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Physicochemical characteristics and sensory evaluation of fermented sausage supplemented with Jerusalem artichoke and milk permeate powder

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ABSTRACT:

Fermented sausage was manufactured with adding Jerusalem artichoke (JAP), as a prebiotic, and milk permeate powder, as a milk sugar, and fermented with 5% of probiotic lactic acid bacteria. Sausage samples were produced in six treatments, A10, P10, B10, A40, P40 and B40, fermented by *Lb. acidophilus* (A), *Lb. paracasei* (P) or *Bifido. Bifidum* (B) both of them was mixed with *Str. thermophilus* in 1:1 and 10% or 40% of JAP. . Control (C) was represented by mixing sausage with *Str. thermophilus* (5%) without adding JAP. Titratable acidity%, pH, TVB-N, and TBA were determined at intervals of (fresh, 7, 14, 21, and 28 days). Moisture, protein, fat and ash were analyzed at intervals of (fresh, 14, and 28 days). Sensory evaluation was performed at the end of ripening period. Results showed that acidity, fat, protein, ash, TVB-N, and TBA increased during ripening period. However, pH values and moisture content decreased throughout ripening, but the pH values started to increase at the end of ripening period. Moreover, TBA and TVB-N contents were higher in C sample than the other samples. No significant differences were found in sensory evaluation among all treatments, except P10, which had a higher total sensory score.

KEYWORDS: Fermented sausage, Jerusalem artichoke, Milk permeate, Prebiotics, Probiotics.

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1.INTRODUCTION:

Meat and meat products are essential sources of proteins, fats, essential amino acids, minerals, vitamins, and other nutrients **(Biesalski, 2005)**. In recent years, there has been a growing demand for healthier meat and meat products with improved functional value. Health-enhancing ingredients such as vegetable proteins, dietary fibers, herbs, spices, and probiotics are rapidly increasing worldwide. High-fat processed meat products can be associated with increased risk of cardiovascular, metabolic diseases and cancer **(Domingo & Nadal, 2017; Han & Bertram, 2017).**

Meat fermentation is a low-energy, biological-acidulation preservation method that results in unique and distinctive meat properties. Changes from raw meat to a fermented product are caused by "cultured" or "wild" microorganisms, which lower the pH. Factors influencing this process include fresh, low-contaminated, consistent raw material, strict sanitation, control of time, temperature, and humidity during production, smoke, and appropriate additives **(Ockerman & Basu, 2014)**.

Fermented sausages are produced worldwide due to their convenience and sensory characteristics (**Leroy et al., 2018**). Inoculating suitable starter cultures is considered the main improvement method. *Lactobacillus* and *Pediococcus* species are widely used as starter cultures in fermented sausages due to their tolerance to high salt low pH environments and desirable fermented characteristics in meat tissues **(Ikonić et al., 2014).** Bioprotective strategies, particularly the use of bacteriocin-producing LAB, exhibit antimicrobial activity against gram-positive bacteria **(Martín et al., 2022)**.

Jerusalem artichoke JA (*Helianthus tuberosus*), is gaining increasing interest in food applications due to its nutritional value and antioxidant activity **(Nemeth- & Izsaki, 2006; Paseephol et al., 2007).** JA was also useful in fermented foods because it acts as a prebiotic. Ultrafiltered milk permeate, a byproduct of milk filtration, separates lactose, vitamins, and minerals from milk proteins and fats. **(Paugam et al., 2022).**

This study evaluates the influence of adding JA tubers powder and ultrafiltered milk permeate powder as a sugar replacer in the fermented sausage. Also, this work aimed to enhance the quality and safety of fermented sausage.

2. MATERPALS AND METHODS:

2.1. Materials

The study used local beef meat, hung, and fat which were obtained from Fayoum governorate market. Jerusalem artichoke tubers were obtained from Al Qanater Charity Horticulture Research Station, local condiments. Milk permeate powder was obtained from MEFAD company, Giza, Egypt. Probiotic starter cultures, *Lactobacillus acidophilus* ATCC 11975, *Lactobacillus paracasei* DSM 16105, *Streptococcus thermophilus*DSM 24731 and *Bifidobacterium bifidum* DSM 22892 were obtained from CHR-Hansen laboratories, Denmark.

