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Sensory characteristics of developed probiotic chicken meat spread fermented with *Lactobacillus acidophilus*

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Abstract
The aim of this study was to develop a probiotic chicken meat spread fermented with Lactobacillus acidophilus (LAB) and malted sorghum flour as a substrate, and to assess its quality during storage for 16 days at refrigeration temperature. Chicken meat spread formulations were prepared by adding malted sorghum flour at levels of 0%, 2%, 4%, and 6% as a substrate, along with Lactobacillus acidophilus at a concentration of 1 million cfu/g of product. Different formulations, labeled as C (meat spread only), C1 (meat spread with 0% malted sorghum flour + LAB), T_1 (meat spread with 2% malted sorghum flour + LAB), T_2 (meat spread with 4% malted sorghum flour + LAB), and T_3 (meat spread With 6% malted sorghum flour + LAB), were evaluated for their storage stability at refrigeration temperature for 16 days, with sensory attributes being analyzed. Sensory evaluation of the products revealed a significant ($p \leq 0.05$) decline in color and appearance, flavor, juiciness, texture, sourness, mouth coating, spreadability and overall acceptability in all the groups throughout the study, however, there was a substantial difference which was significant ($p \leq 0.05$) among all the groups indicating the superiority of T_2 group followed by T_1. In conclusion, the addition of 4% malted sorghum flour to chicken meat spread, along with LAB, showed positive effects on its sensory attributes, resulting in Appreciable quality probiotic chicken meat spread.

Keywords: Probiotic, fermentation, chicken meat spread, lactobacillus, sensory

1. Introduction
Poultry is one of the fastest-growing segments of the agricultural sector in India today. While the production of crops has been rising at a rate of 1.5 to 2 percent per annum that of eggs and broilers has been rising at a rate of 8 to 10 percent per annum. The country has exported 664,753.46 MT of Poultry products to the world for the worth of Rs. 1,081.62 Crores/ 134.04 USD Millions during the year 2022-23 (https://apeda.gov.in/apedawebsite/SubHead).

Poultry meat, like other meats, milk, and eggs, has a protein component usually defined as 'high quality'. the average recommended daily intake of protein (i.e. the minimum consumption level required to satisfy the recommended intake for 50% of healthy subjects for adults (both men and women)) is 0.66 g protein/kg body weight per day based on nitrogen balance data, and reaches up to 1.12 g per kg of body weight for infants (Marangoni *et al*., 2015) [17]. Hence, the poultry meat has all the potential to address the protein deficiency widely prevalent in Indian sub population, and considering its acceptability in the non-vegetarian population its role as a animal protein source is more remarkable. Developing snacks or functional products based on chicken will surely enhance its role in alleviating the protein deficiency in the country's affected population.

Spreadable products, such as cheese spread and mayonnaise, are popular convenience foods typically used as toppings or fillings. Meat spread, a cooked spreadable product containing meat, fat, spices, condiments and other additives, is not yet available in the Indian market. Introducing spreadable meat products could bring a new dimension to convenience food processing and marketing in India.

Research indicates that probiotics offer various benefits including enhancing the microbial ecosystem, synthesizing nutrients, improving growth performance, increasing carcass weight, promoting muscle production and improving meat quality preventing enteric diseases and boosting immunity (Li *et al*., 2019) [13]. Supplementation of lambs with probiotics containing *Lacticaseibacillus casei* and *Lactiplantibacillus plantarum* resulted in enhanced tenderness and flavor of meat (Liu *et al*., 2022) [15]. According to Picard and Gagaoua, (2020) [20] probiotics have the potential to regulate muscle fiber characteristics, which play a direct role in carcass yield and meat quality characteristics. The utilization of microorganisms for fermenting meat and meat products is recognized as an efficient preservation technique. Lactic acid bacteria break down carbohydrates, while micrococci convert nitrates and nitrites into nitric oxide, resulting in the production of volatile and nonvolatile compounds and changes in flavor and odor of the product (Lorenzo *et al*., 2013) [16]. Additionally, fermentation imparts various health-promoting properties to fermented meat products compared to non-fermented ones, including antioxidant, antimicrobial, anti-hypertensive, and antithrombotic effects (Ashaolu and Reale, 2020) [2].

Sorghum, a versatile and vital cereal crop, holds significant importance as a dietary staple for millions of people across diverse regions in Africa, Asia, and parts of America. As the fifth most important cereal globally, sorghum plays a crucial role in ensuring food security and economic stability for numerous communities. (ICRISAT, 2023) [7]. Sorghum is a crop from the Gramineae family that is high in carbohydrates and has the scientific name *Sorghum bicolor* L. It is one of the staple crops for millions of semi-arid residents, is also known as “The KING OF MILLETS'. Its main ingredient is starch, which is digested more slowly than in other cereals and also has a low protein and fat digestibility. The onset of non-communicable diseases is significantly influenced by oxidative stress and excessive free radical production. The expression of the phase II enzyme is controlled by sorghum derived phenolic chemicals. These operate as the body's natural defense against oxidative stress by converting highly reactive electrophilic species (RES) into harmless and excretable metabolites (https://apeda.gov.in/milletportal/Sorghum.html). Sorghum is additionally utilized as a gluten-free alternative to wheat in food products (Lim, 2013) [14]. Sorghum grain, specifically Sorghum bicolor, contains various health-promoting phytochemicals, including a diverse range of phenolic compounds. Malting of cereal grains is known to enhance the bioavailability of both macro- and micronutrients. Notably, all varieties of sorghum grains examined were found to be devoid of tannins. Malting was observed to reduce the total phenolic content (TPC) in all samples (Khoddami *et al*., 2017) [11].

