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Effect of Nitrite Substitution with Olive Leaves Extract on Color and Sensory Properties of Beef Mortadella

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Abstract

Six mortadella treatments were prepared for studying the effect of olive leaf extract (OLE) at a level of 240 mg OLE/100 g meat as nitrite alternative on the color and sensory characteristics. These treatments were: control with the addition of 120 ppm sodium nitrite only, and the second one with the addition of 240 mg OLE/100 g meat but without the addition of sodium nitrite as a negative control, the other four treatments were combination of 240 mg OLE/100 g meat with 80, 60, 40 and 20 ppm sodium nitrite, respectively. All samples were stored at 5 °C for 1, 3, 6, 9, and 12 weeks.

There were no significance differences ($P > 0.05$) between all mortadella treatments regarding their proximate parameters. Hunter lightness (*L*), redness (*a*), and yellowness (*b*) color, and sensory attributes including the appearance, color, tenderness, juiciness, flavor, and overall acceptability showed that 80 and 60 ppm nitrite in combination with OLE at 240 mg/100 g meat had the best results in comparison with the other four treatments indicating an additive combined effect of the OLE with nitrite that enhanced mortadella characteristics.

These results revealed the ability to substitute 50% of the used nitrite in mortadella stored at 5 °C when using combinations of 60 ppm nitrite with 240 mg OLE/100 g meat.

Keywords: beef mortadella, nitrite, olive leaves extract, color, senasory properties

1. Introduction

Mortadella is an emulsion meat product produced by chopping or comminuting one or more than one type of meat, which is seasoned and cured with sodium nitrite, and other ingredients such as soya protein, starch, salt, phosphate, ascorbate, ice-water and spices (Jordanian Standard JS: 816/2008).

To keep the product safe through the food chain is of great importance. Sodium nitrite is most commonly used. It retards the development of meat rancidity and unpleasant flavors and odors of meat during storage, also it is a very effective inhibitor of the growth of *Clostridium botulium*, the bacteria that causes botulism (Honikel, 2008), in addition to other pathogens and spoilage bacteria associated with the product. However, significant concerns exist because nitrite may react with amines and amino acids to produce *N*-nitrosamines, which are known to be a potential carcinogenic and mutagenic (Byun et al., 2004).

Therefore, there has been a growing interest in natural ingredients to be used in food and food products as preservatives instead of synthetic chemicals that may cause health hazards, because natural ingredients have greater application for increasing consumer acceptability, palatability, stability and shelf-life of food products. Consequently, search for natural additives, especially of plant origin, has notably increased in recent years (Naveena et al., 2008).

As the significance of functional foods is growing rapidly in food science, usage of whole olive leaf and olive leaf extracts has been increased rapidly in food industries as food additives and functional food materials. Ghanbari et al. (2012) found that, olive leaves have a valuable benefits over centuries. Due to many potentially compounds containing in olive leaves many other health benefits were also mentioned such as anti-atherogenic activity, inhibition of the changes of DNA bases caused by peroxinitrite, reduction of free radical production,

decrease oxidized LDL, anti-platelet aggregation, anti-inflammatory, antioxidant, antimicrobial, decrease production of aflatoxin, hypoglycaemic, hypocholesterolemic, anti-hypertensive and others. These potential health benefits are related to polyphenols and flavonoids (Ghanbari et al., 2012).

Therefore, the aim of this study was to evaluate the ability of production of mortadella with the addition of olive leaf extract at the level of 240 mg/100 g meat, as natural additive, and evaluating the color and sensory characteristics. And studying the possibility of complete or partial nitrite replacement by olive leaf extract in mortadella product.

2. Materials and Methods

2.1 Sampling of Olive Leaves

In March 2013, olive (Olea europaea) leaves were randomly and directly picked from an olive tree (*Baladi* variety) from local farm in Jarash. The trees were of about 25 years old, not irrigated and no phytosanitary treatments had been applied since 10 years ago. The leaves were collected at appropriate height around the whole perimeter of each tree. The collected samples were kept in plastic bags. Leaves were washed to remove impurities such as dust then dried in the dark at room temperature and then grounded (Moulinex Miller, France) (20 mesh).