2.2. Methods:

2.2.1.Jerusalem artichoke tuberspreparation

Jerusalem artichoke tubers were cleaned, peeled, and immersed in citric acid solution. They were cut into small pieces, dried at 50°C, homogenized, and stored **(Tchoné et al., 2005).**

2.2.2. Bacterial cultures preparation

Bacterial cultures were prepared using lactic acid bacteria strains and *Bifidobacterium bifidum* strain. Cultures were incubated anaerobically in fresh MRS broth at 40°C for 24 h and inoculated in Sterilized skimmed milk.

2.2.3. Making of fermented sausage

The study focuses on the production of fermented sausage, a traditional laboratory process that involves mixing minced beef meat with various ingredients, including JA as a prebiotic (10 and 40%), salt, ascorbic acid, compound spices, and milk permeate as a milk sugar. Control and six treatments of fermented sausage were prepared as described in Table 1. The six sausage treatments, A10, P10 and B10, fermented by 1:1 ratio of *Str. thermophilus* with *Lb. acidophilus, Lb. paracasei* or *Bifido. bifidum* with 10% JAP respectively. A40, P40 and B40, fermented by 1:1 ratio of *Str. thermophilus* with *Lb. acidophilus, Lb. paracasei* or *Bifido. bifidum* with 40% JAP respectively. Control C was only fermented by *Str. thermophilus* without adding JAP. The sausages were filled into sheep casings and air-dried for 7 days the temperature was controlled at 22°C during this period, then stored at 5°C for 28 days. Physicochemical analysis were performed at different ripening periods, fresh, 14 and 28 days, and microbiological analysis at fresh, 7, 14, 21 and 28 days. Sensory evaluation was done at the 28th day of the ripening period.

Table 1.Ingredients of fermented sausage for each treatment.

Ingredients	Amount/g	Percentage%
Beef meats	343	62.00
Fat	175	31.64
Salt	17.5	3.20
Permeate	10.5	1.90
Condiment	3.5	0.63
Ascorbic acid	3.5	0.63
Total	553	100

2.2.4. Physico-chemical analysis

The study focuses on the physicochemical analysis of fermented sausage, a type of meat. The pH value was measured using a pH meter, and moisture content was determined by drying five grams of the sample at 100-102 °C for 24 hrs. Ash content was also determined. Fat content was extracted using ethyl ether at 40°C. Total nitrogen (TN) and protein content were measured using the macro-Kjeldahl method. All analyses were determined according to (Lawrence, 2023)

2.2.5. Thiobarbituric acid (TBA)

Thiobarbituric acid (TBA) value, as an index of fat oxidation, was determined directly in the sample as described by **Beare-Rogers et al., (2016)**. Ten grams of minced fermented sausage was homogenized with 50 ml of distilled water using a stomacher lab-blender 400 for 2 min. The homogenate was transferred to a distillation flask with 47.5 ml of distilled water, then 2.5 ml of 4N.HC1 (pH 1.5) was added. A volume of 50 ml distillate was collected, from which 5 ml was pipetted into a glass stoppered tube and mixed with 5 ml TBA reagent (0. 2883 g/ml glacial acetic, acid 90%) the mixture was heated in a boiling water bath for 35 min. After cooling to the ambient temperature, the absorbance was measured at 538 nm using Spectrophotometer Spectronic 20 D (Bauch and Lamb), the blank was carried out in the same manner using 5 ml of distilled water. The TBA value was expressed as mg malonaldehyde/kg sample by using the following equation:

TBA value (mg malonaldehyde/kg sample) = absorbance X 7.8

2.2.6. Total volatile basic nitrogen (TVB-N)

Total volatile basic nitrogen (TVB-N) was estimated using the semi-micro distillation method as described by **Qiao et al., (2017)**.

2.5. Sensory Evaluation of fermented sausage

The sensory evaluation of fermented sausage samples was conducted by ten staff members of Fayoum University's Food Science and Technology Department at the end of ripening period. The sausages were cooked separately for 7 minutes, then placed in coded dishes and served to panelists. A hedonic ten-point scale was used to assess the taste, texture, acceptability, taste, and color according to the method of **Zong et al., (2022).**

2.6. Statistical analysis

The data was analysed using SPSS version 25.0 and Sigma Plot 11.0 software programs.The results were expressed as mean ± SD and analysis of variance (ANOVA) was used. When $p \leq 0.05$, the variation was considered to change the dependent variables significantly.

