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Role of *Lactobacillus plantarum*, dextrose and starch on the storage stability and quality attributes of fermented chicken sausages

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ABSTRACT

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This study aimed to investigate the influence of starter culture, *Lactobacillus plantarum* and substrate, specifically dextrose and starch, on the storage stability of fermented chicken sausages under both refrigerated (4±1°C) and frozen (-20±1°C) conditions. In this study, two groups of sausages were analyzed: T_1 group fermented with *L. plantarum* (10^8cfu/g) and T_2 group fermented with *L. plantarum* (10^8cfu/g) in combination with 1% each of dextrose and starch. The sausages from both groups were evaluated at regular intervals: 0, 3, 5, 7, 9 and 12 days for refrigerated storage and 0, 15, 30 45 and 60 days for frozen storage. Throughout the storage period, T_2 group exhibited higher antioxidant potential compared to the T_1 group, whether stored in refrigerated or frozen conditions. Based on a comprehensive assessment of physicochemical, antioxidant, microbiological and sensory parameters, both groups of fermented chicken sausages remained safe for consumption up to 12 days under refrigerated storage and up to 60 days under frozen storage. This research study demonstrated that, the incorporation of dextrose and starch, together with *L. plantarum* (10^8cfu/g), enhances the antioxidant properties and overall value of fermented chicken sausages, extending their shelf life under refrigerated and frozen storage conditions.

Keywords: *Lactobacillus plantarum,* Dextrose, Starch, Storage stability

INTRODUCTION

Fermented sausage, with its distinct flavor and global popularity, stands as an appreciated meat product amongst consumers (Liu *et al.*, 2021). Traditionally enjoyed at room temperature, its convenience and palatable taste have made it a staple in many diets worldwide. However, the journey from processing to storage presents a numerous of safety challenges, together with the fear of oxidative rancidity, the presence of pathogenic bacteria, and an surplus of biological amines (Luan *et al.*, 2021). These issues underscore the need for inventive approaches to enhance the storage stability and overall quality of fermented chicken sausages.

In the 21st century, as nutrition trends gradually drift towards the pursuit of optimal nutrition, researchers and professionals have turned their consideration to reformulating and incorporating functional ingredients to side with evolving consumer perceptions of food healthiness (Kaur and Sharma, 2019). This growing demand for original and health-conscious food products has ignited a force to create novel fermented meat products with better nutritional profiles and health benefits (Agüero *et al.*, 2020). Therefore, food technologists are now embarking on efforts to develop meat and meat-based products that not only satisfy culinary cravings but also contribute to overall well-being by replacing or increasing specific components (Fernández-López *et al.*, 2021). In this framework, the roles of *Lactobacillus plantarum*, dextrose, and starch in the storage stability and quality attributes of fermented chicken sausages grasp significant potential offering a glance into the future of meat processing and its efficiency to provide the growing dietary requirements of consumers. In this study, our primary purpose was to explore the impact of a starter culture, *L. plantarum* and specific substrates, namely dextrose and starch, on the storage stability of fermented chicken sausages, subject to both refrigerated and frozen conditions. This study serves as a crucial step toward understanding the role of these components in maintaining the quality and stability of fermented chicken sausages, contributing valuable insights for both consumers and the food industry.

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MATERIALS AND METHODS

The starter culture, namely *L. plantarum* (NCDC No. 020) was procured rom ICAR-National Dairy Research Institute, Karnal, in a freeze-dried, vacuum-sealed form. The initial stock culture was revived following the manufacturer’s instructions, with sub-culturing at fortnight intervals to maintain the mother culture. *L. plantarum* was then sub-cultured in duplicate in Lactobacillus MRS Broth, harvested and adjusted to a concentration of 10^{10} bacterial cells/ml using spectrophotometry. For minced meat preparation, White Leghorn spent hens were sourced from ICAR-Central Avian Research Institute, Izatnagar, and processed through fasting, bleeding, scalding, defeathering, and evisceration before being transported to the laboratory for deboning.

