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Cost economics of developed probiotic chicken meat spread fermented with *Lactobacillus acidophilus*

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Abstract

The objective of this research was to develop a probiotic chicken meat spread fermented with *Lactobacillus acidophilus* (LAB-Lactic acid bacteria)) and malted sorghum (millet) flour as a substrate, and to evaluate its quality as a fresh product and during storage for 16 days at refrigeration temperature. The chicken meat spread was prepared by adding malted sorghum flour at levels of 0%, 2%, 4%, and 6% as a substrate in the product formulation, along with *Lactobacillus acidophilus* at a concentration of 1 million cfu/g of product. Various formulations of the product were prepared: C (meat spread only), C_1 (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). The sensory parameters revealed that there was a substantial difference which was significant ($p \leq 0.05$) indicating the superiority of T_2 group followed by T_1. Hence, the addition of 4% malted sorghum flour to chicken meat spread, along with LAB, showed appreciable effects on its sensory attributes, resulting in appreciable quality probiotic chicken meat spread. The cost economics analysis revealed that final cost of chicken meat spread estimated per kg ranged as Rs. 396.20, 413.70, 376.29, 338.35 and 307.43 in C, C_1, T_1, T_2 and T_3 respectively.

Keywords: Cost economics, probiotic chicken meat spread, *Lactobacillus acidophilus*, LAB

Introduction

In 2022, India's meat production reached 9.29 million tonnes, with chicken contributing the largest share (DAHD, 2022) [6]. Poultry meat production in India specifically amounted to 4.2 million tons. Over the past twenty years, the demand for poultry meat has surged, with it now representing approximately 45% of total meat consumption and standing as the preferred meat from any singular livestock species. Poultry meat has become a popular consumer choice due to its affordability, nutritional value, widespread availability and lack of religious restrictions.

Spreadable products, a type of convenient snack designed to be spread on or sandwiched between a base such as bread, are commonly used to enhance the flavor and texture of food items that may otherwise be considered bland. While cheese spread, mayonnaise, jam, and jelly are readily available in the Indian snack market, spreadable meat products are not yet widespread among Indian consumers. Today's consumers prioritize health consciousness and consider various factors such as pricing, availability, choice, sustainability, palatability, safety and health when selecting convenience foods. The global meat snacks market is experiencing growth due to factors such as the demand for low-calorie, high-protein food products and increasing health and fitness awareness among consumers (Troy and Kerry, 2010) [13]. Chicken meat aligns well with these requirements, making it a suitable option for the development of spreadable meat products. Meat spread is value added convenient product containing various ingredients like meat, fat, spices and other food additives. The product is cooked to make it palatable, digestible and microbiologically safe. Meat products undergo many changes during cooking, including weight loss, modifications of water holding capacity, texture, colour etc. (Khanam *et al*., 2020) [4].

With the advancement of the food industry and increased understanding of fermented meat products, the use of starter cultures has emerged as a significant strategy for enhancing processing control and quality (Laranjo *et al*., 2019) [5]. Among the various options available for starter cultures in

fermented meat products, there is a growing interest among researchers in selecting microorganisms that offer additional health benefits (Sirini *et al*., 2021) [11]. Particularly, there has been a focus on probiotics, which are live microorganisms capable of providing health benefits when consumed in sufficient quantities and altering the gut microbiome (Binda *et al*., 2020) [1]. LAB strains typically employed as starters in fermented meat products are typically facultative anaerobes, predominantly belonging to the genera Lactobacillus, Leuconostoc, Pediococcus, Lactococcus, and Enterococcus (Fraqueza *et al*., 2016) [3]. Sorghum, also known as Jowar or the "King of millets," is a crucial staple cereal for millions of individuals, primarily in Africa, India, and central Asia. India boasts the largest share (32.3%) of global sorghum cultivation and ranks second in production after the US. It holds the fifth position among major cereal crops worldwide, following wheat, rice, maize, and barley. In terms of acreage, sorghum ranks fifth and contributes 3.5% to total cereal grain production (FAO, 2002) [2]. Malting serves as a significant processing method that enhances the *in-vitro* digestibility of proteins and availability of minerals by reducing anti-nutritional factors such as tannins and phytates. Through malting, sorghum grain components undergo modification, leading to a decrease in starch gelatinization temperature and an increase in the water-holding capacity of sorghum flour. Consequently, the properties of sorghum flour are improved, making it more suitable for bread preparation (Sharma *et al*., 2014) [10]. Furthermore, there is a growing trend in utilizing sorghum as an industrial raw material for producing snack products like bread, biscuits, confectionery, and weaning foods. Sorghum has been identified as an excellent substitute for wheat in composite flours, with a wheat and sorghum ratio of 70:30 proving to be optimal for bread preparation due to its nutritional significance (Omary *et al*., 2012) [7]. As incorporation substrate in the form of malted sorghum flour may affect the sensory acceptability of the fermented product. Hence the present study was taken up with an objective to develop a probiotic chicken meat spread fermented with *Lactobacillus acidophilus* and assess its sensory acceptance along with cost economics.