Hence keeping all the above facts in view, the present study was designed to develop Probiotic Chicken Meat Spread Fermented with *Lactobacillus acidophilus* to have enhance functional properties. As processing variations result in change in the product characteristics and hence, its acceptability, therefore the present work focuses on the sensory acceptability of the developed product.

2. Materials and Methods

The investigation was conducted in the department of Livestock Products Technology, College of Veterinary Science and Animal Husbandry, Jabalpur.

2.1 Materials

2.1.1 Meat procurement

Dressed chicken carcass was obtained from authorized meat shops in Jabalpur. The carcasses were initially refrigerated at 4±1 °C for 12 hours, followed by manual deboning and stored the deboned meat in a deep freezer at -18 °C until further use.

2.1.2 Additives and other ingredients

Table salt (Tata Chemicals Ltd., Mumbai) and Soyabean oil (Fortune) were procured from the local market.

2.1.3 Condiments mix

Fresh onion, garlic and ginger were procured from the local market of Jabalpur. They were separately peeled and a fine paste was prepared in domestic grinder (Bajaj-make). The condiment mix was prepared by mixing onion, garlic and ginger paste in 3:1:1 ratio and packed in LDPE (Low Density Poly-Ethylene) bags and stored at -18±1 °C till further use.

2.1.4 Spice mix

The spice ingredients were procured from local market of Jabalpur. After cleaning, the spices were oven dried at 45±2 °C for 2 hrs. These ingredients were then ground in domestic grinder (Bajaj-make) and sieved through fine mesh. The fine powders of different spices ingredients so obtained were mixed to prepare the spice mixture and was stored in a moisture proof PET (polyethylene terephthalate) jar till further use.

2.1.5 Chemicals, reagents and media

All the media, chemicals and reagents used were of analytical grade, and were procured from reputed firms for analytical study.

2.1.6 Sorghum

Sorghum was procured from the local market of Jabalpur to prepare malted sorghum flour in the laboratory.

2.1.7 Procurement of starter culture

The required starter culture of *Lactobacillus acidophilus* was procured from the market and were utilized for the product preparation.

2.1.8 Packaging material

Thermo-rigid, airtight PET (polyethylene terephthalate) containers were acquired from the local market and pre-sterilized using ultraviolet light for 30 minutes before use.

2.2 Methods

2.2.1 Preparation of malted sorghum flour

Malted sorghum flour was prepared by soaking whole sorghum grains in water (1:4 ratio) for 4-5 days at 18–20 ºC and after observing visible sprouts, grains were dried under sunlight followed by hot air oven drying at 50 ºC for 30 min. Dried grains were grounded in the mixer grinder to make malted sorghum flour.

2.2.2 Product development
Modified method of Khanam *et al*. (2020) [10] was followed for the preparation of chicken meat spread. Lean chicken meat was cut into small pieces and minced using meat mincer. Salt, spices, condiments and oil were added and the ingredients were thoroughly mixed. The emulsion was then mixed with malted sorghum flour at 2, 4 and 6% levels (10, 20 and 30% respectively as rehydration was done with water in ratio of 1:4). The prepared emulsion was steam cooked for 35 minutes without pressure and the cooked mixture (after cooling to room temperature) was then blended for 2 minutes after adding the starter culture (*Lactobacillus acidophilus* @ 1 million CFU/g meat emulsion) to achieve a fine paste-like consistency, followed by fermentation for 12 hours. Fermentation was optimized at a temperature of 20 °C with a relative humidity of 90±5%. Finally, it was packaged in PET jars followed by storage at refrigeration temperature for evaluation.

The study was conducted using 5 groups i.e., Control group (C), Control group 1 (C1), Treatment group 1 (T_1), Treatment group 2 (T_2) and Treatment group 3 (T_3). The control group (C) where LAB was not added was stored under refrigeration after blending without subjecting it to fermentation.

Table 1: Different treatment groups of chicken meat spread

Groups	Variation in chicken meat spread
C	Meat spread only
C1	Meat spread with 0% malted sorghum flour added +LAB
T_1	Meat spread with 2% malted sorghum flour added +LAB
T_2	Meat spread with 4% malted sorghum flour added +LAB
T_3	Meat spread with 6% malted sorghum flour added +LAB

2.2.3 Storage study of the product
The products were subjected to storage study. Products were stored at refrigeration temperature and samples were analyzed from 0 day at regular intervals of 4 days for a period up to 16 days or spoilage, whichever was earlier. The samples were drawn at 4 days interval for the analysis of sensory evaluation (Keeton, 1983) [8].

