Investigation on processing of fermented camel sausage by using Lactobacillus casei and paracasei

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ABSTRACT

Probiotic fermented sausages are safe and healthy meat products. Semi-dry fermented sausages were manufactured from camel meat inoculated with Lactobacillus casei and Lactobacillus paracasei and control. All treatments were analyzed for the physico-chemical characteristics (Protein, moisture, fat, ash, lactic acid value and pH), microbiological features (total aerobic, total mold and yeast and lactic acid bacteria count) and sensory evaluation (color, flavor, texture and overall acceptability) after 0, 10, 20, 30, 40 and 45 days of refrigerated storage at 4°C. Microbial analysis demonstrated the predominance of lactic acid bacteria in semi-dry fermented sausage during the cold storage which reached (8.07) log CFU/gm in samples inoculated with L. paracasei at 4°C for 45 days. Chemical analysis of semi-dry fermented sausage showed a significant difference (p≤ 0.05) in moisture content which decrease in all samples during the period of cold storage. However, all other parameters such as protein, fat and ash increased. The drop in pH value in all samples was as a result of producing lactic acid during the fermentation by lactic acid bacteria. The best results were obtained in the fermented sausage inoculated with L. paracasei in physicochemical, microbial and sensory characteristics. Also, we could preserve the product at 4°C for 45 days. The sensory evaluation appeared superior in the semi-dry fermented sausage that had L. casei and L. paracasei as compared with the control.

Keywords: Lactic acid bacteria, production semi-dry fermented sausage, quality characteristics.

INTRODUCTION

Camel meat is healthier as they produce carcasses with less fat as well as, having less level of cholesterol and somewhat high polyunsaturated fatty acids than other meat animals (Tanizadeh et al., 2010). Fermentation is the chemical conversion of organic substances into primary compounds by the act of enzymes and organic catalysts, which are created by micro-organisms such as molds, yeasts, or bacteria. It may be aerobic or anaerobic in the environment. It is considered as an anaerobic method when sugar is transformed into acid or alcohol (Ray and Roy, 2014).

Lactic Acid Bacteria (LAB) are a functional group of micro-organisms containing Gram-positive, non-sporulated anaerobic bacteria. Catalase negative bacteria produces lactic acid as the main metabolic end-product of carbohydrate fermentation. Among LAB, Lactobacillus is the genus comprising a high number of GRAS species (mostly known as Safe) and many strains are among the most important bacteria in food microbiology and human nutrition due to their contribution to fermented food production or their use as probiotics (Salvetti et al., 2012). The preserved effect exerted by lactic acid bacteria is due to their ability to produce organic acids (such as Lactic acids) which result in dropped pH; LAB also provides antimicrobial compounds including acetic acids, hydrogen peroxide and bacteriocins (Yang et al., 2012).
Sausage is known to be the oldest and most continuous form of processed meat. Various types of fermented sausages are manufactured using different spice mixtures, starter cultures and types of raw materials and meat (Papavergou, 2011). One of the strategies for the development of low-fat fermented sausages was the decrease of fat content and the simultaneous addition of non-lipid fat replacers to minimize texture defects (Olivares et al., 2010).

Probiotics are live micro-organisms that are used to develop the common health conditions of hosts (Hempel et al., 2012) and exert their benefits through several mechanisms; they inhibit colonization, cellular adhesion and invasion by pathogenic organisms. They have direct antimicrobial activity and modulate the host immune response (Nair et al., 2017).

Starter cultures are used to ensure food safety and superior quality attributes such as sensorial, nutritional and technological properties (Simion et al., 2014). They also provide rapid lactic acid development from the fermentation of sugars added to the sausage resulting in a decreased pH that delays the growth of most spoilage micro-organisms and promotes flavor, the texture of the final product and the fermentation by controlling the microflora of the food (Dogbatesy, 2011).