2.2 Extraction of Olive Leaves

The ground leaves were extracted in ethanol (80% v/v) at 20% (w/v) concentration. The mixture was mixed on rotary shaker (New Brunswick Scientific, USA) for two hours which was fixed to 180 rpm at room temperature and then for 15 minutes in ultrasonic bath at 37 °C (Bandelin Electronic-RK-103 H, Germany). The mixture was filtered through Whatman no: 4 and then membrane filter (0.45 μm). The crude extract was obtained using a rotary evaporator (Büchi, RE 121, Switzerland) to remove solvent under reduced pressure at 38 °C, 120 rpm (Haddadin, 2010).

2.3 Mortadella Preparation and Quality Evaluation

2.3.1 Formulation of Mortadella Samples

Samples of mortadella were prepared at a local meat factory as described by Abdullah (2004). The composition is shown in Table 1. Frozen beef meat was tempered at 2 °C for 24 hours before processing. The tempered meat was coarsely ground, chopped and blended in two stages: first, ground meat was blended in a bowl chopper (Alpina, Geneva, Switzerland) at low speed for 2 minutes at a temperature of 0 °C. Sodium chloride (salt), ascorbate, sodium tripolyphosphate and ice-water were added and blended for 2 minutes at high speed, at this stage the temperature of the mixture reached 2 °C. Finally, starch, soya and spices were added and the mixture blended for 3 minutes at low speed, after which the temperature of the final meat blend was 8 °C. Immediately after chopping, the batter was loaded into a trolley and divided into six batches of fifteen kilograms, where sodium nitrite in different levels and olive leaf extract at the level of 240 mg/100 g meat, were added as in Table 2 and mixed to form the final treatments, these treatments were: the first treatment was a control with the addition of 120 ppm sodium nitrite only, and the second one with the addition of 240 mg OLE/100 g meat but without the addition of sodium nitrite as a negative control, the other four treatments were with 240 mg OLE/100 g meat per each and 80, 60, 40 and 20 ppm sodium nitrite, respectively. Then, the treatments were transferred to the filling machine (Handtmann, Biberach, Germany), loaded into the funnel of the machine and vacuum-stuffed into the polythene casing weighing 500 g and a diameter of 16 cm. The vacuum was created by a vacuum pump, which is constitutes part of the filling machine.

Mortadella batches were thermally cooked in a steam oven as follows:

1) Cooked at an oven temperature of 60 °C, achieved within the first 2 hours (internal product temperature 50 °C);

2) Oven temperature increased to 85 °C, achieved within the next 1 hours; and

3) Cooled in the oven (cold water spray) for 30 minutes, to decrease core temperature of mortadella to 55 °C.

The mortadella was removed from the oven to temper at room temperature for 2 hours, by which time a product temperature of 20 °C was reached, and then refrigerated, achieving a temperature of 5 °C within 2 hours. The cooked mortadella was retained in its original casing and held at 5 °C throughout the duration of the experiment. The freshly prepared and withdrawn mortadella after 1, 3, 6, 9 and 12 weeks were analyzed for the microbial and chemical properties.

Table 1. Composition of mortadella batter

Ingredients	Quantity (kg)
Meat	90
Starch	2.7
Soya	1.8
Sodium chloride	1.35
Ice-water	9
Spices	0.900
Sodium tripolyphosphate	0.045
Ascorbate	0.045

Table 2. Final mortadella treatments

Ingredients	120 ppm nitrite	240 mg OLE/ 100 g meat	240 mg OLE/100 g meat + 80 ppm nitrite	240 mg OLE/100 g meat + 60 ppm nitrite	240 mg OLE/100 g meat + 40 ppm nitrite	240 mg OLE/100 g meat + 20 ppm nitrite
Meat butter (kg)	15	15	15	15	15	15
Olive leaf extract (g)	0.0	36	36	36	36	36
Sodium nitrite (g)	1.80	0.0	1.20	0.90	0.60	0.30

2.3.2 Proximate Analyses

Samples after cooking were analyzed for moisture, fat, protein and ash contents according to AOAC (1995) in duplicate runs.