Hot dressed carcasses were deboned without delay and the minced meat was then subjected to a 24-hour fermentation process with *L. plantarum* (10^8 cfu/g) for T_1 group and *L. plantarum* (10^8 cfu/g) and additional substrates (i.e. 1% each of dextrose and starch) for T_2 group. The fermentation was done in a controlled fermentation chamber set at an optimized temperature of 18-20°C with a relative humidity of 90±5%. The resulting fermented minced chicken meat was used for emulsion formulation in both groups.

The emulsion for chicken sausages was prepared by mixing fermented minced lean meat with ingredients such as common salt, sodium nitrite, sodium nitrate, natural fat, condiment mix, spice mix, and refined wheat flour. Care was taken to keep the emulsion temperature below 10°C with the use of ice cubes. After preparation, the emulsion was refrigerated at 4±1°C. Using sausage filler, the emulsion was transferred into casings, linked for uniform sizing and then cooked in boiling water until getting an internal temperature of 72°C. After cooking, the sausages were cooled to room temperature. Samples were initially collected from both groups and underwent comprehensive analysis on day 0, including assessments of antioxidant activity (ABTS, SASA and DPPH radical scavenging), TBA, pH, free fatty acids (FFA), microbiological and sensory evaluation. Subsequently, these samples were stored under refrigerated and frozen conditions and re-evaluated at specific intervals: 3, 5, 7, 9 and 12 days for refrigerated storage and 15, 30, 45 and 60 days for frozen storage.

In the estimation of antioxidant parameters, we followed well-known methodologies, utilizing the approaches of Shirwaikar *et al.* (2006) for ABTS, Kumar and Chattopadhyay (2007) for SASA and Kato *et al.* (1988) for DPPH radical scavenging activity. Thiobarbituric acid (TBA) analysis was conducted according to the method outlined by Tarladgis *et al.* (1960). Physicochemical parameter such as pH was measured in alliance with the methodology described by Keller *et al.* (1974). The quantification of free fatty acids (FFA) was carried out as described by Koniecko (1979). Microbiological parameters were assessed in strict accordance with the standard methods detailed by Speck (1992). Moreover, sensory evaluation was performed using an 8-point hedonic scale to gauge the overall sensory attributes of the samples. The data obtained in this study were analyzed using SPSS software (Version 21; IBM SPSS, 2012). One-way analysis of variance (ANOVA) and T-test were conducted for all the parameters. Statistical significance was determined at the $P<0.05$ level and the means were separated using the Duncan multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Antioxidant parameters

During a 12-day refrigeration and 60-day frozen storage period, the T_2 group consistently exhibited higher antioxidant activity compared to T_1, assessed through the $ABTS^+$ assay, DPPH, and superoxide anion scavenging activity (Table 1 and 2). A study conducted by Li Shengyu *et al.* (2012) also found impressive hydroxyl radical and DPPH scavenging activities with L. plantarum C88. Another study conducted by Kachouri *et al.* (2015) highlighted the capacity of Lactobacillus to produce high-value antioxidants from phenolic compounds in olives, while Li Zhongxi *et al.* (2018) demonstrated improved antioxidant capacity when fermenting apple juice with L. plantarum ATCC14917. With the significance of oligosaccharide metabolism for the ecological fitness of Lactobacillus in different food-related and intestinal environments (Walter, 2008; Tannock *et al.*, 2012), the synergistic role of dextrose and starch, which may be likely owing to the creation of a favorable environment for Lactobacillus plantarum, would have contributed to enhanced fermentation ability and antioxidant properties, as evidenced by the increased inhibition activity of L. plantarum against ABTS, DPPH, and SASA radicals (Geeta and Yadav, 2017).

Physicochemical parameters

In our study, both groups exhibited a consistent decline in pH during refrigerated and frozen storage, with the lowest pH recorded at the end of each storage phase (Table 3 and 4). This pH reduction is comparable to the findings by Christiansen *et al.* (1975) on summer-style sausage storage and is attributed to lactic acid bacteria multiplying and converting residual carbohydrates into lactic acid. In our study, the T_2 group, enriched with extra sugar substrates during fermentation with L. plantarum, exhibited a more significant pH decline throughout storage, likely due to increased lactic acid production with the added sugar substrates (Antara *et al.*, 2004; Ahmad and Shrivastav, 2007).