The purpose of the present investigation was production and formulation of semi-dry fermented sausage from camel meat using two strains of probiotics (Lactobacillus casei and Lactobacillus paracasei) and to evaluate products: physicochemical, microbiological and sensorial characteristics during the cold storage at 4°C for (45 days).

### MATERIALS AND METHODS

Fresh boneless camel meat was obtained from a local market in Karaj, Iran. Other ingredients such as soy oil, sodium chloride, sodium nitrite, red pepper powder, sugar powder, black pepper powder, polyphosphate, garlic, special spices, ascorbic acid, starch and flour were obtained from Kadur Factory (Tehran, Iran).

#### Inoculum preparation

Two bacterial strains: *L. casei* (DSM-20011) and *L. paracasei* (DSM-20006) were obtained from the BioProcess Engineering Laboratory (BPEL), Department of Food Science and Engineering, Faculty of Agricultural Engineering and Technology, University of Tehran, Iran. These bacteria were reactivated thrice in de Man Rogosa and Sharpe (MRS) broth (Merck, Darmstadt, Germany) at 37°C for 24 h and under aseptic conditions, transferred to (MRS) agar streaked and incubated at 37°C for 48 h. The lactic acid bacteria were identified by microscopic morphological checking tests. After purification and enumeration of these lactic acid bacteria, isolated typical colonies were transferred from MRS agar to MRS broth overnight incubated at 37°C until they achieved a turbidity and the number of cells about1×10⁶ CFU Colony Forming Units/mL. Thereafter, each strain was centrifuged at 4025 × g, 4°C for 10 min, the pellets were washed twice with 0.85% sterile saline solution water and used for inoculation separately in the product. The purity of cultures were tested periodically and at the starting of each experiment by Gram staining and identifies the strains belonging to the LAB group (Nanasombat and Wimuttigosol, 2012; Ahmed and Elwy, 2015).

#### Sausage manufacture

Three samples from each type of semi-dry fermented sausage were prepared as requested: A control sample produced without starter culture). Two other samples were produced with starter cultures containing one strain from each of starter culture *L. casei* or *L. paracasei* respectively. Meat and other ingredients earlier mentioned were used in certain percentages per kg batter for the production of fermented sausages. The respective starter cultures were added to each sample as a 2 ml wet inoculums per kg of batter. In control sample, 2 ml of sterile saline water were added per kg of batter. A Naturin Cutter (Naturin, Germany) was used for the preparation of batter; the cutter was sterilized before the preparation of meat mixture for each treatment. The spice mixture and other ingredients including starter culture were added and mixed with minced meat in a cutter for about 20 min. The batter was then filled into artificial collagen casings of 20 mm diameter using a filling machine (Naturin, Germany) at 5°C (Bozkurt and Bayram, 2006).

Produced sausages were fermented at 30°C for 24 h and then dried at two stages (at 60°C for 4 h and at 75°C for 20 min). These heating steps improved the quality (sensory evaluation) and inhibit bacterial development. They were finally stored in a refrigerator at 4°C according to the method of Ahmad (2012). Sampling was performed by randomly choosing from each sausage group after 0, 10, 20, 30, 40 and 45 days in order to analyze physicochemical, microbiological and sensorial properties.

#### Microbiological analysis

After removing the casings from samples, one gram of each sample was diluted aseptically with 9 ml of sterile normal saline-peptone water (0.85%, w v⁻¹ saline, 0.1%, w v⁻¹ peptone water). Serial decimal dilutions were prepared from (10⁻¹ to 10⁻⁶). Nutrient agar (Merck, Darmstadt, Germany), Yeast extract glucose chloramphenicol agar (YGC) (Merck, Darmstadt, Germany) and (MRS) agar (de Man, Rogosa and Sharp agar) (Oxoid limited, Basing-Stoke, Hampshire, England) were used to count (in triplicate) Total Aerobic Counts (TAC), mould and yeasts counts (M
and YC) and lactic acid bacteria counts (LAB), respectively. A colony counter was used for counting colonies grown in the incubated Petri-dishes after incubated at 37°C for 48 h for (TAC) and (LAB) while (M and YC) incubated at 25°C for (3 to 5) days (APHA, 1992). Finally, the viable cell counts were calculated as log^{10} value.