2.3.3 Determination of Product Color

Color measurements of the prepared and stored mortadella samples (*L*, *a* and *b* values) were obtained using a colourimeter Hunter Lab ColourFlex (Chroma Meter, CR-400, Konica Minolta, Sensing, INC., Japan). The instrument was standardized each time with a white and black ceramic plate (L_0 = 48, a_0 = -1.6 and b_0 = 8). The Hunter values of *L*, *a* and *b* values correspond to lightness (*L*), greenness (-*a*), redness (+*a*), blueness (-*b*) and yellowness (+*b*), respectively. The color measurements were performed on mortadella at room temperature (25±2 °C) in duplicate runs (Maskan, 2001).

2.3.4 Sensory Evaluation

The sensory quality of mortadella samples was assessed by 18 panelists chosen from the the Department of Nutrition and Food Technology, University of Jordan. The panelists were from both sexes, and from different ages, and familiarized with the questionnaire. The samples were evaluated for desirability in appearance, color, tenderness, flavor, juiciness and overall acceptability using a 9-hedonic scale test as described by Larmond (1991), varying from 9, which means like extremely to 1, which means dislike extremely. Pieces of bread and water were used to neutralize the taste between samples testing.

2.4 Statistical Analysis

Data were subjected to a one-way ANOVA, followed by a Least Significant Differences test at 95% confidence level (SAS Institute, 2007).

3. Results and Discussions

3.1 Proximate Analyses

There were no significant differences ($P > 0.05$) between all mortadella treatments regarding their proximate parameters. Moisture was ranged between 65.98-66.15%, protein 19.37-19.64%, fat 10.23-10.48%, and ash 2.11-2.18% for all treatments. These values are in accordance with the requirements of the emulsion type sausages standard specified by Jordanian Institution for Standards and Methodology (2008).

3.2 Determination of Product Color

Table 3 shows the lightness (*L*) values of mortadella treatments during storage periods. As reveals from these results, lightness increased significantly ($P \leq 0.05$) for all treatments as the storage time proceeded. Although, the lightness trend of the treatments was not steady, in general, combination treatments that contained OLE and

nitrite were lighter ($P \leq 0.05$) than of 120 ppm nitrite treatment or OLE treatment, individually.

Table 3. Changes in Hunter *L* (lightness) values of mortadella treatments during storage periods

Time (weeks)	120 ppm nitrite	240 mg OLE/ 100 g meat	240 mg OLE/100 g meat + 80 ppm nitrite	240 mg OLE/100 g meat + 60 ppm nitrite	240 mg OLE/100 g meat + 40 ppm nitrite	240 mg OLE/100 g meat + 20 ppm nitrite
0	$^{*d}50.56_{f**}$	$^{c}52.41_{e}$	$^{a}53.18_{d}$	$^{ab}53.02_{f}$	$^{b}52.75_{f}$	$^{b}52.89_{f}$
1	$^{d}51.62_{e}$	$^{c}53.06_{d}$	$^{ab}53.43_{d}$	$^{ab}53.44_{e}$	$^{a}53.63_{e}$	$^{bc}53.18_{e}$
3	$^{c}52.48_{d}$	$^{b}54.05_{c}$	$^{a}54.72_{c}$	$^{b}54.10_{d}$	$^{b}54.06_{d}$	$^{b}53.88_{d}$
6	$^{d}55.30_{c}$	$^{a}57.21_{b}$	$^{b}56.68_{b}$	$^{c}55.69_{c}$	$^{c}55.86_{c}$	$^{c}55.82_{c}$
9	$^{c}55.82_{b}$	$^{a}58.96_{a}$	$^{b}58.24_{a}$	$^{b}58.09_{b}$	$^{a}58.87_{a}$	$^{a}58.70_{a}$
12	$^{e}56.98_{a}$	$^{a}59.11_{a}$	$^{cd}58.13_{a}$	$^{b}58.58_{a}$	$^{bc}58.50_{b}$	$^{d}57.85_{b}$

Note. * Means within the same row with different superscript letters have significant differences between treatments using LSD ($p \leq 0.05$).

** Means within the same column with different subscript letters have significant differences between storage periods using LSD ($p \leq 0.05$).