Table 2. Chemical composition of fermented sausage supplemented with *Jerusalem artichoke* and milk permeate during ripening period.

Treatments	Ripening period (days)	Moisture%	Fat%	Protein%	Ash%
	Fresh	$50.8{\pm}0.01^{b}$	$21.8{\pm}0.08^{c}$	$15.8{\pm}0.04^{o}$	$2.05{\pm}0.04^{j}$
C	14	$49.0{\pm}0.02^{i}$	$22.3{\pm}0.07^{b}$	$16.0{\pm}0.02^{n}$	$2.44{\pm}0.02^{hi}$
	28	$46.8{\pm}0.02^{o}$	$22.9{\pm}0.04^{a}$	$16.4{\pm}.04^{k}$	$2.58{\pm}0.05^{gh}$
	Fresh	$50.9{\pm}0.07^{a}$	$19.5{\pm}0.08^{h}$	$16.9{\pm}0.02^{g}$	$2.07{\pm}0.01^{j}$
A10	14	$48.1{\pm}0.07^{k}$	$19.9{\pm}0.07^{fg}$	$17.2{\pm}0.04^{e}$	$2.42{\pm}0.02^{i}$
	28	$45.5{\pm}0.04^{t}$	$20.0{\pm}0.04^{efg}$	$17.4{\pm}0.01^{d}$	$2.65{\pm}0.05^{efg}$
	Fresh	$50.2{\pm}0.05^{g}$	$9.7{\pm}0.09^{u}$	$17.6{\pm}0.04^{c}$	$2.16{\pm}0.01^{j}$
A40	14	$47.4{\pm}0.04^{l}$	$10.0{\pm}0.05^{t}$	$17.9{\pm}0.07^{b}$	$2.61{\pm}0.04^{fg}$
	28	$46.6{\pm}0.04^{q}$	$10.5{\pm}0.05^{s}$	$18.0{\pm}0.04^{a}$	$2.84{\pm}0.02^{bcd}$
	Fresh	$50.9{\pm}0.08^{ab}$	$19.9{\pm}0.08^{efg}$	$16.8{\pm}0.07^{h}$	$2.06{\pm}0.01^{j}$
P10	14	$48.7{\pm}0.01^{j}$	$20.2{\pm}0.07^{e}$	$17.0{\pm}0.01^{fg}$	$2.57{\pm}0.01^{ghi}$
	28	$45.7{\pm}0.03^{w}$	$21.0{\pm}0.03^{d}$	$17.2{\pm}0.07^{e}$	$2.64{\pm}0.05^{efg}$
	Fresh	$50.4{\pm}0.05^{ef}$	$10.5{\pm}0.07^{s}$	$17.1{\pm}0.09^{ef}$	$2.15{\pm}0.01^{j}$
P40	14	$46.3{\pm}0.02^{q}$	$10.8{\pm}0.07^{e}$	$17.4{\pm}0.02^{d}$	$2.69{\pm}0.02^{defg}$
	28	$45.3{\pm}0.05^{u}$	$11.2{\pm}0.04^{q}$	$17.6{\pm}0.41^{c}$	$2.83{\pm}0.04^{bcd}$
	Fresh	$50.6{\pm}0.05^{c}$	$19.8{\pm}0.07^{g}$	$16.1{\pm}0.04^{m}$	$2.07{\pm}0.01^{j}$
B10	14	$49.2{\pm}0.04^{h}$	$20.1{\pm}0.08^{ef}$	$16.9{\pm}0.05^{g}$	$2.75{\pm}0.02^{cde}$
	28	$46.2{\pm}0.07^{q}$	$21.2{\pm}0.04^{d}$	$17.2{\pm}0.05^{e}$	$2.85{\pm}0.05^{abc}$
	Fresh	$50.3{\pm}0.09^{fg}$	$10.0{\pm}0.07^{t}$	$17.0{\pm}0.05^{fg}$	$2.16{\pm}0.01^{j}$
B40	14	$47.2{\pm}0.04^{m}$	$10.8{\pm}0.07^{e}$	$17.5{\pm}0.01^{cd}$	$2.86{\pm}0.02^{abc}$
	28	$45.7{\pm}0.05^{s}$	$11.6{\pm}0.04^{p}$	$17.6{\pm}0.02^{c}$	$3.00{\pm}0.04^{a}$

Means ± (St. Dev.) having different superscripts within each column are significantly different (*$p \leq 0.05$)*.C: fermented sausage without JAP and probiotic strains. A10 and A40: fermented sausage containing *Lb. acidophilus* and (10, and 40%) of JAP replaced with fat. P10 and P40: fermented sausage containing *Lb. paracasei* and (10 and 40%) of JAP replaced with fat. B10, and B40: fermented sausage containing *Bifido. bifidum* and (10 and 40%) of JAP replaced with fat.