**Physico-chemical analysis**

**Moisture determination**

The moisture content was determined by weighing 5 g of the sample and drying in an oven at 105°C until reaching a constant weight (AOAC, 2006).

**Fat content**

Fat content was measured using the Soxhlet method with a solvent extraction system which is based on the method of AOAC (2006).

**Protein content**

Total protein content was determined according to Kjeldahl method with an automatic Kjeldahl nitrogen analyzer used to determine the amount of nitrogen (%) and to calculate the ratio of protein by multiplying the amount of nitrogen to the constant factor (6.25) as mentioned in the method of AOAC (2006).

**Ash content**

5 g of each sample were put inside a muffle furnace at 550°C as earlier mentioned in the method of AOAC (2006).

**pH**

The Ph value of semi-dry fermented sausage was determined by weighted 10 g of each sample and homogenized in 90 ml of distilled water (Wang, 2000) and measured by pH meter (Crisson Instruments S.A., Alella, Spain) by submerging the electrode directly into the samples of sausage.

**Lactic acid value**

Lactic acid value was determined by filtration samples and then titration with NaOH 0.1 N (1 ml 0.1 N NaOH = 0.0090 g lactic acid) containing phenolphthalein (0.1% in 95% ethanol % wv⁻¹) as the indicator (AOAC, 2000).

**Sensorial analysis**

Sensory evaluation (color, texture, flavor and overall acceptability) were carried out for semi-dry fermented sausage inoculated with \(L.\) casei and \(L.\) paracasei and control using ten trained panelists. For each sample, the ranking scale ranged from 1 (very dislike) to 9 (very like) according to Al-Ahmad (2014 to 2015). Average of the panelist scores was calculated for the samples stored at 4°C after 0, 10, 20, 30, 40 and 45 days, respectively.

**Statistical analysis**

SPSS software (version 17.0) was used to determine the effect of the refrigerated storage period and inoculation (addition \(L.\) casei and \(L.\) paracasei) on the quality characteristics of semi-dry fermented sausage. Each trial was repeated thrice. The obtained data were analyzed by one-way (ANOVA), and significant differences (p < 0.05) among the means of samples compared using Duncan’s test.

**RESULTS AND DISCUSSION**

**Physicochemical analysis**

Tables 1, 2 and 3 showed the results of the physical and

Table 1: Physico-chemical analysis of semi-dry fermented sausages inoculated with Lactobacillus casei during refrigerated storage at 4°C.

<table>
<thead>
<tr>
<th>Storage/day</th>
<th>Protein (%)</th>
<th>Moisture (%)</th>
<th>Fat (%)</th>
<th>Ash (%)</th>
<th>PH</th>
<th>Lactic acid (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10.88±0.03(^a)</td>
<td>63.8±0.03(^a)</td>
<td>15.4±0.03(^c)</td>
<td>2.44±0.01(^c)</td>
<td>5.48±0.01(^a)</td>
<td>0.248±0.001(^f)</td>
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<tr>
<td>10</td>
<td>12.33±0.03(^b)</td>
<td>63.08±0.05(^b)</td>
<td>15.57±0.01(^c)</td>
<td>2.49±0.01(^d)</td>
<td>5.42±0.01(^b)</td>
<td>0.54±0.003(^c)</td>
</tr>
<tr>
<td>20</td>
<td>12.39±0.01(^c)</td>
<td>63.04±0.21(^b)</td>
<td>15.93±0.03(^d)</td>
<td>2.53±0.02(^c)</td>
<td>5.41±0.04(^b)</td>
<td>0.57±0.003(^d)</td>
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<tr>
<td>30</td>
<td>12.68±0.01(^b)</td>
<td>62.89±0.16(^b)</td>
<td>16.04±0.04(^c)</td>
<td>2.57±0.005(^b)</td>
<td>5.40±0.3(^c)</td>
<td>0.59±0.001(^c)</td>
</tr>
<tr>
<td>40</td>
<td>12.78±0.02(^a)</td>
<td>62.65±0.17(^c)</td>
<td>16.18±0.01(^b)</td>
<td>2.6±0.02(^b)</td>
<td>5.36±0.01(^c)</td>
<td>0.67±0.001(^b)</td>
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<td>45</td>
<td>12.82±0.02(^a)</td>
<td>62.26±0.02(^d)</td>
<td>16.39±0.02(^a)</td>
<td>2.64±0.03(^a)</td>
<td>5.21±0.015(^d)</td>
<td>0.702±0.001(^a)</td>
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</tbody>
</table>