2.2.3.1 Sensory evaluation
An eight member experienced panel of judges consisting of teachers and postgraduate students of C.V.Sc and A.H, Jabalpur evaluated the samples for the sensory attributes of colour and appearance, texture, flavour, juiciness etc. using 8-point descriptive scale (Keeton, 1983) [8], where 8=excellent and 1=extremely poor. The test samples were presented to the panelists after assigning the suitable codes. Water was served for rinsing the mouth between the samples for the sensory evaluation.

2.5 Statistical analysis
Data was analyzed statistically on 'SPSS-22.0' (SPSS Inc., Chicago, II USA) software package as per standard methods (Snedecor and Cochran, 1980) [23]. The average values were reported along with standard deviation. The statistical significance was estimated at 5% level ($p \leq 0.05$).

3. Results and Discussion
Different levels of malted sorghum flour i.e. 2%, 4% and 6% was incorporated in pre-standardized formulation of chicken meat spread.

3.1 Sensory properties of chicken meat spread
3.1.1 Colour/ appearance scores: The colour/appearance scores obtained for chicken meat spread stored under refrigeration in C, C1, T_1, T_2 and T_3 samples on 0 day were 7.54, 7.42, 7.63, 7.58 and 7.42 respectively, which gradually decreased in all the groups throughout the study period (Table-04, Fig-02). The study revealed that there was significant ($p \leq 0.05$) change in colour/ appearance scores obtained on subsequent day of storage and on the last day (16th) the scores observed in C, C1, T_1, T_2 and T_3 were 5.75, 5.63, 6.21, 6.17 and 6.08 respectively (Table-02). The observation indicated that the product in all the treatments had acceptable sensory grade on the scale of colour/appearance even when the 16th day of storage was studied. The present study is in agreement with the findings of Pradhan (2019) [21] where he reported that there was a significant decline in colour and general appearance scores as storage days progressed under refrigeration for fermented meat sausages.

The colour/appearance score observed was non significantly ($p \leq 0.05$) different in trials over the study period except on the last day of storage study where a significant ($p \leq 0.05$) difference was observed between the samples containing malted sorghum flour and those without the flour. The study showed that maximum change in colour/ appearance score was observed in C and C1 group with change from day 0 score obtained from 7.54 and 7.42 to 5.75 and 5.63 on day 16 (Table-04) whereas comparatively lesser variation in scores obtained were observed in T_1 and T_2 group. The results are in agreement with those observed by Pradhan (2019) [21], where sensory scores of fermented chicken sausage deteriorated with the progression of storage days. Significantly ($p \leq 0.05$) higher scores recorded in T_1, T_2 and T_3 samples on the last day of storage in comparison to other groups could be due to the appreciable effect of malted sorghum flour along with the *lactobacillus acidophilus* culture. Owusu-Ansah *et al.* (2022) [19] worked on using non-meat ingredients in meat products and concluded that incorporating non-meat ingredients offer various advantages such as colour improvement and stabilization.

Table 2: Colour/appearance scores of the chicken meat spread

S. No.	Treatment	Storage days				
		0	4	8	12	16
1.	C	7.54^{Ad}±0.33	7.17^{Acd}±0.20	7.04^{Ac}±0.25	6.17^{Ab}±0.38	5.75^{Aa}±0.50
2.	C1	7.42^{Ac}±0.49	7.27^{Ac}±0.28	7.00^{Ac}±0.22	6.13^{Ab}±0.38	5.63^{Aa}±0.44
3.	T_1	7.63^{Ad}±0.49	7.29^{Acd}±0.25	6.96^{Abc}±0.64	6.50^{Aab}±0.35	6.21^{Ba}±0.33
4.	T_2	7.58^{Ac}±0.26	7.17^{Ab}±0.20	6.92^{Ab}±0.34	6.42^{Aa}±0.13	6.17^{Ba}±0.20
5.	T_3	7.42^{Ab}±0.41	7.17^{Ab}±0.41	7.00^{Ab}±0.63	6.25^{Aa}±0.42	6.08^{Ba}±0.26

Means (Mean ± SD, n=6) with different superscripts in upper case in a column and lower case in a row differ significantly ($p \leq 0.05$).C = Control, C1= 0% malted sorghum flour + LAB, T_1 = 2% malted sorghum flour + LAB, T_2 = 4% malted sorghum flour + LAB, T_3 = 6% malted sorghum flour + LAB.