3.RESULTS AND DISCUSSION:

3.1. Chemical composition

Chemical compositions of fermented sausage were shown in Table 2. It was found that moisture content in fermented sausage decreased as refrigerated storage period increased, these results were in agreement with those obtained by **Kelly Karr Getty, (2006),** possibly due to water evaporation. Treatments containing 40% JAP (A40, P40, and B40) had lower moisture content due to high JAP content. Small differences in moisture content were found between samples, possibly due to JAP's high carbohydrate content (inulin) or manufacturing procedures **(Stimbirys et al., 2015).** However, the use of lactic acid bacteria (LAB) increased water release, resulting in low water retention in cooked sausages **(Singh, V.P.2012).** Other factors controlling moisture content include selecting the right meat type, stuffing, casing, and grinding. LABs can reduce moisture content, improve product safety, and extend shelf life **(Laranjo et al., 2017).**
Fat content was significantly different in fermented sausages at the fresh time due to the fat replacement process with JAP. The control sample had a higher fat content, but the fat content significantly decreased as the proportional of JAP increased. The Lowest fat content was found in treatments A40, P40, and B40, possibly due to the highest concentration of JAP. These results were supported by the fact that inulin led to a decrease in the water, lipid, and protein content of the product, according to **Menegas et al. (2013).**
The protein content of fermented sausage treatments increased during ripening. This increase may be due to the release of microbial proteins during solid-state fermentation, and increase the protein content by increasing JAP concentration, which raises crude protein as well as total solids **(Luo et al., 2020).**
No significant differences in ash content were found between fermented sausage treatments during fresh and ripening periods. Ash content slightly increased with increasing JAP concentrations, but significant differences were observed between fresh and ripening periods. JAP concentrations containing 40% and 10% showed higher ash content, while the control sample had lower ash content. JAP, with a high percentage of ash content (5.7%), increased ash content in all fermented sausage samples containing JAP **(Nairfana & Afgani, 2021).**

3.2. pH values

The pH values of fermented sausages made with probiotic strains were found to be lower than that in control sample. The use of milk permeate as a sugar substitute led to more production of lactic acid, resulting in increased acidity and decreasing pH values. The pH values of all fermented sausage treatments significantly decreased at the first 14 days of storage. These results were in agreement with that obtained by **Liu et al., (2021) and Gu et al., (2023).** Acidity could decrease the risk of foodborne pathogens and extend the shelf life of the sausages. The pH values of samples inoculated with probiotic strains (*lactobacilli and Bifidobactria*) were generally lower than the control on the 28^{th} day of ripening at 5°C these results were in agreement with **Angmo et al., (2016).**

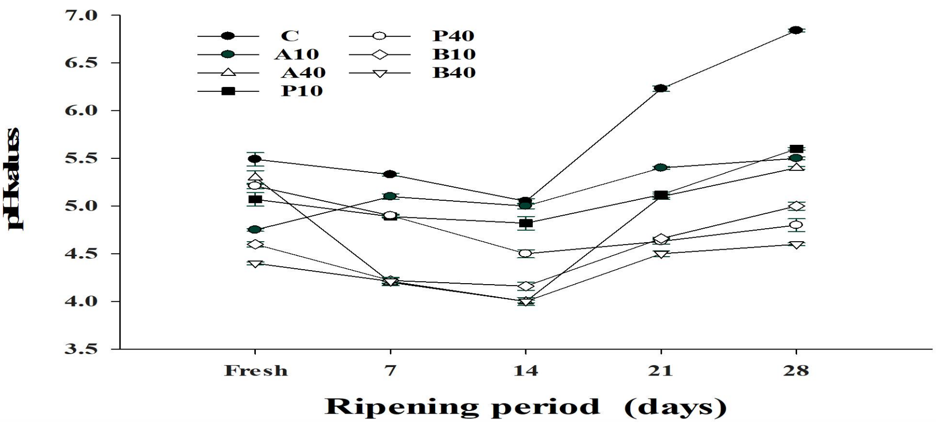

Fig 1. Effect of *Jerusalem artichoke* and milk permeate on pH values of fermented sausage during ripening period

