion of tea catechins had little effect on the proximate analysis. Similar finding was achieved by Perez-Rodriguez et al., (1996) in frankfurter –type sausages.

Table 2: Proximate analysis and feder values of sausage during chilling storage (on fresh weight basis):

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Moisture %</th>
<th>Protein%</th>
<th>Fat%</th>
<th>Ash%</th>
<th>Feder Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>62.9</td>
<td>16.1</td>
<td>18.1</td>
<td>1.8</td>
<td>3.90</td>
</tr>
<tr>
<td>T1</td>
<td>62.4</td>
<td>15.9</td>
<td>17.8</td>
<td>1.9</td>
<td>3.92</td>
</tr>
<tr>
<td>T2</td>
<td>62.8</td>
<td>16.0</td>
<td>18.0</td>
<td>1.7</td>
<td>3.93</td>
</tr>
<tr>
<td>T3</td>
<td>62.6</td>
<td>15.8</td>
<td>18.3</td>
<td>1.8</td>
<td>3.96</td>
</tr>
<tr>
<td>T4</td>
<td>63.0</td>
<td>16.0</td>
<td>18.2</td>
<td>1.9</td>
<td>3.94</td>
</tr>
</tbody>
</table>

From the same given results of Table 2, it is evident that all sausage samples exhibit good quality even after 30 days of chilling storage, since their proximate within the permissible limit ES(1972-2005). Results in Table 2 also indicated that Feder value (moisture/protein) ratio were below 4, indicating good quality of sausage samples (Pearson, 1981).
**Ph Changes:**

PH values of sausage samples were illustrated in Fig. 1, from which it is apparent that pH values of control, T1, T2, T3 and T4 samples were 5.92, 5.87, 5.84, 5.89 and 5.91; respectively, after one day of sausage processing. Neither nitrite concentration nor tea catechins addition alter the acidity of sausage formulas, the pH values were approximately 5.88. Similar results were achieved in other sausages by Fernandez-Lopez et al., (2007) and Wojciak et al., (2011).

From the same given results illustrated in Fig. 1, it could be noticed that after 10 days of chilling storage pH values of sausages samples slightly decreased, which could be explained in the basis of formation of lactic acid (Viuda-Martos et al., 2009). After 20 days of chilling storage, all pH values of sausages increased reaching higher values than initially values after processing, by the end of chilling storage sausages samples exhibit higher values reaching 6.24, 6.15, 6.10, 6.12 and 6.07 for control, T1, T2, T3 and T4; receptively. However, the increase of pH value noticed during 20 and 30 days of chilling storage could be due to protein denaturation and/or accumulation of basic substance (Kemp et al., 1975).

![Fig. 1: pH changes during chilling storage.](image)

Data illustrated in Fig. 1, also showed that as the concentration of nitrite increased in the formula the pH values decreased. The addition of tea catechin kept the pH values at the lowest values as compared to T1 and T2. However, the pH values of sausage samples were below the critical limit value of 7.0 (Pearson, 1981) during chilling storage, which could be due to the ability of nitrite and/or tea catechin to inhibit or reduce the development of spoilage microorganisms (Yetim et al., 2006; Wojciak et al., 2011). Similar trend of pH evolution was observed in other cured sausages by Fernandez-Lopez et al., (2007).

**TVBN Changes:**

TVBN is the commonly used method assessing meat spoilage (Pearson, 1981). Table 3 shows the TVBN values of sausage samples during chilling storage, from which it could be noticed that control, T1, T2, T3 and T4 samples exhibit 12.4, 12.1, 11.8, 11.6 and 11.4 mgN/100 flesh; receptively which reflects high quality of raw meat and good conditions during processing. During the chilling storage, TVBN values of all samples, gradually increased as the time of chilling progressed with lower rates in treated samples as compared to control samples. Similar trend of changes was observed in cured sausages treated with nitrite and/or plant extract. (Fernandez-Lopez et al., 2007; Wojciak et al., 2011).

By examining data of Table 3, it is clear that by the end of refrigerated storage (30 days), the TVBN of control, T1, T2, T3 and T4 reached 18.9, 17.0, 16.3, 16.5 and 15.1 mgN/100 flesh; respectively. It is apparent from the same given results that as the concentration of nitrite increased the TVBN of sausages decreased. This indicated that nitrite alone or in combination with tea catechins posses antimicrobial properties and reduced the accumulation of basic substances results from bacterial activity. Similar results were achieved by Choi et al., (2003) in cured sausages treated with nitrite and/or green tea. These results (Table 3) confirmed our finding on pH measurements. However, total volatile basic nitrogen of all samples were accepted and below the critical limit value of 20 mg N/100g flesh, as recommended by the ES (1972-2005).