3.1.2 Flavour scores

The flavour scores of chicken meat spread stored under refrigeration revealed that in C, C1, T_1, T_2 and T_3 on 0 day the observations were 7.46, 7.58, 7.71, 7.75 and 7.67 respectively, which gradually showed decrease throughout the study (Table-05, Fig-03). The study shows that there was significant ($p\leq0.05$) change in flavour on subsequent day of storage and on the last day (16th) the scores noticed in C, C1, T_1, T_2 and T_3 were 5.50, 5.88, 6.71, 6.75 and 6.08 respectively (Table-03). The current study is in agreement with Owusu-Ansah *et al.* (2022) [19] and Ranade *et al.* (2022) [22]. This decrease in flavour may be due to development of off flavours caused by the enhance ed levels of TBA, FFA and titratable acidity noticed with the progress of storage period. However flavour in all the fermented samples were within the acceptable limit and ranged from moderate to very high ranking. de Marins *et al*. (2022) [4] found similar results while studying the effect of fermentation on cooked burger.

When the comparison was done between different group it was noticed that the flavour scores in T_1 and T_2 samples were significantly ($p\leq0.05$) higher than other groups on the 12th and 16th day of study. The study shows that highest flavour loss was observed in C and C1 group with change from day 0 flavour from 7.46 and 7.58 to 5.50 and 5.88 respectively on day 16 (Table-03) whereas comparatively lesser change in flavour was observed in T_2 group with 7.75 on day 0 to 6.75 on day 16 (Table-03). Similar results were observed by Arya *et al.* (2017) [1] and Pradhan (2019) [21]. Significantly ($p\leq0.05$) superior scores recorded for T_1 and T_2 samples on the 12th and 16th day of storage in comparison to C and C1 indicated that chicken meat spread containing 2 and 4% malted sorghum flour respectively with *Lactobacillus acidophilus* were more acceptable for flavour than the samples where the flour was not included in the formulation. Ranade *et al.* (2022) [22] concluded in an experiment on development and quality evaluation of spent hen meat spread incorporated with corn starch that the 6% corn starch variant received significantly ($p\leq0.05$) higher flavour scores, possibly due to starch granule expansion during cooking. However, the significant ($p\leq0.05$) difference observed between T_2 and T_3 could be due to higher TBA, FFA and TA scores observed in T_3 samples which might have impacted the flavour scores of T_3 samples indicating the masking effect on the effect of sorghum flour.

Table 3: Flavour scores of the chicken meat spread

S. No.	Treatment	Storage days				
		0	4	8	12	16
1.	C	$7.46^{Ad}\pm0.25$	$6.96^{Ac}\pm0.56$	$6.46^{Ab}\pm0.46$	$5.96^{Aa}\pm0.25$	$5.50^{Aa}\pm0.47$
2.	C1	$7.58^{Ac}\pm0.34$	$6.92^{Ab}\pm0.52$	$6.54^{Ab}\pm0.19$	$5.92^{Aa}\pm0.38$	$5.88^{ABa}\pm0.21$
3.	T_1	$7.71^{Ab}\pm0.40$	$7.04^{Aa}\pm0.29$	$6.79^{Aa}\pm0.51$	$6.75^{Ba}\pm0.50$	$6.71^{Ca}\pm0.60$
4.	T_2	$7.75^{Ab}\pm0.32$	$7.18^{Aa}\pm0.22$	$6.83^{Aa}\pm0.41$	$6.75^{Ba}\pm0.50$	$6.75^{Ca}\pm0.32$
5.	T_3	$7.67^{Ac}\pm0.47$	$7.00^{Ab}\pm0.16$	$6.63^{Ab}\pm0.14$	$6.17^{Aa}\pm0.41$	$6.08^{Ba}\pm0.34$

Means (Mean ± SD, n=6) with different superscripts in upper case in a column and lower case in a row differ significantly ($p\leq0.05$).C = Control, C1= 0% malted sorghum flour + LAB, T_1 = 2% malted sorghum flour + LAB, T_2 = 4% malted sorghum flour + LAB, T_3 = 6% malted sorghum flour + LAB.

3.1.3 Juiciness scores

The juiciness scores of chicken meat spread during storage in C, C1 T_1, T_2 and T_3 on 0 day was found to be 7.21, 7.21, 7.58, 7.79 and 7.42 respectively, which gradually decreased with the progress of study period (Table-04). The study showed that there was significant ($p\leq0.05$) change of juiciness scores on continuation of storage and the samples evaluated on the last day (16th) showed that in C, C1, T_1, T_2 and T_3 the scores were 5.92, 5.88, 6.46, 6.50 and 6.13 respectively (Table-04). The scores also revealed that the product in T_1, T_2 and T_3 treatments were of moderate to extremely juiciness scores even on the 16th day of storage in comparison to C and C1 where scores fell below 6.0 indicating noticeable low score. The study is in agreement with de Marins *et al*. (2022) [4] who observed the addition of probiotics to burgers didn't impact their sensory acceptance, a crucial factor in consumer choice; scores for attributes like texture ranged from moderate to very high liking.