*Values are means of three replicates ± standard deviation. **Means with different superscript letters in the same column represent significant differences (p ≤ 0.05).
Table 2: Physico-chemical analysis of semi-dry fermented sausages inoculated with Lactobacillus paracasei during refrigerated storage at 4°C.

<table>
<thead>
<tr>
<th>Storage/day</th>
<th>Protein (%)</th>
<th>Moisture (%)</th>
<th>Fat (%)</th>
<th>Ash (%)</th>
<th>PH</th>
<th>Lactic acid (%)</th>
</tr>
</thead>
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<td>62.63±0.04&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.35±0.01&lt;sup&gt;d&lt;/sup&gt;</td>
<td>2.53±0.03&lt;sup&gt;d&lt;/sup&gt;</td>
<td>5.3±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.302±0.001&lt;sup&gt;f&lt;/sup&gt;</td>
</tr>
<tr>
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<td>62.57±0.09&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>2.54±0.04&lt;sup&gt;d&lt;/sup&gt;</td>
<td>5.23±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.568±0.001&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
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<td>62.29±0.05&lt;sup&gt;b&lt;/sup&gt;</td>
<td>16.5±0.03&lt;sup&gt;d&lt;/sup&gt;</td>
<td>2.56±0.04&lt;sup&gt;de&lt;/sup&gt;</td>
<td>5.41±0.01&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.758±0.003&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>30</td>
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<td>62.14±0.05&lt;sup&gt;c&lt;/sup&gt;</td>
<td>16.7±0.02&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.57±0.01&lt;sup&gt;bd&lt;/sup&gt;</td>
<td>5.09±0.01&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.643±0.001&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
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<td>61.73±0.05&lt;sup&gt;d&lt;/sup&gt;</td>
<td>16.75±0.02&lt;sup&gt;bd&lt;/sup&gt;</td>
<td>2.61±0.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.07±0.01&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.679±0.002&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>14.58±0.01&lt;sup&gt;e&lt;/sup&gt;</td>
<td>61.68±0.08&lt;sup&gt;d&lt;/sup&gt;</td>
<td>17.13±0.01&lt;sup&gt;e&lt;/sup&gt;</td>
<td>2.66±0.01&lt;sup&gt;e&lt;/sup&gt;</td>
<td>4.91±0.02</td>
<td>0.784±0.001&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

*Values are means of three replications ± standard deviation (SD). **Means with different superscript letter within column represent significant differences (p ≤ 0.05).

Table 3: Physico-chemical analysis of semi-dry fermented sausages (control) during refrigerated storage at 4°C.