Values of redness (*a*) are presented in Table 4. The highest ($P \leq 0.05$) reading of Hunter *a* at the beginning and during of the storage was seen in 120 ppm nitrite treatment, then in 80 ppm nitrite with OLE and 60 ppm nitrite with OLE treatments, respectively. The lowest ($P \leq 0.05$) redness values were observed in 240 mg OLE treatment without nitrite. As the nitrite concentration decreased *a* values decreased. This indicates the significance role of nitrite as a curing agent in developing of the pink red color of mortadella when converted to nitric oxide that combined with meat myoglobin and converted it to nitric oxide myoglobin. At the end of storage time, the redness was decreased significantly ($P \leq 0.05$) in all treatments.

Table 4. Changes in Hunter *a* (redness) values of mortadella treatments during storage

Time (weeks)	120 ppm nitrite	240 mg OLE/ 100 g meat	240 mg OLE/100 g meat + 80 ppm nitrite	240 mg OLE/100 g meat + 60 ppm nitrite	240 mg OLE/100 g meat + 40 ppm nitrite	240 mg OLE/100 g meat + 20 ppm nitrite
0	$^{*a}17.88_{a**}$	$^{f}7.59_{ab}$	$^{b}17.05_{a}$	$^{c}16.76_{a}$	$^{d}16.19_{a}$	$^{e}14.77_{a}$
1	$^{a}18.24_{a}$	$^{e}7.63_{a}$	$^{b}16.85_{ab}$	$^{b}16.62_{ab}$	$^{c}15.91_{b}$	$^{d}14.47_{b}$
3	$^{a}18.14_{a}$	$^{e}7.62_{a}$	$^{b}16.64_{b}$	$^{b}16.52_{b}$	$^{c}15.45_{c}$	$^{d}14.14_{c}$
6	$^{a}17.82_{a}$	$^{f}7.37_{b}$	$^{b}16.61_{b}$	$^{c}15.94_{c}$	$^{d}15.37_{c}$	$^{e}13.18_{d}$
9	$^{a}17.35_{b}$	$^{e}7.43_{ab}$	$^{b}15.71_{c}$	$^{b}15.67_{d}$	$^{c}14.97_{d}$	$^{d}12.50_{e}$
12	$^{a}16.63_{c}$	$^{f}6.90_{c}$	$^{b}15.41_{c}$	$^{c}14.74_{e}$	$^{d}14.37_{e}$	$^{e}11.70_{f}$

Note. * Means within the same row with different superscript letters have significant differences between treatments using LSD ($p \leq 0.05$).

** Means within the same column with different subscript letters have significant differences between storage periods using LSD ($p \leq 0.05$).

Table 5 shows the Hunter yellowness (*b*) values of mortadella treatments during storage. As shown from this table, the highest ($P \leq 0.05$) yellowness value was observed in 240 mg OLE treatment then in 20 ppm nitrite with OLE and 40 ppm nitrite with OLE treatments. While the lowest *b* values ($P \leq 0.05$) were seen in 120 ppm nitrite treatment followed by 80 ppm nitrite with OLE and 60 ppm nitrite with OLE treatments. During storage periods *b* values were numerically much closed, with slight increased ($P \leq 0.05$) at the second half of storage.

Table 5. Changes in Hunter *b* (Yellowness) values of mortadella treatments during storage

Time (weeks)	120 ppm nitrite	240 mg OLE/ 100 g meat	240 mg OLE/100 g meat + 80 ppm nitrite	240 mg OLE/100 g meat + 60 ppm nitrite	240 mg OLE/100 g meat + 40 ppm nitrite	240 mg OLE/100 g meat + 20 ppm nitrite
0	$^{*e}12.36_{a**}$	$^{a}13.95_{b}$	$^{d}12.63_{c}$	$^{c}12.86_{c}$	$^{b}13.13_{c}$	$^{b}13.24_{d}$
1	$^{d}12.36_{a}$	$^{a}14.02_{b}$	$^{c}12.78_{c}$	$^{bc}12.98_{bc}$	$^{b}13.18_{c}$	$^{b}13.25_{d}$
3	$^{e}12.31_{a}$	$^{a}14.11_{b}$	$^{cd}13.19_{b}$	$^{d}13.12_{ab}$	$^{c}13.37_{b}$	$^{b}13.74_{c}$
6	$^{d}12.56_{a}$	$^{a}14.44_{a}$	$^{c}13.39_{b}$	$^{c}13.34_{a}$	$^{c}13.44_{b}$	$^{b}13.84_{bc}$
9	$^{e}12.53_{a}$	$^{a}14.55_{a}$	$^{bc}13.69_{a}$	$^{d}13.15_{ab}$	$^{c}13.49_{ab}$	$^{b}13.96_{ab}$
12	$^{e}12.32_{a}$	$^{a}14.53_{a}$	$^{c}13.67_{a}$	$^{d}13.22_{ab}$	$^{c}13.61_{a}$	$^{b}14.05_{a}$