Throughout the successive refrigerated and frozen storage, there was an increase in the TBA (Thiobarbituric Acid) value observed for both groups (Table 3 and 4). However, this increase was less pronounced during the two-month frozen storage period compared to the twelve-day refrigerated storage period. Furthermore, the TBA values for the T_2 group were a little lower than those for the T_1 group, both during refrigerated storage and frozen storage. The increase in TBA values during refrigerated and frozen storage can be accredited to the oxidation of polyunsaturated fatty acids within the phospholipids fraction, in line with the findings of Igene *et al.* (1980) and Brewer *et al.* (1982). It is significant that the TBA values for both groups remained within acceptable limits (1-2 mg malonaldehyde/kg of meat) during the entire storage period, as specified by Witte *et al.* (1970). Though, previous studies suggest that the functional attributes deteriorate with the extension of the frozen storage time (Smiecinska *et al.*, 2015; Ablikim *et al.*, 2016; Wei *et al.*, 2017). Moreover, the maximum Free

Table 1: Effect of refrigerated storage (4±1°C) on antioxidant activity of fermented chicken sausages

Group	Storage Days						
	Day 0	Day 3	Day 5	Day 7	Day 9	Day 12	Total
				ABTS (%)			
T_1	46.09±0.12^{aq}	45.52±O.26^{aQ}	44.48±0.17^{bQ}	42.59±0.02^{cQ}	39.65±0.18^{dQ}	37.94±0.30^{eQ}	42.71±0.73
T_2	74.25±0.02^{aP}	71.99±0.01^{bP}	66.61±0.25^{cP}	56.96±0.07^{dP}	50.34±0.03^{eP}	48.98±0.10^{fP}	61.52±2.42
				SASA (%)			
T_1	64.59±0.22^{aQ}	60.41±0.19^{bQ}	50.97±0.04^{cQ}	40.85±0.01^{dQ}	38.41±0.04^{eQ}	36.62±0.06^{fQ}	48.64±2.63
T_2	86.84±0.07^{aP}	82.03±0.02^{bP}	71.73±0.23^{cP}	63.07±1.42^{dP}	50.45±0.08^{eP}	43.78±0.16^{fP}	66.32±3.79
				DPPH (%)			
T_1	26.54±0.20^{aQ}	25.13±0.63^{bQ}	20.47±0.00^{cQ}	18.91±0.02^{dQ}	15.90±0.05^{eQ}	11.44±0.14^{fQ}	19.73±1.25
T_2	51.77±0.01^{aP}	49.90±0.05^{bP}	48.45±0.03^{cP}	46.23±0.05^{dP}	44.19±0.02^{eP}	40.16±0.07^{fP}	46.78±0.93

Mean±S.E. with different superscripts row wise (small alphabets-a b c d e f) differ significantly at P<0.05.
Mean±S.E. with different superscripts column wise (capital alphabet-PQ) differ significantly at P<0.05
T_1=Sausages prepared with starter culture *Lactobacillus plantarum* (10^8 cfu/g), $T_{2=}$ Sausages prepared with starter culture *Lactobacillus plantarum* (10^8cfu/g) with additional supplementation of 1% each of Dextrose and Starch

Table 2: Effect of frozen storage (-20±1^{0}C) on antioxidant activity of fermented chicken sausages

Group	Storage Days					
	Day 0	Day 15	Day 30	Day 45	Day 60	Total
			ABTS (%)			
T_1	46.09±0.12^{aQ}	42.78±0.24^{bQ}	39.44±0.23^{cQ}	37.52±0.18^{dQ}	35.68±0.10^{eQ}	40.30±0.99
T_2	74.25±0.02^{aP}	73.62±0.12^{bP}	71.24±0.10^{cP}	70.46±0.18^{dP}	69.43±0.15^{eP}	71.80±0.49
			SASA (%)			
T_1	64.59±0.22^{aQ}	63.51±0.18^{bQ}	61.33±0.16^{cQ}	59.36±0.15^{dQ}	57.44±0.22^{eQ}	61.24±0.70
T_2	86.84±0.07^{aP}	84.44±0.22^{bP}	82.37±0.15^{cP}	79.32±0.07^{dP}	76.60±0.14^{eP}	81.91±0.97
			DPPH (%)			
T_1	26.54±0.20^{aQ}	25.46±0.23^{bQ}	23.58±0.17^{cQ}	20.60±0.22^{dQ}	15.65±0.22^{eQ}	22.37±1.04
T_2	51.77±0.01^{aP}	48.58±0.18^{bP}	47.43±0.13^{cP}	45.68±0.05^{dP}	42.93±0.03^{eP}	47.28±0.78