<table>
<thead>
<tr>
<th>Storage/day</th>
<th>Protein (%)</th>
<th>Moisture (%)</th>
<th>Fat (%)</th>
<th>Ash (%)</th>
<th>PH</th>
<th>Lactic acid (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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<td>63.85±0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15.05±0.1&lt;sup&gt;d&lt;/sup&gt;</td>
<td>2.6±0.03&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.56±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.207±0.0002&lt;sup&gt;f&lt;/sup&gt;</td>
</tr>
<tr>
<td>10</td>
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<td>63.78±0.03&lt;sup&gt;c&lt;/sup&gt;</td>
<td>15.43±0.03&lt;sup&gt;d&lt;/sup&gt;</td>
<td>2.63±0.02&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>5.5±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.222±0.002&lt;sup&gt;e&lt;/sup&gt;</td>
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<tr>
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<td>15.73±0.03&lt;sup&gt;c&lt;/sup&gt;</td>
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<td>0.540±0.002&lt;sup&gt;d&lt;/sup&gt;</td>
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<td>30</td>
<td>15.53±0.02&lt;sup&gt;c&lt;/sup&gt;</td>
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<td>0.574±0.002&lt;sup&gt;c&lt;/sup&gt;</td>
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<td>40</td>
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<td>62.86±0.01&lt;sup&gt;d&lt;/sup&gt;</td>
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<td>2.7±0.03&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.36±0.010&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.602±0.001&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
<td>45</td>
<td>15.9±0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>62.68±0.01&lt;sup&gt;c&lt;/sup&gt;</td>
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<td>2.72±0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.34±0.01&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.624±0.001&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

*Values are means of three replications ± standard deviation (SD). **Means with different superscript letter within column represent significant differences (p ≤ 0.05).

Chemical analyses of semi-dry fermented sausage inoculated with L. casei after 0, 10, 20, 30, 40 and 45 days of cold storage at 4°C. The protein content increased significantly (p ≤ 0.05) in all samples until it reached 15.90% for control during the storage period (Table 3). The moisture content of semi-dry fermented sausage decreased significantly (p ≤ 0.05) in all samples until it reached 61.68% for semi-dry fermented sausages inoculated with L. paracasei (Table 2). The trend in the fat content of samples was similar to protein content that significantly increased (p ≤ 0.05) in all samples during storage period at 4°C until it reached 17.13% for semi-dry fermented sausages inoculated with L. paracasei (Table 2). Ash content was almost increased significantly (p ≤ 0.05) in all sample until it reached 2.72% for control in the final stage of storage at 4°C (Table 3).

This increase in the protein of semi-dry fermented sausages can be due to the proteolytic activities of enzymes produced by micro-organisms during fermentation and ripening which can cause increase in the bioavailability of amino acids (Moret et al., 2004). Our results coincide with those of Asmare and Admassu (2013) who reporting on increase of protein content in all dry fermented sausages; this may be due to the decrease in water content and high concentration of nutrients during processing. Our findings are in agreement with that of Ahmad et al. (2012) demonstrating lowering down of moisture content of semi-dry fermented sausage. Asmare and Admassu (2013) showed that fat content was also significantly (p ≤ 0.05) increased in all dry fermented sausage. Our findings are almost as consistent with results of Hemat et al. (2010); there was also a significant (p ≤ 0.05) increase in mineral components for the final dry fermented sausage treatment and these values of ash increased in the end products due to the drying process. Salt (sodium chloride, NaCl) is one of the major ingredients in dry fermented sausages and play an essential role in assuring the microbiological stability, influence on the final taste, color and texture (Zanardi et al., 2010).

pH and lactic acid values

The pH of all samples decreased significantly (p ≤ 0.05) during the cold storage period. Fewer declines in pH value (4.91) of semi-dry fermented sausages was inoculated with L. paracasei (Table 2). The production of lactic acid during fermentation by lactic acid bacteria led to a decrease in pH values. The amount of lactic acid significantly increased (p ≤ 0.05) in all samples of semi-dry fermented sausages during the storage at 4°C. Control sample had a lower value of lactic acid 0.624% (Table 3) as compared to those inoculated with L. casei and L. paracasei which had 0.702 and 0.784% respectively.