At the end of the ripening period, pH values increased for all fermented sausage treatments, possibly due to the generation of non-protein nitrogen in the meat due to proteolytic processes **(Chen et al., 2016)**. Low pH values restrict the growth and stability of probiotic bacteria.

3.3. Titratable acidity

The acidity of fermented sausage samples increased throughout the ripening period, these results were in agreement with **Yoo et al., (2015) and Comi et al., (2005)**. The total acid levels in sausages containing probiotics were higher than the control sample.

This could be due to the presence of lactobacilli, which are major producers of lactic acid and contribute to the increase in acidity during fermentation **(Cui & Fan, 2019).** *Lb. acidophilus* sausage samples had higher acidity than those fermented with *Lb. paracasei* and *Bifido. bifidum.* Also,**Todorov et al., (2017)** found that concentration of lactic acid ranging from 0.3% to 0.9% in fermented sausage manufactured with *Lb. acidophilus.*

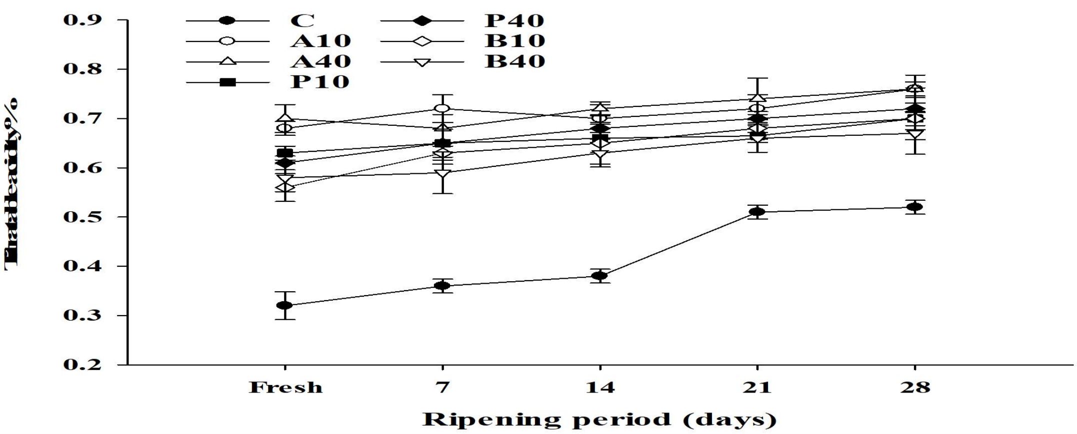

Fig 2. Effect of Jerusalem artichoke and milk permeate on (TA) of fermented sausage during ripening period.

As shown from Figure 2., titratable acidity of fermented sausage containing JAP (A10, P10, B10, A40, P40, and B40) recorded higher values than control sample C. This might be attributed to lactobacilli and *Bifidobacterium* which produce acidity more than *Str. thermophilus*.

3.4. Thiobarbituric acid (TBA)

There were no significant differences in TBA of all fermented sausage treatments at the fresh time of ripening period. However, significant differences (p<0.05) started to detect at the 14th, 21st and 28th day of ripening period. The higher TBA value was recorded by control sample, that reached 1.10 mgMDA/kg at the end of ripening period. Whereas, the lowest TBA value was detected in B40 sample, that recorded 0.76 mg MDA/kg at the end of ripening period, as illustrated in Table 3. suggesting that fermentation can reduce lipid oxidation in the final products. *Bifidobacterium bifidum* and *Lb. acidophilus* had greater anti-oxidative capacities, suggesting that fermentation can improve the extraction of phenolics and antioxidants **(Kim et al., 2010).** The study also found that replacing beef fat with Jerusalem artichoke (JAP) in sausage production significantly decreased TBA values, **(Furlan et al. 2014)**. possibly due to the reduction of beef fat and increased JAP content which contain bioactive components as flavonoids.