Mean±S.E. with different superscripts row wise (small alphabets-a b c d e f) differ significantly at P<0.05.
Mean±S.E. with different superscripts column wise (capital alphabet-PQ) differ significantly at P<0.05
T_1=Sausages prepared with starter culture *Lactobacillus plantarum* (10^8cfu/g), $T_{2=}$ Sausages prepared with starter culture *Lactobacillus plantarum* (10^8cfu/g) with additional supplementation of 1% each of Dextrose and Starch

Table 3: Effect of refrigerated storage (4±1^{0}C) on physico-chemical parameters of fermented chicken sausages

Group	Storage Days						
	Day 0	Day 3	Day 5	Day 7	Day 9	Day 12	Total
				pH			
T_1	6.02±0.04^{aP}	5.94±0.07^{abP}	5.82±0.02^{bcP}	5.76±0.02^{cdP}	5.67±0.03^{dP}	5.53±0.03^{eP}	5.79±0.04
T_2	5.49±0.01^{aQ}	5.37±0.03^{bQ}	5.28±0.03^{bcQ}	5.18±0.01^{cdQ}	5.14±0.04^{dQ}	5.08±0.05^{dQ}	5.25±0.03
				TBA			
T_1	0.76±0.000^{eP}	0.98±0.11^{dP}	1.34±0.11^{cP}	1.62±0.07^{bP}	1.83±0.04^{abP}	1.93±0.00^{aP}	1.38±0.10
T_2	0.74±0.004^{cQ}	0.80±0.02^{cQ}	0.90±0.05^{cQ}	1.29±0.12^{bQ}	1.68±0.06^{aQ}	1.83±0.01^{aQ}	1.17±0.10
				FFA			
T_1	0.053±0.003^{c}	0.073±0.012^{c}	0.110±0.015^{b}	0.123±0.014^{ab}	0.136±0.008^{ab}	0.150±0.005^{a}	0.107±0.009
T_2	0.040±0.005^{c}	0.053±0.008^{bc}	0.070±0.011^{bc}	0.080±0.010^{b}	0.123±0.008^{a}	0.133±0.013^{a}	0.083±0.009

Mean±S.E. with different superscripts row wise (small alphabets-a b c d e f) differ significantly at P<0.05.
Mean±S.E. with different superscripts column wise (capital alphabet-PQ) differ significantly at P<0.05
T_1=Sausages prepared with starter culture *Lactobacillus plantarum* (10^8cfu/g), $T_{2=}$ Sausages prepared with starter culture *Lactobacillus plantarum* (10^8cfu/g) with additional supplementation of 1% each of Dextrose and Starch

Fatty Acid (FFA) values for both groups were recorded on the final day of both refrigerated and frozen storage. Though, both groups exhibited non-significant differences in their FFA values on the same day of their respective storage periods (Table 3 and 4).

Table 4: Effect of frozen storage (-20±1^{0}C) on physico-chemical parameters of fermented chicken sausages