Lactic acid bacteria utilized the carbohydrate portion of the meat to produce acid and thus lower the PH, improving the texture of the products, providing stability against the proliferation of food pathogens and producing some
aromatic compounds (Bacus, 1986). Moreover, lactic acid bacteria inhibit the growth of spoilage and pathogens micro-organisms through the production of lactic acid and antimicrobial compound (Albano et al., 2009). The current study is in agreement with results of Ahmad et al. (2012) demonstrating that refrigerated storage significantly (p ≤ 0.05) decreased pH of semi-dry fermented sausage.

**Microbiology analysis**

**Lactic acid bacteria**

Significant increase (p ≤ 0.05) in the numbers of lactic acid bacteria during the period of storage at 4°C in all fermented samples and became the predominant flora in the final products and they reached 7.92, 8.07 and 6.67 log CFU gm⁻¹ for L. casei, L. paracasei and control respectively at the end of storage due to the inoculation with L. casei and L. paracasei (Figure 1).

Lactic acid bacteria were able to resist the drying process and to maintain its growth during refrigerated storage stages. Increase in numbers of lactic acid bacteria could be due to the environment of meat being suitable for the growth of lactic acid bacteria and a good adaptation of these bacteria to fermentation conditions (Al-ahmad et al., 2014). These results are in line with those of Ferreira et al. (2007) in fermented sausages where a rapid increase in lactic acid bacteria count was observed. The number of lactic acid bacteria decreased at the end of the refrigerated storage due to the exhaustion of the sugar and the low temperature conditions (Fernandez-Lopez et al., 2008) and may also be attributable to the decrease in moisture and increase in acidity of sausage during refrigerated storage (Al-ahmad et al., 2014).

**Total aerobic count**

Total aerobic counts of semi-dry fermented sausage were significantly increased (p ≤ 0.05) in all samples during storage period at 4°C (Figure 2). Control sample had lower number 6.63 log CFU gm⁻¹ as compared to those inoculated with L. casei and L. paracasei which had number 7.23 and 6.80 log CFU gm⁻¹ respectively at the end of the refrigerated storage period. Bacha et al. (2010) observed similar loads of Total Aerobic Count (TAC) on other sausages. These increases in (TAC) numbers can be due to the initial ingredients and the properties of used meat (Talon et al., 2007). Microbial growth during storage is one of the main factors affecting the quality of meat products, leading to the spoilage and hence, economic losses (Afshin et al., 2011). Sausage may be contaminated after heat processing and during other processes such as slicing.
packaging and peeling (Cygnarowicz-provost et al., 1994).

**Yeast and mold count**

The numbers of yeast and mold count were lower than lactic acid bacteria and TAC of semi-dry fermented sausages and were significantly ($p \leq 0.05$) decreased in all samples during the period of storage at 4°C (Figure 3). Control sample had higher number 3.17 log CFU gm$^{-1}$ as compared to others inoculated with *L. casei* and *L. paracasei* which had numbers ranging between 2.15 and 2.33 log CFU gm$^{-1}$ respectively after 45 days of refrigerated storage. Al-ahmad et al. (2014) demonstrated decrease in
the number of yeast and molds in treatment content of lactic acid bacteria as compared to control in smoked and fermented semi-dry sausages. This decline in the number of yeast and molds in the sausage inoculated with lactic acid bacteria as compared with control can be due to the competition between lactic acid bacteria, yeasts and molds (Al-ahmad et al., 2014).

**Sensory evaluation**

The addition of starter culture that has improved the sensorial properties of samples inoculated with starter culture was compared to control. There are many factors affecting the sensory characteristics of meat products such as the meats used as raw materials (genetic type, feed, age, sex and rearing system), micro-organisms selected as microbial starters for the fermentation and type of processing technologies (cooking, drying, ripening and smoking, etc) (Ahmad and Amer, 2013). Sensorial analysis included the evaluation of color, flavor, texture and overall acceptability.