Note. * Means within the same row with different superscript letters have significant differences between treatments using LSD ($p \leq 0.05$).

** Means within the same column with different subscript letters have significant differences between storage periods using LSD ($p \leq 0.05$).

Our results are coincide with those evaluated by Aytul (2010) when he studied the effect of addition of 1, 2, and 3% olive leaf extract into beef cubes on *L*, *a*, and *b* color values, he found that addition of OLE and storage time increased values of *L* and *b* while decreased *a* values of the beef cubes. He attributed these changes in color to the natural yellow-brown color of the added OLE.

In determination of color parameters of breast turkey stored at -18 °C for six months, the *L* values increased during storage, while *a* values decreased significantly after two months of storage, which may be related to oxidation of heme pigments. However, *b* values changed slightly (Jouki et al., 2012).

3.3 Sensory Evaluation

3.3.1 Appearance and Color

Sensory evaluation of appearance and color of the mortadella treatments at zero time and during storage periods are presented in Tables 6 and 7, respectively. The highest ($P \leq 0.05$) appearance and color values were scored by 80 ppm nitrite with OLE and 60 ppm nitrite with OLE treatments that scored from like moderately to like very much from beginning and at later stages of the storage, followed by 120 ppm nitrite treatment that scored like moderately during the first three weeks of storage then decreased to like slightly after 6 weeks until the end of storage, 240 mg OLE treatment had the lowest ($P \leq 0.05$) appearance as well as color scores within dislike slightly to neither like nor dislike, indicating no noticeable curing action of the OLE. The other two treatments were between the highest and lowest values ranged from neither like nor dislike to like slightly. During storage periods 80 ppm nitrite with OLE and 60 ppm nitrite with OLE treatments kept the best ($P \leq 0.05$) appearance and color evaluation.

As shown from Tables 6 and 7, the appearance and color are correlated sensory parameters, alteration one of them will affect another character. Appearance and color are the major food sensory attributes that determine customer choice (Fernández-López et al., 2006).

Oiye et al. (2012) found that reduced nitrite sausages formulated with rosemary spice had lower color scores than sausage with nitrite with no rosemary spice. This agrees with our results in the case of addition of OLE alone or 20 ppm nitrite with OLE.

Treatments with reduced nitrite of 80 and 60 ppm with OLE significantly ($P \leq 0.05$) had higher evaluation scores than other treatments, indicating that the combination between OLE and nitrite at these levels enhanced the appearance and color of the mortadella. This result may be explained by the formation of compounds due to interactions between nitrite, OLE, and meat components that may affect appearance and color of the mortadella positively, the second reason behind this result could be due to the enhancement of the chemical parameters as shown previously from the oxidation analyses of these two mortadella combination treatments which was reflected positively on the sensory characteristics. Nascimento et al. (2013) concluded that celery extract was effective for production of low sodium nitrite turkey ham considering the pH, a_w, color and lipid oxidation at the end of the processing.

Table 6. Sensory evaluation of appearance of mortadella treatments during storage