Groups	Storage Days					
	Day 0	**Day 15**	**Day 30**	**Day 45**	**Day 60**	**Total Mean±SE**
			pH			
T_1	6.02±0.04^{aP}	5.91±0.01^{bP}	5.80±0.02^{cP}	5.73±0.02^{cP}	5.63±0.02^{dP}	5.82±0.03
T_2	5.49±0.01^{aQ}	5.42±0.02^{abQ}	5.37±0.02^{bcQ}	5.30±0.01^{cdQ}	5.24±0.02^{dQ}	5.36±0.02
			TBA			
T_1	0.76±0.000^{eP}	0.78±0.001^{dP}	0.79±0.001^{cP}	0.80±0.001^{bP}	0.82±0.000^{aP}	0.79±0.004
T_2	0.74±0.004^{eQ}	0.75±0.002^{dQ}	0.76±0.000^{cQ}	0.78±0.002^{bQ}	0.79±0.001^{aQ}	0.76±0.005
			FFA			
T_1	0.053±0.003^{c}	0.060±0.005^{c}	0.086±0.008^{bc}	0.116±0.020^{ab}	0.126±0.012^{a}	0.088±0.008
T_2	0.040±0.005^{c}	0.046±0.012^{c}	0.073±0.008^{bc}	0.103±0.016^{ab}	0.116±0.008^{a}	0.076±0.009

Mean±S.E. with different superscripts row wise (small alphabets-a b c d e f) differ significantly at P<0.05.
Mean±S.E. with different superscripts column wise (capital alphabet-PQ) differ significantly at P<0.05
T_1=Sausages prepared with starter culture *Lactobacillus plantarum* (10^{8}cfu/g), $T_{2=}$ Sausages prepared with starter culture *Lactobacillus plantarum* (10^{8}cfu/g) with additional supplementation of 1% each of Dextrose and Starch

Microbiological parameters

The total plate count increased with successive storage days under refrigerated as well as frozen storage for both the groups; however, difference in TPC of successive days was less under frozen storage conditions (Table 5). Under refrigerated and frozen storage conditions, the TPC count was comparatively low and was highly acceptable for both groups as *L. plantarum* is capable of producing bacteriocin and was found to be effective against both gram positive and gram negative bacteria as suggested by Kaktcham *et al.* (2012) and Das *et al.* (2014). *Total* coliform count, *Salmonella* count and *Staphylococcus* count were not detected at any storage interval of refrigerated and frozen storage. Another study conducted by Ahmad and Shrivastav (2007*), LAB present in the sausages inhibits the proliferation of other harmful and spoilage microorganisms*. The absence of these organisms during storage period might also be accredited to exclusion of these pathogens during heat processing, hygienic handling and safe packaging of fermented chicken sausages.

Sensory parameters

Both groups were evaluated for sensory parameters including general appearance, flavor, texture, juiciness, sourness and overall acceptability during refrigerated and frozen storage at various time intervals (Table 6 and 7). During refrigerated storage, sensory scores slowly declined over time. Notably, the T_2 group consistently outperformed the T_1 group in all sensory attributes during this period. In contrast, sensory scores remained relatively stable for both groups during frozen storage, maintaining levels similar to day 0. This suggests that frozen storage had no significant impact on sensory attributes, even after 60 days, while refrigerated storage resulted in a slight decline in sensory attributes on the 9th day, still within acceptable limits as refrigeration is a recognized preservation method (Jay, 1996). In contrast, the study conducted by Wereñska and Okruszek (2023) depicted that freezing meat can lessen water holding capacity during thawing and lead to higher meat juice losses during heat treatment, potentially affecting sensory quality. As per the findings of Lagerstedt *et al.* (2008) chilled meat

Table 5: Effect of refrigerated (4±1°C) and frozen storage (-20±1°C) on microbiological parameters of fermented chicken sausages

			Total Plate Count				
			Refrigerated storage days				
Group	**Day 0**	**Day 3**	**Day 5**	**Day 7**	**Day 9**	**Day 12**	**Total**
T_1	1.16±0.01^{fP}	1.39±0.02^{eP}	1.70±0.03^{dP}	1.86±0.05^{cP}	2.17±0.06^{bP}	2.34±0.04^{aP}	1.77±0.18
T_2	1.13±0.01^{fP}	1.27±0.01^{eQ}	1.42±0.02^{dQ}	1.57±0.03^{cQ}	1.74±0.02^{bQ}	1.93±0.02^{aQ}	1.51±0.12
			Frozen storage days				
Group	Day 0	Day 15	Day 30	Day 45	Day 60		Total
T_2	1.16±0.01^{dP}	1.23±0.02^{cP}	1.25±0.01^{bcP}	1.29±0.01^{bP}	1.36±0.02^{aP}		1.25±0.03
T_2	1.13±0.01^{dP}	1.18±0.03^{cdP}	1.22±0.02^{bcP}	1.26±0.01^{bP}	1.34±0.01^{aP}		1.22±0.03