The juiciness scores revealed that the observation was significantly ($p\leq0.05$) different for T_1 and T_2 trials when compared to C and C1 samples throughout the storage period except the scores observed on 4th day. The study showed that maximum juiciness value was observed in T_2 group with change from day 0 juiciness grades from 7.79 to 6.50 on day 16 (Table-04) whereas comparatively considerable change in juiciness scores were observed in C1 group with 7.21 on day 0 to 5.88 on day 16 (Table-04). The T_2 samples had significantly ($p\leq0.05$) superior scores in comparison to T_3 samples in majority of the observations, indicating the optimization effect of malted sorghum flour and *Lactobacillus* culture. This could have been due to less acceptability of higher sorghum flour and higher fermentation affecting the juiciness of the product. Although Owusu-Ansah *et al*. (2022) [19] reviewed on using non-meat ingredients in meat products and concluded that incorporating non-meat ingredients offer various advantages such as increased water-holding capacity. They found that non-meat ingredients notably influence sensory attributes like juiciness of processed meat products, with generally positive acceptance, but at the same time observed that waxy starches produce high viscosity and reduce purge of fluid from product which might have resulted in reduction in juiciness on increased malted sorghum flour concentration in the spread.

Table 4: Juiciness scores of the chicken meat spread

S. No.	Treatment	Storage days				
		0	4	8	12	16
1.	C	$7.21^{Ad}\pm0.19$	$6.71^{Ac}\pm0.40$	$6.50^{Abc}\pm0.27$	$6.17^{Aab}\pm0.13$	$5.92^{Aa}\pm0.47$
2.	C1	$7.21^{Ad}\pm0.10$	$6.88^{Ac}\pm0.14$	$6.50^{Ab}\pm0.16$	$6.13^{Aa}\pm0.14$	$5.88^{Aa}\pm0.44$
3.	T_1	$7.58^{BCb}\pm0.47$	$6.92^{Aa}\pm0.20$	$6.88^{Ba}\pm0.31$	$6.58^{BCa}\pm0.41$	$6.46^{Ca}\pm0.46$
4.	T_2	$7.79^{Cb}\pm0.25$	$7.00^{Aa}\pm0.63$	$6.96^{BCa}\pm0.43$	$6.67^{Ca}\pm0.47$	$6.50^{Ca}\pm0.35$
5.	T_3	$7.42^{ABd}\pm0.13$	$7.00^{Ac}\pm0.16$	$6.62^{ABb}\pm0.20$	$6.25^{ABa}\pm0.32$	$6.13^{ABa}\pm0.21$

Means (Mean ± SD, n=6) with different superscripts in upper case in a column and lower case in a row differ significantly ($p\leq0.05$).C = Control, C1= 0% malted sorghum flour + LAB, T_1 = 2% malted sorghum flour + LAB, T_2 = 4% malted sorghum flour + LAB, T_3 = 6% malted sorghum flour + LAB.

3.1.4 Texture scores

The texture scores of chicken meat spread stored under refrigeration in C, C1, T_1, T_2 and T_3 on 0 day was 7.21, 7.25, 7.46, 7.46 and 7.33 respectively, and they gradually decreased with the storage of the product (Table-05). During the last day of the storage significantly ($p\leq0.05$) higher texture value was found in T_1 and T_2 in comparison to C, C1 and T_3, however overall, a significant ($p\leq0.05$) decrease in scores were noticed with the storage in all the groups under study. The present study co-relates with Pradhan (2019) [21], that the sensory scores were initially higher in treatment group but decreased over storage. According to Owusu-Ansah *et al*. (2022) [19], waxy starches produce high viscosity and weak gels in products. This may explain reduction in texture scores on increased malted sorghum flour concentration in the meat spread samples of T_3. The scores also revealed that the product in T_1 and T_2 samples had moderate to extremely desirable texture throughout the storage and in control groups (C and C1) the scores recorded were below 6.0 on the 16th day indicating considerable fall in the scores. In a similar study, de Marins *et al*. (2022) [4] conducted an experiment on effect of the addition of culture to cooked burger and concluded that the addition of probiotics to burgers didn't impact their sensory acceptance, a crucial factor in consumer choice; scores for attributes like texture, ranged from moderate to very high liking. However, contrary to the present finding, Pradhan (2019) [21] reported that parameters like texture were least affected with the storage of product.

During the storage of the product T_1 and T_2 showed minimum decrease in value from 0 day 7.46 to 6.08 on day 16 and 0 day 7.46 to 6.00 on day 16 respectively in comparison to control showing maximum decrease in value from 0 day 7.21 to 5.50 on day 16 (Table-05). The samples T_1 and T_2 had superior score for texture in comparison to the C and C1 where sorghum flour was not incorporated. In agreement to present study Ranade *et al*. (2022) [22] reported that the products with 6% and 8% corn starch levels, used for development of meat spread had similar trend in texture scores.