Time (weeks)	120 ppm nitrite	240 mg OLE/ 100 g meat	240 mg OLE/100 g meat + 80 ppm nitrite	240 mg OLE/100 g meat + 60 ppm nitrite	240 mg OLE/100 g meat + 40 ppm nitrite	240 mg OLE/100 g meat + 20 ppm nitrite
0	$^{*a}7.50_{a**}$	$^{c}5.78_{ab}$	$^{a}7.83_{a}$	$^{a}7.72_{a}$	$^{b}6.61_{a}$	$^{c}5.94_{b}$
1	$^{a}7.22_{ab}$	$^{c}5.00_{b}$	$^{a}7.33_{ab}$	$^{ab}7.06_{b}$	$^{ab}6.78_{a}$	$^{b}6.39_{ab}$
3	$^{a}7.00_{ab}$	$^{b}5.78_{ab}$	$^{a}7.11_{b}$	$^{a}7.06_{b}$	$^{ab}6.39_{a}$	$^{a}6.72_{a}$
6	$^{bc}6.67_{b}$	$^{c}6.11_{a}$	$^{a}7.89_{a}$	$^{a}7.67_{a}$	$^{b}7.00_{a}$	$^{bc}6.39_{ab}$
9	$^{b}6.94_{ab}$	$^{d}4.83_{b}$	$^{a}7.89_{a}$	$^{ab}7.44_{ab}$	$^{bc}6.72_{a}$	$^{c}5.94_{b}$
12	$^{ab}6.89_{ab}$	$^{c}5.28_{ab}$	$^{a}7.61_{ab}$	$^{a}7.56_{ab}$	$^{b}6.78_{a}$	$^{b}6.28_{ab}$

Note. * Means within the same row with different superscript letters have significant differences between treatments using LSD ($p \leq 0.05$).

** Means within the same column with different subscript letters have significant differences between storage periods using LSD ($p \leq 0.05$).

Table 7. Sensory evaluation of color of mortadella treatments during storage

Time (weeks)	120 ppm nitrite	240 mg OLE/ 100 g meat	240 mg OLE/100 g meat + 80 ppm nitrite	240 mg OLE/100 g meat + 60 ppm nitrite	240 mg OLE/100 g meat + 40 ppm nitrite	240 mg OLE/100 g meat + 20 ppm nitrite
0	$^{*a}7.39_{ab**}$	$^{d}4.61_{ab}$	$^{a}7.83_{a}$	$^{a}7.61_{a}$	$^{b}6.56_{a}$	$^{c}5.78_{a}$
1	$^{a}7.56_{a}$	$^{c}4.11_{ab}$	$^{a}7.39_{a}$	$^{ab}7.11_{ab}$	$^{ab}6.78_{a}$	$^{b}6.22_{a}$
3	$^{a}7.39_{ab}$	$^{c}4.39_{ab}$	$^{ab}7.28_{a}$	$^{ab}6.72_{b}$	$^{ab}6.44_{a}$	$^{b}6.33_{a}$
6	$^{ab}6.78_{b}$	$^{d}5.06_{a}$	$^{a}7.50_{a}$	$^{a}7.33_{ab}$	$^{bc}6.56_{a}$	$^{c}5.89_{a}$
9	$^{ab}7.00_{ab}$	$^{d}3.83_{b}$	$^{a}7.78_{a}$	$^{a}7.44_{a}$	$^{b}6.56_{a}$	$^{c}5.56_{a}$
12	$^{ab}6.83_{ab}$	$^{d}4.67_{ab}$	$^{a}7.50_{a}$	$^{a}7.39_{a}$	$^{bc}6.44_{a}$	$^{c}5.89_{a}$

Note. * Means within the same row with different superscript letters have significant differences between treatments using LSD ($p \leq 0.05$).

** Means within the same column with different subscript letters have significant differences between storage periods using LSD ($p \leq 0.05$).

3.3.2 Tenderness and Juiciness

Tenderness and juiciness evaluation shown in Tables 8 and 9, respectively, were relatively ($P > 0.05$) convergent for all treatments with slight favorability toward 80 ppm nitrite with OLE and 60 ppm nitrite with OLE treatments. In general, tenderness and juiciness scores ranged from like slightly to like moderately. Storage time didn't affect tenderness and juiciness significantly ($P > 0.05$) of all treatments except slight decrease in 120 ppm nitrite treatment.

In our results tenderness as well as juiciness were not significantly ($P > 0.05$) different, this could be due to the using of the same formula for all treatments except of the nitrite concentration. This was demonstrated by the proximate analyses that were similar to the all treatments with no significant differences, which could be reflected on the textural characteristics of the treatments.

Abdullah (2007) reported that when he studied the sensory properties of five canned luncheon meat formulations, juiciness was related to the type of meat used in the formulations, rather than to the chemical composition of the luncheon meat.