Mean±S.E. with different superscripts row wise (small alphabets-a b c d e f) differ significantly at P<0.05.
Mean±S.E. with different superscripts column wise (capital alphabet-PQ) differ significantly at P<0.05
T_1=Sausages prepared with starter culture *Lactobacillus plantarum* (10^{8}cfu/g), $T_{2=}$ Sausages prepared with starter culture *Lactobacillus plantarum* (10^{8}cfu/g) with additional supplementation of 1% each of Dextrose and Starch

Table 6: Effect of refrigerated storage (4±1^{0}C) on sensory quality of fermented chicken sausages

Parameter	Group	Day 0	Day 3	Day 5	Day 7	Day 9	Total
General	T_1	$5.80±0.20^{aQ}$	$5.40±0.24^{abQ}$	$5.00±0.31^{bc}$	$5.00±0.00^{bc}$	$4.40±0.24^{cQ}$	5.12±0.23
Appearance	T_2	$7.00±0.00^{aP}$	$6.60±0.24^{abP}$	$6.00±0.31^{bc}$	$5.40±0.40^{c}$	$5.40±0.24^{cP}$	6.08±0.32
Flavour	T_1	$6.00±0.00^{a}$	$5.60±0.24^{a}$	$5.40±0.24^{ab}$	$4.80±0.20^{bcQ}$	$4.60±0.24^{c}$	5.28±0.25
	T_2	$6.60±0.24^{a}$	$6.40±0.24^{ab}$	$5.80±0.20^{bc}$	$5.60±0.24^{cP}$	$5.40±0.24^{c}$	5.96±0.23
Texture	T_1	$6.20±0.20^{aQ}$	$5.80±0.20^{aQ}$	$5.60±0.24^{ab}$	$5.40±0.40^{ab}$	$4.80±0.37^{bQ}$	5.56±0.23
	T_2	$7.00±0.00^{aP}$	$6.60±0.24^{abP}$	$6.40±0.24^{bc}$	$6.00±0.00^{cd}$	$5.80±0.20^{dP}$	6.36±0.21
Juiciness	T_1	$6.00±0.00^{aQ}$	$5.40±0.40^{ab}$	$5.20±0.37^{abQ}$	$5.00±0.31^{ab}$	$4.60±0.40^{b}$	5.24±0.23
	T_2	$7.20±0.20^{aP}$	$6.40±0.24^{abQ}$	$6.20±0.20^{bP}$	$6.00±0.31^{b}$	$5.60±0.40^{b}$	6.28±0.26
Sourness	T_1	$5.80±0.20^{aQ}$	$5.40±0.24^{abP}$	$4.80±0.37^{bc}$	$4.60±0.24^{bc}$	$4.40±0.24^{c}$	5.00±0.26
	T_2	$6.80±0.20^{aP}$	$6.40±0.24^{ab}$	$5.80±0.48^{abc}$	$5.40±0.24^{bc}$	$5.20±0.37^{c}$	5.92±0.30
Overall	T_1	$5.80±0.20^{aQ}$	$5.20±0.37^{abQ}$	$4.80±0.37^{bcQ}$	$4.40±0.24^{bcQ}$	$4.20±0.20^{cQ}$	4.88±0.28
Acceptability	T_2	$7.00±0.00^{aP}$	$6.60±0.24^{aP}$	$6.40±0.24^{abP}$	$5.80±0.20^{bcP}$	$5.60±0.24^{cP}$	6.28±0.25

Mean±S.E. with different superscripts row wise (small alphabets-a b c d e f) differ significantly at P<0.05.
Mean±S.E. with different superscripts column wise (capital alphabet-PQ) differ significantly at P<0.05
T_1=Sausages prepared with starter culture *Lactobacillus plantarum* (10^8cfu/g), $T_{2=}$ Sausages prepared with starter culture *Lactobacillus plantarum* (10^8cfu/g) with additional supplementation of 1% each of Dextrose and Starch