Table 5: Texture scores of the chicken meat spread

S. No.	Treatment	Storage days				
		0	4	8	12	16
1.	C	7.21Ae±0.10	6.83ABd±0.13	6.38Ac±0.14	5.88Ab±0.14	5.50Aa±0.32
2.	C1	7.25ABe±0.16	6.88Ad±0.14	6.38Ac±0.21	6.00Ab±0.16	5.71ABa±0.37
3.	T_1	7.46Bc±0.25	7.17BCc±0.26	6.58Ab±0.26	6.17Aa±0.41	6.08Ca±0.34
4.	T_2	7.46Bc±0.25	7.21Cc±0.25	6.63Ab±0.31	6.21Aa±0.25	6.00Ca±0.27
5.	T_3	7.33ABe±0.13	6.92ABd±0.26	6.46Ac±0.29	6.08Ab±0.34	5.75ABa±0.27

Means (Mean ± SD, n=6) with different superscripts in upper case in a column and lower case in a row differ significantly ($p\leq0.05$).C = Control, C1= 0% malted sorghum flour + LAB, T_1 = 2% malted sorghum flour + LAB, T_2 = 4% malted sorghum flour + LAB, T_3 = 6% malted sorghum flour + LAB.

3.1.5 Sourness acceptability scores

The scores for sourness acceptability of chicken meat spread during storage in C, C1 T_1, T_2 and T_3 on 0 day was found to be 7.33, 7.33, 7.71, 7.71 and 7.29 respectively, which gradually decreased with the progress of study period (Table-08, Fig-06). The study shows that there was significant ($p\leq0.05$) change in sourness acceptability scores on subsequent day of storage and the samples evaluated on the last day (16th) showed that in C, C1, T_1, T_2 and T_3 the scores were 6.13, 6.08, 6.04, 6.17 and 5.75 respectively (Table-06). The scores also revealed that the product in all the groups except T_3 were of moderately to extremely desirable grade on the 16th day of storage however the T_3 samples had scores below 6.0 indicating slightly desirable category. This could have been due to higher substrate as malted sorghum flour supporting maximum fermentation and producing highest sourness in the product. However, it was observed that to some extent the sourness was desired in the product as indicated by the scores of C1, T_1 and T_2. The study is in agreement with de Marins *et al*. (2022) [4] who reported reduced sourness acceptability scores resulting from excessive fermentation and increased acid production in the products during storage.

The sourness acceptability scores revealed that the observation was significantly ($p\leq0.05$) higher in trials from T_1 and T_2 when compared to T_3 samples. The study showed that minimum sourness acceptability value was observed in T_3 group with change from day 0 sourness acceptability scores from 7.29 to 5.75 on day 16 (Table-06) whereas comparatively lesser change in sourness scores were observed in T_2 group with 7.71 on day 0 to 6.17 on day 16 (Table-06). The T_2 samples significantly ($p\leq0.05$) superior scores in comparison T_3 indicated that the tanginess developed due to intermediate amount of acidity developed in T_2 as compared to T_3, was preferred by taste panel. Due to the production of lactic acid the sourness acceptability value decreased along with storage period. This is in accordance with results observed by Pradhan (2019) [21] and de Marins *et al.* (2022) [4] in their study on meat products.

Table 6: Sourness acceptability scores of the chicken meat spread

S. No.	Treatment	Storage days				
		0	4	8	12	16
1.	C	$7.33^{ABd}\pm0.26$	$7.12^{ABcd}\pm0.34$	$6.87^{Abc}\pm0.44$	$6.54^{Bb}\pm0.43$	$6.13^{Ba}\pm0.14$
2.	C_1	$7.33^{ABc}\pm0.26$	$7.13^{ABc}\pm0.34$	$6.67^{Ab}\pm0.30$	$6.38^{Bab}\pm0.41$	$6.08^{Ba}\pm0.20$
3.	T_1	$7.71^{Bc}\pm0.37$	$7.42^{Bc}\pm0.26$	$6.88^{Ab}\pm0.38$	$6.54^{Bb}\pm0.43$	$6.04^{Ba}\pm0.19$
4.	T_2	$7.71^{Bd}\pm0.37$	$7.42^{Bd}\pm0.26$	$6.96^{Ac}\pm0.33$	$6.58^{Bb}\pm0.34$	$6.17^{Ba}\pm0.20$
5.	T_3	$7.29^{Ac}\pm0.29$	$6.88^{Ab}\pm0.31$	$6.50^{Ab}\pm0.42$	$5.83^{Aa}\pm0.26$	$5.75^{Aa}\pm0.39$

Means (Mean ± SD, n=6) with different superscripts in upper case in a column and lower case in a row differ significantly ($p\leq0.05$).C = Control, C1= 0% malted sorghum flour + LAB, T_1 = 2% malted sorghum flour + LAB, T_2 = 4% malted sorghum flour + LAB, T_3 = 6% malted sorghum flour + LAB.