Table 8. Sensory evaluation of tenderness of mortadella treatments during storage

Time (weeks)	120 ppm Nitrite	240 mg OLE/ 100 g meat	240 mg OLE/100 g meat + 80 ppm nitrite	240 mg OLE/100 g meat + 60 ppm nitrite	240 mg OLE/100 g meat + 40 ppm nitrite	240 mg OLE/100 g meat + 20 ppm nitrite
0	*ab7.44 a**	ab7.11 a	a7.67 a	ab7.39 a	b6.94 a	b7.00 a
1	a6.78 ab	a6.83 a	a6.94 bc	a7.17 a	a6.61 a	a6.72 a
3	a6.61 b	a6.50 a	a6.72 c	a7.00 a	a6.78 a	a6.94 a
6	b6.56 b	ab6.89 a	a7.44 ab	a7.44 a	ab7.00 a	b6.67 a
9	b6.39 b	ab7.06 a	a7.39 ab	a7.33 a	b6.50 a	b6.44 a
12	bc6.56 b	c6.50 a	ab7.22 abc	a7.44 a	bc6.56 a	c6.59 a

Note. * Means within the same row with different superscript letters have significant differences between treatments using LSD ($p \leq 0.05$).

** Means within the same column with different subscript letters have significant differences between storage periods using LSD ($p \leq 0.05$).

Table 9. Sensory evaluation of juiciness of mortadella treatments during storage

Time (weeks)	120 ppm Nitrite	24 mg OLE/ 100 g meat	24 mg OLE/10 g meat + 80 ppm nitrite	24 mg OLE/10 g meat + 60 ppm nitrite	24 mg OLE/10 g meat + 40 ppm nitrite	24 mg OLE/10 g meat + 20 ppm nitrite
0	*ab7.22 a**	ab 7.22 a	a 7.61 a	a 7.50 a	b 6.78 a	b 6.72 a
1	a6.67 ab	a 6.50 ab	a 7.06 ab	a 7.11 ab	a 6.67 a	a 6.50 a
3	a 6.50 ab	a 6.89 ab	a 6.72 b	a 6.83 b	a 6.67 a	a 6.89 a
6	c 6.61 ab	bc 6.78 ab	ab 7.33 a	a 7.44 a	bc 6.72 a	c 6.56 a
9	c 6.33 b	abc 7.00 ab	a 7.28 a	ab 7.39 ab	c 6.50 a	bc 6.61 a
12	abc 6.56 ab	bc 6.33 b	ab 7.06 ab	a 7.28 ab	bc 6.44 a	c 6.22 a

Note. * Means within the same row with different superscript letters have significant differences between treatments using LSD ($p \leq 0.05$).

** Means within the same column with different subscript letters have significant differences between storage periods using LSD ($p \leq 0.05$).

3.3.3 Flavor

As reported from Table 10, sensory evaluation of mortadella flavor was higher ($P \leq 0.05$) in 80 ppm nitrite with OLE and 60 ppm nitrite with OLE treatments and ranged from like moderately to like very much. 120 ppm nitrite, 240 mg OLE, and 40 ppm nitrite with OLE treatments scored lower than those of 80 and 60 ppm nitrite with OLE treatments and it fall within the range of like slightly to like moderately. The lowest likeness ($P \leq 0.05$) was received by 20 ppm nitrite with OLE treatment in the range of neither like nor dislike to like slightly. In general, flavor scores of all treatments were didn't affected significantly ($P > 0.05$) during storage periods, except those of 120 ppm nitrite and 20 ppm nitrite with OLE that showed slight decrease in the later stages of the storage.

Combination between OLE and nitrite at 80 and 60 ppm in mortadella treatments may be develop a chemical compounds that contributed special flavors scored highly in these two treatments and differentiate them from other treatments. The panelists informed us that mortadella treatments containing OLE had detectable bitterness that was varied according to the concentration of the combined nitrite although they were not told about the treatments formulations. The highest bitterness we informed about was in OLE treatment with no nitrite, whilst the lower was in 80 and 60 ppm nitrite with OLE treatments, 20 and 40 ppm nitrite with OLE treatments were between them. These results may indicate formation of flavor compounds as a result of the combination between the nitrite and the OLE that may be masking the bitter flavor.