Table 3. Effect of *Jerusalem artichoke* and milk permeate on TBA values (mg MDA/Kg) of fermented sausage during ripening period.

Treatments	Ripening Periods (days)				
	Fresh	7	14	21	28
C	0.28 ± 0.01^{j}	0.35 ± 0.01^{i}	0.70 ± 0.04^{fg}	0.89 ± 0.01^{d}	1.1 ± 0.02^{a}
A10	0.27±0.02j	0.30±0.01ij	0.69 ± 0.02^{gh}	0.73 ± 0.01^{ef}	0.78 ± 0.02^{cd}
A40	0.26 ± 0.01^{j}	0.29 ± 0.05^{ij}	0.65 ± 0.02^{h}	0.70 ± 0.02^{fg}	0.77 ± 0.02^{cd}
P10	0.25 ± 0.04^{j}	0.28 ± 0.01^{j}	0.71 ± 0.04^{fg}	0.74 ± 0.01^{ef}	0.82 ± 0.04^{cd}
P40	0.27 ± 0.01^{j}	0.29 ± 0.02^{ij}	0.69 ± 0.05^{gh}	0.74 ± 0.05^{ef}	0.81 ± 0.02^{cd}
B10	0.26 ± 0.01^{j}	0.29 ± 0.01^{ij}	0.69 ± 0.04^{gh}	0.72 ± 0.01^{ef}	0.77 ± 0.01^{cd}
B40	0.26 ± 0.01^{j}	0.28 ± 0.02^{j}	0.65 ± 0.04^{h}	0.69 ± 0.01^{gh}	0.76 ± 0.02^{de}

Means ± (St. Dev.) having different superscripts within each column are significantly different (*p ≤ 0.05)*.C: fermented sausage without JAP and probiotic strains. A10 and A40: fermented sausage containing *Lb. acidophilus* and (10, and 40%) of JAP replaced with fat.P10 and P40: fermented sausage containing *Lb. paracasei* and (10 and 40%) of JAP replaced with fat. B10, and B40: fermented sausage containing *Bifido. bifidum* and (10 and 40%) of JAP replaced with fat.

Phenolic compounds, may also contribute to decrease TBA values. This result also confirmed the result of **Chen et al., (2017)** who reported that the lipid oxidation was inhibited by LAB fermentation.

3.5. Total volatile basic nitrogen content (TVB-N)

TVB-N content as shown in Table 14. increased in control as time passed, ranged from 11 to 32.3 mg/100 g of fermented sausage. However, there were no significant differences (p<0.001) in TVB-N between all the treatments at the beginning of the ripening period. However, the significant differences (p<0.001) were detected between the samples containing probiotics and JAP, when comparing with the control sample throughout the rest of ripening period. The higher TVB-N was recorded by the control sample, while lower values were observed in samples P10 and B40. Fermentation with probiotics delayed TVB-N increase and improved sausage quality. LAB in meat fermentation can inhibit TVB-N accumulation by producing lactic acid and bacteriocins that led to neutralize TVB-N or inhibit spoilage bacteria and pathogens. Therefore, the fermentation with probiotics delay the increase of TVB-N and improve the quality of the fermented sausage. This result agreed with that obtained by **Hu et al., (2008)** in addition to **Xu & Zhu, (2021)** who mentioned that *Lactobacillus fermentum* could reduce protein decomposition and microbial risks.

Table 4. Effect of *Jerusalem artichoke* and milk permeate on TVB-N content (mg/100g) of fermented sausage during ripening period.

Treatments	Ripening Periods (days)				
	Fresh	7	14	21	28
C	11.0±0.07^{x}	19.5±0.02^{i}	23.5±0.05^{g}	25.2±0.01^{f}	32.3±0.03^{a}
A10	11.2±0.07^{wx}	13.3±0.02^{t}	18.1±0.02^{n}	19.4±0.01^{ij}	28.2±0.02^{b}
A40	11.0±0.06^{w}	12.6±0.02^{u}	17.5±0.05^{o}	19.1±0.01^{jk}	27.4±0.01^{c}
P10	11.1±0.07^{x}	14.0±0.02^{s}	18.3±0.04^{mn}	19.9±0.01^{h}	25.0±0.04^{f}
P40	11.1±0.07^{x}	14.0±0.04^{s}	15.2±0.05^{r}	18.5±0.04^{lm}	26.2±0.01^{e}
B10	11.2±.02^{wx}	13.2±0.02^{t}	16.1±0.05^{q}	18.8±0.01^{kl}	26.0±0.07^{e}
B40	11.0±.07^{x}	12.1±0.02^{v}	15.3±0.02^{r}	18.1±0.01^{m}	25.1±0.02^{f}