3.1.6 Mouth coating scores

The mouth coating scores of chicken meat spread during storage in C, C1 T_1, T_2 and T_3 on 0 day was found to be 7.16, 7.21, 7.50, 7.54 and 7.29 respectively, which gradually decreased with the progress of study period (Table-07). The study showed that there was significant ($p\leq0.05$) change in mouth coating scores on subsequent day of storage and the samples evaluated on the last day (16^{th}) showed that in C, C1, T_1, T_2 and T_3 the scores were 5.87, 5.75, 6.04, 6.17 and 5.88 respectively (Table-07). The scores also revealed that the product in all the groups except T_1 and T_2 was of slightly fine grade and scores well below 6.0 on the 16^{th} day of storage and moderately fine mouth coating was observed only in T_1 and T_2. This could have been due to acceptability of malted sorghum flour at 2 and 4% level, which was comparatively less acceptable at the 6% level and even the samples without sorghum flour had less score for this parameter, again indicating some effect of the combination of malted sorghum flour and LAB in enhancing the mouth coating scores. Similar results have been reported by Khanam (2017) [9] where chicken meat spread had decreasing scores for the mouth coating characteristics with the progress of storage period.

The mouth coating scores revealed that the observation was significantly ($p\leq0.05$) different in trials for the T_2 samples in majority of the observations when compared with other groups. The study showed that extremely fine mouth coating value was observed in T_2 group with change from day 0 sourness grades from 7.54 to 6.17 on day 16 (Table-07) whereas moderately fine mouth coating scores was observed in T_3 group with 7.29 on day 0 to 5.88 on day 16 (Table-07). The T_2 samples with superior scores indicated the combined optimum effect of malted sorghum flour and lactobacillus culture. Due to the production of lactic acid the mouth coating value decreases along with storage period and same was the reason for the T_3 samples lower scores. Similar results were observed by Khanam (2017) [9] and Owusu-Ansah *et al.* (2022) [19].

Table 7: Mouth coating scores of the chicken meat spread

S. No.	Treatment	Storage days				
		0	4	8	12	16
1.	C	$7.16^{Ad}\pm0.13$	$6.95^{Acd}\pm0.25$	$6.58^{ABbc}\pm0.26$	$6.17^{ABab}\pm0.66$	$5.87^{Aa}\pm0.44$
2.	C_1	$7.21^{ABc}\pm0.19$	$7.13^{Ac}\pm0.34$	$6.46^{Ab}\pm0.40$	$6.21^{Aab}\pm0.43$	$5.75^{Aa}\pm0.47$
3.	T_1	$7.50^{ABd}\pm0.22$	$7.33^{Bd}\pm0.30$	$6.79^{BCc}\pm0.25$	$6.46^{CDb}\pm0.37$	$6.04^{Ba}\pm0.19$
4.	T_2	$7.54^{Bc}\pm0.43$	$7.29^{Bc}\pm0.29$	$6.71^{Cb}\pm0.40$	$6.50^{Dab}\pm0.32$	$6.17^{Ba}\pm0.38$
5.	T_3	$7.29^{ABb}\pm0.29$	$7.04^{Bb}\pm0.33$	$6.21^{ABCa}\pm0.33$	$6.00^{BCa}\pm0.32$	$5.88^{ABa}\pm0.31$

Means (Mean ± SD, n=6) with different superscripts in upper case in a column and lower case in a row differ significantly ($p\leq0.05$).C = Control, C1= 0% malted sorghum flour + LAB, T_1 = 2% malted sorghum flour + LAB, T_2 = 4% malted sorghum flour + LAB, T_3 = 6% malted sorghum flour + LAB.

3.1.7 Spreadability scores

The Spreadability scores of chicken meat spread during storage in C, C1 T_1, T_2 and T_3 on 0 day were found to be 6.95, 7.00, 7.71, 7.71 and 7.63 respectively, which gradually decreased with the progress of study period (Table-8). The study showed that there was significant ($p\leq0.05$) change in spreadability scores on subsequent day of storage and the samples evaluated on the last day (16^{th}) showed that in C, C1, T_1, T_2 and T_3 the scores were 5.83, 5.75, 6.33, 6.54 and 6.17 respectively (Table-8). The scores also revealed that the product in all the sorghum flour containing treatments were of moderately spreadable grade on the 16^{th} day of storage and acceptable to the panel. The study is in agreement with Ranade *et al.* (2022) [22] indicating ease of spreading, with the increasing content of starch level, albeit decreasing at the highest level, potentially due to protein dilution by starch.

The spreadability scores revealed that the observation was significantly ($p\leq0.05$) different in for the T_1 and T_2 treatments when compared with other groups throughout the study period. The study showed that maximum spreadable scores were observed in T_2 group with change from day 0 spreadability grades from 7.71 to 6.54 on day 16 (Table-8) whereas comparatively lesser change in Spreadability grade was observed in T_3 group with 7.63 on day 0 to 6.17 on day 16 (Table-8). The T_2 samples had numerically superior scores even when compared to T_3 samples from the 0 day onwards indicating the combined effect of malted sorghum flour and LAB where it can be deduced that acceptability of sorgum flour and LAB combined effect was reduced with increase in sorghum flour. The similar results were observed by Ranade *et al*. (2022) [22] indicating the adhesive ability showed non-significant differences between control and 8% corn starch variants, possibly due to gel formation between starch granules and meat proteins, as proposed by the observed increase in adhesive scores with rising starch levels.