### Table 3: TVBN Changes During Chilling storage (as mg N/100 g flesh, on fresh weight basis).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>(1) day</th>
<th>10 days</th>
<th>20 days</th>
<th>30 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>12.4</td>
<td>13.8</td>
<td>15.6</td>
<td>18.9</td>
</tr>
<tr>
<td>T1</td>
<td>12.1</td>
<td>13.0</td>
<td>14.8</td>
<td>17.0</td>
</tr>
<tr>
<td>T2</td>
<td>11.8</td>
<td>12.4</td>
<td>14.0</td>
<td>16.3</td>
</tr>
<tr>
<td>T3</td>
<td>11.6</td>
<td>12.4</td>
<td>13.6</td>
<td>16.5</td>
</tr>
<tr>
<td>T4</td>
<td>11.4</td>
<td>12.0</td>
<td>13.2</td>
<td>15.1</td>
</tr>
</tbody>
</table>
Lipid Oxidation:

TBARS values of sausage samples were illustrated in Fig. 2, from which it is apparent that after one day of processing the control samples exhibit 0.480 mg MA/kg meat. From data presented in Table 1 and Fig. 2 it is apparent that sausage processing including mincing, mixing with the salt appear to be pro-oxidant. From the same given results in Fig. 2, it is evident that control samples exhibit the highest TBARS values initially and at any given time of chilling storage as compared to treated samples. Also, as the concentration of nitrite were increased in the formula the TBARS of their sausages were decreased. In addition, inclusion of tea catechins in the formula exhibit the highest oxidative stability during chilling storage, as shown by the consistently lower TBARS values. This could be due to the ability of nitrite and/or tea catechins to delay the development of oxidative rancidity (Sanz et al., 1997; Tang et al., 2001 and Choi et al., 2003).

From the same given results illustrated in Fig. 2, it is clear that all sausage samples exhibit quite low and acceptable TBARS values (less than 0.9 mg MA kg⁻¹ meat) even after 30 day of chilling study. These results confirmed the finding of Fernandez-Lopez et al., (2007) and Wojciak et al., (2011) in their framework on cured sausages. In this concern, Sebranek and Bacus, (2007) reported that nitrite is effective at relatively low concentration. Yetim et al., (2006) came to the conclusion that 100 mg/kg of nitrite reduced TBA values by 78%, while Deba et al., (2007) reported that 150 ppm of nitrite reduced TBA values by 43% in frankfurters.

![Fig. 2: TBARS values changes during chilling storage (as mg MA. Kg⁻¹ meat, on fresh weight basis).](image)

Color Measurements:

The color of meat products is determined by a combination of different factors including moisture and fat content, but more important is the chemical form and concentration of the hemoproteins, especially that of myoglobin (Perez-Alvarez and Fernandez-Lopez, 2006).

Hunter L*, a* and b* values of sausage samples are shown in Table 4, from which it could be noticed that, lightness (L*) values decreased during chilling storage, with a higher rate in control samples than treated samples. This could be explained in the basis of moisture losses, as expected in dry-cured sausages (Perez-Fernandez-Lopez et al., 2009).

From the same given results of Table 4, it is apparent that as the concentration of nitrite increased the redness of sausages increased. This increase could be due to nitrosomyoglobin formation and it was probably due to moisture loss, which provokes an increase in heme pigments concentration (Cammak et al., 1999). Redness (a*) values tend to decrease as the time of chilling progressed due to oxidation. However, the most important reason for adding nitrite to cured meat products is the formation of the typical red or pink color, which is particularly enhanced when nitrite is employed with reducing agent (ascorbate) that accelerate the reduction of nitrite into nitric oxide (NO), (Gottterup et al., 2008).

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Time day</th>
<th>Control</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
</tr>
</thead>
<tbody>
<tr>
<td>L*</td>
<td>1</td>
<td>49.6</td>
<td>49.8</td>
<td>50.2</td>
<td>50.6</td>
<td>51.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>46.4</td>
<td>48.3</td>
<td>49.5</td>
<td>50.1</td>
<td>50.7</td>
<td></td>
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<tr>
<td></td>
<td>20</td>
<td>44.8</td>
<td>47.0</td>
<td>48.1</td>
<td>49.6</td>
<td>50.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>41.8</td>
<td>45.6</td>
<td>46.4</td>
<td>47.3</td>
<td>48.5</td>
<td></td>
</tr>
<tr>
<td>a*</td>
<td>1</td>
<td>7.3</td>
<td>9.2</td>
<td>9.6</td>
<td>10.0</td>
<td>10.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>6.2</td>
<td>9.5</td>
<td>10.0</td>
<td>10.8</td>
<td>11.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>5.8</td>
<td>8.3</td>
<td>8.5</td>
<td>9.4</td>
<td>10.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>4.7</td>
<td>6.8</td>
<td>7.3</td>
<td>8.1</td>
<td>8.5</td>
<td></td>
</tr>
<tr>
<td>b*</td>
<td>1</td>
<td>12.6</td>
<td>13.4</td>
<td>13.8</td>
<td>14.0</td>
<td>14.6</td>
<td></td>
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<tr>
<td></td>
<td>10</td>
<td>11.5</td>
<td>12.6</td>
<td>13.2</td>
<td>13.9</td>
<td>13.7</td>
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<td>20</td>
<td>10.2</td>
<td>11.8</td>
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<td></td>
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<tr>
<td></td>
<td>30</td>
<td>9.4</td>
<td>10.7</td>
<td>11.4</td>
<td>12.0</td>
<td>12.8</td>
<td></td>
</tr>
</tbody>
</table>
By examining data of Table 4 also indicated that inclusion of tea catechins in sausage formula protect sausage from lipid and pigment oxidation and hence exhibit the lower deterioration effect during chilling storage. Similar results were achieved by Choi et al., (2003) and Wojciak et al., (2011).