Means ± (St. Dev.) having different superscripts within each column are significantly different (*$p \leq 0.05$)*.C: fermented sausage without JAP and probiotic strains. A10 and A40: fermented sausage containing *Lb. acidophilus* and (10, and 40%) of JAP replaced with fat.P10 and P40: fermented sausage containing *Lb. paracasei* and (10 and 40%) of JAP replaced with fat. B10, and B40: fermented sausage containing *Bifido. bifidum* and (10 and 40%) of JAP replaced with fat.

3.6. Sensory evaluation of fermented sausage.

Eventually, it was shown in Table 5. that the scores of the sensory evaluation of fermented sausage treatments had no significant differences ($p \leq 0.05$) between the control and the other treatments. However, the higher flavour score was recorded by A10 that reached 26.2, while the lower was recorded by the control sample that reached 22.5. Meanwhile, the treatments C, B10, and A10 were recorded the highest score of color that reached 18.3, 18.2, and 18.1 respectively. Moreover, the lowest color score was recorded by A40 that reached 17.2. The treatments had the highest texture scores were A10 and B40 that recorded 9.3 for both. However, the lowest texture score was recorded by P40 that reached 7.6. Whereas, the taste score was high in P10 that recorded 17.6, and low in P40 which recorded 15.5. Finally, the high acceptability and total scores were recorded by P10 which reached 18.4 and 88.1 respectively. However, the low acceptability and total scores were recorded by P40 that reached 15.1 and 79.9 respectively.

Table 5. Effect of *Jerusalem artichoke* and milk permeate on sensory properties of fermented sausage at the end of ripening period.

Treatments	Flavor (30)	Color (20)	Texture (10)	Taste (20)	Acceptability (20)	Total (100)
C	22.5±3.5[a]	18.3±2.3[a]	8.4±1.4[a]	16.3±3.4[a]	16.1±3.7[ab]	81.6±11.3[a]
A10	26.2±3.3[a]	18.1±1.9[a]	9.3±4.0[a]	16.6±2.4[a]	17.2±2.5[ab]	87.4±9.2[a]
A40	24.6±3.5[a]	17.2±2.4[a]	7.8±2.0[a]	15.9±2.9[a]	15.7±3.4[ab]	81.2±9.4[a]
P10	25.6±3.5[a]	17.5±2.3[a]	9.0±1.0[a]	17.6±1.8[a]	18.4±1.9[a]	88.1±8.4[a]
P40	24.2±3.1[a]	17.5±2.5[a]	7.6±1.9[a]	15.5±2.8[a]	15.1±2.6[b]	79.9±7.1[a]
B10	25.2±3.3[a]	18.2±2.0[a]	8.3±1.2[a]	17.4±1.4[a]	15.9±3.8[ab]	85.0±5.8[a]
B40	25.4±3.5[a]	17.7±2.1[a]	9.3±4.2[a]	16.3±3.1[a]	16.8±3.0[ab]	85.5±10.5[a]

Means ± (St. Dev.) having different superscripts within each column are significantly different ($p \leq 0.05$).C: fermented sausage without JAP and probiotic strains. A10 and A40: fermented sausage containing *Lb. acidophilus* and (10, and 40%) of JAP replaced with fat. P10 and P40: fermented sausage containing *Lb. paracasei* and (10 and 40%) of JAP replaced with fat. B10, and B40: fermented sausage containing *Bifido. bifidum* and (10 and 40%) of JAP replaced with fat.

Conclusion:

Based on the previous results, it could be concluded that acidity, fat, protein, ash, TVB-N, and TBA increased during ripening period. However, pH values and moisture content decreased throughout ripening, but the pH values started to increase at the end of ripening period. Moreover, TBA and TVB-N contents were higher in C sample than the other samples. No significant differences were obtained in sensory evaluation among all treatments, except P10, which had the highest total sensory score.

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