These results are similar to that found by Al-Shuibi and Al-Abdullah (2002) when replacing nitrite with sorbate in that mortadella samples formulated with combined nitrite and sorbate had intense flavor than with nitrite or sorbate individually. Gök and Bor (2012) found that sensory evaluation of meatball formulated with 1000 ppm

blueberry extract were higher than the ones having olive leaf extract and *Zizyphus jujube.*

Table 10. Sensory evaluation of flavor of mortadella treatments during storage periods

Time (weeks)	120 ppm Nitrite	240 mg OLE/ 100 g meat	240 mg OLE/100 g meat + 80 ppm nitrite	240 mg OLE/100 g meat + 60 ppm nitrite	240 mg OLE/100 g meat + 40 ppm nitrite	240 mg OLE/100 g meat + 20 ppm nitrite
0	*ab 7.11 a**	bc 6.61 a	a 7.72 a	a 7.67 ab	bc 7.50 a	c 6.22 ab
1	abc 6.72 ab	bc 6.56 a	a 7.44 a	ab 7.17 b	bc 6.44 a	c 6.28 ab
3	a 6.67 ab	a 6.44 a	a 7.17 a	a 7.22 b	a 6.44 a	a 6.94 a
6	b 6.39 ab	b 6.30 a	a 7.67 a	a 7.89 a	b 6.39 a	b 5.83 b
9	b 6.28 b	b 6.17 a	a 7.50 a	a 7.39 ab	b 6.22 a	b 5.94 b
12	bc 6.72 ab	c 6.33 a	ab 7.44 a	a 7.50 ab	c 6.67 a	c 6.22 ab

Note. * Means within the same row with different superscript letters have significant differences between treatments using LSD ($p \leq 0.05$).

** Means within the same column with different subscript letters have significant differences between storage periods using LSD ($p \leq 0.05$).

3.3.4 Overall Acceptability

Table 11 presents overall acceptability of mortadella treatments. As presented from this table the highest ($P \leq 0.05$) overall acceptability was shown in 80 ppm nitrite with OLE and 60 ppm nitrite with OLE treatments ranged from like moderately to like very much. However, 240 mg OLE treatment received the lowest ($P \leq 0.05$) overall acceptability scores fall in neither like nor dislike to like slightly. 120 ppm nitrite, 40 ppm nitrite with OLE, and 20 ppm nitrite with OLE were similar in the range of like slightly. In general, overall acceptability was affected slightly ($P \leq 0.05$) in some treatments by storage time, while other didn't affected ($P > 0.05$). The most affected treatments by storage are 120 ppm nitrite and 20 ppm nitrite with OLE.

Gök and Bor (2012) found that overall acceptability evaluation of meatballs formulated with blueberry, olive leaf, and *Zizyphus jujube* extracts decreased significantly during storage.

Table 11. Sensory evaluation of overall acceptability of mortadella treatments during storage periods

Time (weeks)	120 ppm Nitrite	240 mg OLE/ 100 g meat	240 mg OLE/100 g meat + 80 ppm nitrite	240 mg OLE/100 g meat + 60 ppm nitrite	240 mg OLE/100 g meat + 40 ppm nitrite	240 mg OLE/100 g meat + 20 ppm nitrite
0	*a 7.39 a**	c 6.06 ab	a 7.78 a	a 7.56 ab	b 6.72 a	bc 6.28 ab
1	ab 6.89 ab	c 5.83 ab	a 7.56 ab	ab 7.17 ab	b 6.61 a	bc 6.50 ab
3	a 6.83 ab	a 6.44 a	a 7.06 b	a 7.11 b	a 6.72 a	a 6.78 a
6	b 6.50 b	b 6.28 ab	a 7.72 a	a 7.67 a	b 6.67 a	b 6.33 ab
9	b 6.56 b	b 5.94 ab	a 7.61 a	a 7.33 ab	b 6.39 a	b 6.06 b
12	bc 6.72 b	e 5.56 b	ab 7.39 ab	a 7.44 ab	cd 6.67 a	de 6.00 b

Note. * Means within the same row with different superscript letters have significant differences between treatments using LSD ($p \leq 0.05$).

** Means within the same column with different subscript letters have significant differences between storage periods using LSD ($p \leq 0.05$).

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