Table 8: Spreadability scores of the chicken meat spread

S. No.	Treatment	Storage days				
		0	4	8	12	16
1.	C	6.95^{Ac}±0.37	6.92^{Ac}±0.44	6.54^{ABbc}±0.40	6.20^{ABab}±0.25	5.83^{Aa}±0.49
2.	C1	7.00^{Ac}±0.32	6.88^{Abc}±0.26	6.50^{Ab}±0.35	6.08^{Aa}±0.34	5.75^{Aa}±0.42
3.	T_1	7.71^{Bc}±0.37	7.42^{Bc}±0.26	6.96^{BCb}±0.33	6.71^{CDab}±0.37	6.33^{Ba}±0.34
4.	T_2	7.71^{Bc}±0.37	7.42^{Bc}±0.26	7.00^{Cb}±0.35	6.83^{Dab}±0.20	6.54^{Ba}±0.29
5.	T_3	7.63^{Bd}±0.34	7.29^{Bc}±0.25	6.83^{ABCb}±0.20	6.46^{BCa}±0.25	6.17^{ABa}±0.20

Means (Mean ± SD, n=6) with different superscripts in upper case in a column and lower case in a row differ significantly ($p \leq 0.05$).C = Control, C1= 0% malted sorghum flour + LAB, T_1 = 2% malted sorghum flour + LAB, T_2 = 4% malted sorghum flour + LAB, T_3 = 6% malted sorghum flour + LAB.

3.1.8 Overall acceptability scores

The overall acceptance scores of chicken meat spread in C, C1, T_1, T_2 and T_3 on 0 day was reported as 7.33, 7.33, 7.67, 7.71 and 7.29 respectively. The scores constantly decreased in all groups throughout the study (Table-9). The investigation revealed that there was significant ($p \leq 0.05$) change in overall acceptance grades on subsequent day of storage. The samples were evaluated, on the last day (16th) and the scores observed for C, C1, T_1, T_2 and T_3 were 5.91, 6.08, 6.33, 6.46 and 5.92 respectively (Table-9).The study indicated lesser fall in scores for the samples studied under T_1 and T_2 categories in comparison to C and T_3 samples. This could have been due to overall effect of different sensory parameters like colour, flavour, juiciness, texture etc. Similar findings have been reported by Arya *et al*. (2017) [1], Pradhan (2019) [21] and Ranade *et al*. (2022) [22].

With the time the overall acceptance scores gradually reduced in all the samples under study, however the observation was significantly ($p \leq 0.05$) different in trials on the 16th day in T_2 samples when compared with C and T_3, although numerically superior scores for the T_2 were there throughout the study period in comparison to all other samples. The study showed that utmost overall acceptance was observed in T_2 group in comparison to other samples. However, the scores also revealed that the product in C1, T_1 and T_2 treatments were of moderate acceptance even on the last day of storage and in C and T_3 fell below the 6.0 indicating slight acceptability on the 16th day of storage. Hence the sensory scores indicated that the T_2 product was acceptable with highest sensory scores throughout the study. Reduction in overall acceptability scores of meat spread was also reported by Ranade *et al*., (2022) [22] where it was reported that overall acceptability mirrored other sensory parameters, with the 6% corn starch variant exhibiting significantly ($p \leq 0.05$) higher scores across all attributes compared to other treatments including the 8% corn starch and the control, suggesting its superior sensory appeal.

Table 9: Overall acceptability scores of the chicken meat spread

S. No.	Treatment	Storage days				
		0	4	8	12	16
1.	C	7.33^{Ac}±0.26	7.04^{Abc}±0.29	6.70^{Ab}±0.33	6.25^{Aa}±0.42	5.91^{Aa}±0.38
2.	C1	7.33^{Ac}±0.26	7.13^{Ac}±0.34	6.67^{Ab}±0.30	6.38^{Aab}±0.41	6.08^{ABa}±0.20
3.	T_1	7.67^{Ad}±0.44	7.29^{Acd}±0.25	6.96^{Abc}±0.33	6.54^{Aab}±0.43	6.33^{Ba}±0.34
4.	T_2	7.71^{Ac}±0.37	7.42^{Ac}±0.26	7.00^{Ab}±0.32	6.67^{Aab}±0.38	6.46^{Ba}±0.19
5.	T_3	7.29^{Ac}±0.29	7.04^{Abc}±0.33	6.67^{Ab}±0.38	6.25^{Aa}±0.27	5.92^{Aa}±0.34

Means (Mean ± SD, n=6) with different superscripts in upper case in a column and lower case in a row differ significantly ($p \leq 0.05$).C = Control, C1= 0% malted sorghum flour + LAB, T_1 = 2% malted sorghum flour + LAB, T_2 = 4% malted sorghum flour + LAB, T_3 = 6% malted sorghum flour + LAB.

4. Conclusions

Sensory attributes of the products revealed a significant ($p \leq 0.05$) decline for the scores in all the groups throughout the study, however, there was a substantial difference which significantly ($p \leq 0.05$) indicated the superiority of T_2 group followed by T_1 and T_3.

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