Referring to Table 4 it is evident that yellowness (b*) values decreased during the chilling study. The highest b* values were observed in sausage treated with nitrite in combination with 300 mg kg⁻¹ tea catechins. However, the decrease in b* values during chilling could be related to the modification in myoglobin stages (Fernandez-Lopez et al., 2009).

Residual Nitrite Level:

Residual nitrite level (ppm) of raw cured sausage samples were illustrated in Fig. 3, from which it could be noticed that residual nitrite level of control, T1, T2, T3 and T4 samples, one day after processing were 41.13, 53.61, 65.28, 47.53 and 59.10 ppm; respectively. The results indicated that about 50% of added nitrite could be detected as NaNO₂ in the product after processing. Similar results were achieved in frankfurter type sausages by Perez-Rodriguez et al., (1996). It is worth to mention that, nitrate and nitrite occur in the diet from numerous different sources (Cammack et al., 1999). Vegetables are a major source of nitrate, for example 1000 mg/Kg for leaf vegetables such as lettuce, and 200 mg/Kg in root vegetables such as potatoes. Water and seasoning could also be other sources of nitrite and nitrate (Van Loon, 1998).

Fig. 3: Residual nitrite level (ppm) during chilling storage of raw cured sausages (on fresh weight basis).

In this concern, Cassens et al., (1976) came to the conclusion that, most of the added nitrite is present in meat as nitric oxide (NO) bound with myaglobin (5-15%), sulphydryl group (5-15%), lipid (1-5%) and protein (20-30%), therefore, less than 50% of the amount added can be chemically analyzed after processing.

Concerning residual nitrite level, Zahran and Kassem (2011) reported that raw dry-cured sausages produced in Egypt (during second half of 2010) exhibit level ranging from 10.45 to 100.36 ppm. While Sen and Baddoo (1997) reported that the average level of nitrite (as NaNO₂) in cured-meat products are in the range 40–100 ppm.

From the same given results illustrated in Fig 3, it could be observed that added nitrite concentration seems to have a remarkable influence, the higher was its level, the higher was residual nitrite level. These results are in agreement with the findings of Perez-Rodriguez et al., (1996), and Cammack et al., (1999).

From the same given results of Fig. 3, it is apparent that incorporation of tea catechins with nitrite (T3 and T4) exhibit lower level residual nitrite, initially and during chilling storage, as compared to T1 and T2. This could be due to the high reactivity of nitrite allowed its reactions with active biocompounds (polyphenols) presented in tea catechins. Similar results were achieved in other cured meat products by Viuda-Martos et al., (2009); Lui et al., (2010), Abu-Salem et al., (2011) and Tanwisuit and Peuchkamut (2011).

As to the influence of chilling storage on residual nitrite level of sausage samples Fig. 3, also indicated that nitrite declined slowly during the first 10 days, then nitrite was rapidly depleted after 20 days in all samples, and a fairly constant, low level was reached (Fig. 3). These results confirmed the findings of Cassens (1995), who reported that nitrite level declines further during storage. Similar trend of changes was observed by Perez-Rodriguez et al., (1996) and Fernandez-Lopez et al., (2007) in cured sausages.

In this concern, Tanwisuit and Peuchkamut (2011) reported that nitrite depletion is dependent upon various factors, such as pH, initial nitrite level, processing and storage temperatures and the presence of reductants.

Referring to Fig. 3 it is clear that the residual nitrite level of all sausage samples were found to be accepted and below the critical limit value of 100 ppm stated as the maximum permissible ESS (3597-2005). However, important losses of nitrite are expected due to-thermal processing normally used for cured-meat products should be born in mind (Cassens, 1997; and Fernandez-Lopez et al., 2007). However, further study is needed to evaluate the effect of cooking methods on residual nitrite level and nitrosamines formation in cured-meat products.
Conclusion:

An excessive intake of cured-meat products is not recommended from a health point of view. Based on the above mentioned results it could be concluded that nitrite can be used in the lowest concentration, combined with reductants (Sodium ascorbate) and active bio-compounds rich in polyphenols such as tea catechins (TC) as ingredient for dry-cured sausage that has a protective effect from oxidation and due to the decrease in TBARS, TVBN and residual nitrite level could prevent nitrosamines formation and hence, improve safety and quality of meat products.

References