**Color**

Lactic acid bacteria result in increase of the lactic acid, promote the color of the product and reduced enzyme rancidity of fat and improved the sensory evaluation of the final product (Gunter and Hautzinger, 2007). During storage at 4°C, the score values of color decreased significantly (p ≤ 0.05) in all samples. Control sample had lower score 6.10 as compared to those inoculated with L. casei and L. paracasei which obtained 6.13 and 6.66 respectively, at the end of the refrigerated storage period (Figures 4, 5 and 6).

The decrease in color scores during storage may be due to the lipid oxidation and subsequently oxidized compounds reacting with amino acids during non-enzymatic browning of the product (Ahmad and Amer, 2013). Our results are in agreement with those of Ahmad and Amer (2013) reported during refrigerated storage.

**Figure 4:** Sensory evaluation of semi-dry fermented sausages inoculated with Lactobacillus casei during refrigerated storage at 4°C.
where the score values of color significantly (p≤0.05) decreased in semi-dried fermented sausages.

**Flavor**

During refrigerated storage at 4°C, the score values of flavor decreased significantly (p ≤ 0.05) in all samples. Control sample had lower score 5.51 as compared to those inoculated with *L. casei* and *L. paracasei* with scores of 5.60 and 5.80 respectively, at the end of the refrigerated storage (Figures 4, 5 and 6). The characteristic flavor of fermented sausages mainly originates from the breakdown of carbohydrates, lipids, and proteins through the action of microbial and endogenous meat enzymes (Ahmad and Amer, 2013). The development of flavor is also influenced by several variables such as product formulation (especially spices), processing conditions and starter culture (Ahmad and Amer, 2013). These results are similar to those obtained by Ahmad and Amer (2013) which indicated a decrease of flavor during refrigerated storage.

**Texture**

Texture is a powerful element of the quality and acceptability of foods. It is perceived from sensory impressions of the physical properties of material, its nature, composition and behavior on deformation received from senses of touch, sight and hearing (Ahmad and Amer, 2013). During refrigerated storage at 4°C, the score values of texture decreased significantly (p≤0.05) in all samples (Figures 4, 5 and 6). Control sample had lower score 5.67 compared to those inoculated with *L. casei* and *L. paracasei* which had scores 5.95 and 6.10 respectively at the end of the refrigerated storage. The significant decrease in texture during storage may be due to changes in the disulphide bonds and contents of amino acid (Ahmad and Amer, 2013). Increasing levels of fat constantly improved the score values of texture, which obtained by Ahmad and Amer (2013) during refrigerated storage at 2°C indicating that the score of texture for semi-dry fermented sausages incorporated with 20 and 25% fat was significantly (p≤0.05) decreased.

**Overall acceptability**

During refrigerated storage at 4°C, the score values of overall acceptability decreased significantly (p≤ 0.05) in all samples (Figures 4, 5 and 6). Control sample had lower scores 5.80 compared to those inoculated with *L. casei* and *L. paracasei* which scores 6.10 and 6.40 respectively at the end of the refrigerated storage. The best overall

![Figure 5: Sensory evaluation of semi-dry fermented sausages inoculated with Lactobacillus paracasei during refrigerated storage at 4°C.](image-url)
acceptability score was found for semi-dry fermented sausage inoculated with L. paracasei.

Conclusions

The use of L. casei and L. paracasei improved the quality and nutritional value of food by producing probiotic functional food. It was concluded that the fermentation process with L. casei and L. paracasei of the semi-dry fermented sausage processed from camel meat led to lower moisture content and PH and was dominated by lactic acid bacteria on the microflora in fermented sausage; it helped improve the sensory qualities in fermented sausage and kept them within 45 days of refrigerated storage at 4°C. The best sensory evaluation in the color, flavor, texture and overall acceptability scores was obtained in the samples of semi-dry fermented sausage inoculated with L. paracasei.

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