Table 7: Effect of frozen storage (-20±1^{0}C) on sensory quality of fermented chicken sausages

Parameter	Group	Day 0	Day 15	Day 30	Day 45	Day 60	Total
General	T_1	$5.80±0.20^{aQ}$	$5.80±0.20^{aQ}$	$5.80±0.20^{aQ}$	$5.60±0.24^{aQ}$	$5.60±0.24^{aQ}$	5.72±0.04
Appearance	T_2	$7.00±0.00^{aP}$	$7.00±0.00^{aP}$	$6.80±0.20^{aP}$	$6.80±0.20^{aP}$	$6.80±0.20^{aP}$	6.88±0.04
Flavour	T_1	$6.00±0.00^{a}$	$6.00±0.00^{a}$	$5.80±0.20^{a}$	$5.80±0.20^{a}$	$5.80±0.20^{a}$	5.88±0.04
	T_2	$6.60±0.24^{a}$	$6.60±0.24^{a}$	$6.40±0.24^{a}$	$6.40±0.24^{a}$	$6.20±0.20^{a}$	6.44±0.07
Texture	T_1	$6.20±0.20^{aQ}$	$6.20±0.20^{aQ}$	$6.00±0.31^{a}$	$6.00±0.00^{aQ}$	$5.60±0.24^{aQ}$	6.00±0.10
	T_2	$7.00±0.00^{aP}$	$7.00±0.00^{aP}$	$6.80±0.20^{a}$	$6.80±0.20^{aP}$	$6.60±0.24^{aP}$	6.84±0.07
Juiciness	T_1	$6.00±0.00^{aQ}$	$6.00±0.00^{aQ}$	$5.80±0.20^{aQ}$	$5.80±0.20^{aQ}$	$5.80±0.20^{aQ}$	5.88±0.04
	T_2	$7.20±0.20^{aP}$	$7.20±0.20^{aP}$	$7.00±0.00^{aP}$	$7.00±0.00^{aP}$	$7.00±0.00^{aP}$	7.08±0.04
Sourness	T_1	$5.80±0.20^{aQ}$	$5.80±0.20^{aQ}$	$5.60±0.24^{aQ}$	$5.60±0.24^{aQ}$	$5.60±0.24^{aQ}$	5.68±0.04
	T_2	$6.80±0.20^{aP}$	$6.80±0.20^{aP}$	$6.80±0.20^{aP}$	$6.60±0.24^{aP}$	$6.60±0.24^{aP}$	6.72±0.04
Overall	T_1	$5.80±0.20^{aQ}$	$5.80±0.20^{aQ}$	$5.80±0.20^{aQ}$	$5.60±0.24^{aQ}$	$5.60±0.24^{aQ}$	5.72±0.04
Acceptability	T_2	$7.00±0.00^{aP}$	$7.00±0.00^{aP}$	$6.80±0.20^{aP}$	$6.80±0.20^{aP}$	$6.80±0.20^{aP}$	6.88±0.04

Mean±S.E. with different superscripts row wise (small alphabets-a b c d e f) differ significantly at P<0.05.
Mean±S.E. with different superscripts column wise (capital alphabet-PQ) differ significantly at P<0.05
T_1=Sausages prepared with starter culture *Lactobacillus plantarum* (10^8 cfu/g), $T_{2=}$ Sausages prepared with starter culture *Lactobacillus plantarum* (10^8cfu/g) with additional supplementation of 1% each of Dextrose and Starch

was generally perceived as more tender, juicier and had a more intense meat taste compared to frozen meat.

CONCLUSION

This study revealed that incorporation of probiotic L. plantarum, along with dextrose and starch, significantly enhanced the antioxidant properties and overall quality of fermented chicken sausages. These improvements translated to extended shelf lives of up to 12 days under refrigerated conditions and a remarkable 60 days under frozen storage, underscoring the potential for tailored fermentation processes to improve food product stability. These findings have valuable implications for the food industry, offering a pathway to produce safer, longer-lasting meat products.

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