Materials and Methods

The present study was performed in various phases. The investigation was conducted in the department of Livestock Products Technology, College of Veterinary Science and Animal Husbandry, Jabalpur. Here relevant information pertaining to raw material, research design and methodological steps used in investigation have been discussed.

Source of raw material

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. Table salt (Tata Chemicals Ltd., Mumbai) and Soyabean oil (Fortune) were procured from the local market. 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 bags and stored at -18±1 °C till further use. 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.

All the media, chemicals and reagents of analytical grade, required for various analysis were procured from reputed firms for analytical study. Sorghum was procured from the local market of Jabalpur to prepare malted sorghum flour in the laboratory. The required starter culture of *Lactobacillus acidophilus* was procured from the market and were utilized for the product preparation. Thermo-rigid, airtight PET (polyethylene terephthalate) containers were acquired from the local market and pre-sterilized using ultraviolet light for 30 minutes before use.

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.

Product development

Modified method of Khanam *et al*. (2020) [4] 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) Table 1. 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.

Table 1: Formulation used for preparation of chicken meat spread

S. No.	Ingredients	Percentage (%)				
		C	C_1	T_1	T_2	T_3
1.	Chicken meat	86	86	76	66	56
2.	Soyabean oil	6	6	6	6	6
3.	Condiments	3	3	3	3	3
4.	Spice mix	3	3	3	3	3
5.	Salt	2	2	2	2	2
6.	Water	-	-	8	16	24
7.	Malted sorghum flour	-	-	2	4	6
Total		100	100	100	100	100

The study was conducted between 5 groups (Table 2) i.e., Control group (C), Control group 1 (C_1), 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 2: Different treatment groups of chicken meat spread

Groups	Variation in chicken meat spread
C	Meat spread only
C_1	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

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) [14], 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.

Cost economics

The cost economics of the developed product was analyzed for respective samples. While calculating the cost of products a detailed expenses were taken into account for the preparation of 50 kg chicken meat spread of different trials per day. The capital investment and annual depreciation was taken into account for the analysis of cost economics of the developed product.

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). The average values were reported along with standard deviation. The statistical significance was estimated at 5% level ($p \leq 0.05$).

Results and Discussion

Sensory acceptability

The colour/appearance and flavour score observed were non significantly ($p \leq 0.05$) different in trials during the study. The juiciness scores revealed that the observations were significantly ($p \leq 0.05$) different for T_1 and T_2 trials when compared to C and C_1 samples. The study showed that maximum juiciness value was observed in T_2 group with juiciness grades from 7.79 whereas comparatively considerable value in juiciness scores were observed in C_1 group with 7.21 (Fig-1). The samples T_1 and T_2 had superior score for texture in comparison to the C and C_1 where sorghum flour was not incorporated. In agreement to present study Ranade *et al*. (2022) [9] reported that the products with 6% and 8% corn starch levels, used for development of meat spread had similar trend in texture scores. The sourness acceptability scores revealed that the observation was significantly ($p \leq 0.05$) higher in trials from T_1 and T_2 when compared to T_3 samples. The mouth coating scores revealed that the observation was significantly ($p \leq 0.05$) different in trial for the T_2 samples in the observations when compared with other groups. The spreadability scores revealed that the observation was significantly ($p \leq 0.05$) different in for the T_1 and T_2 treatments when compared with other groups during the study. The study showed that utmost overall acceptance was observed in T_2 group in comparison to other samples, Indicating the acceptance of substrate (malted sorghum flour) at 4% level and overall the different sensory parameters indicated the similar trend in strengthening the sensory acceptability of the T_2 products.

Pradhan (2019) [8] in a study on assessment of functional attributes of chicken sausages prepared from minced chicken meat fermented with Lactobacillus plantarum and malted barley flour as substrate, reported that there was a significant ($p<0.01$) decline in sourness, color and general appearance scores as storage days progressed under refrigeration. However, parameters like flavor, texture, juiciness and overall acceptability were less affected. Khanam *et al*. (2020) [4] studied to optimize the processing technology of chicken meat spreads and concluded that overall mean decreased from 7.07±0.05 to 5.50±0.09 during storage between 0 to 35th day for the mouth coating scores of the product.

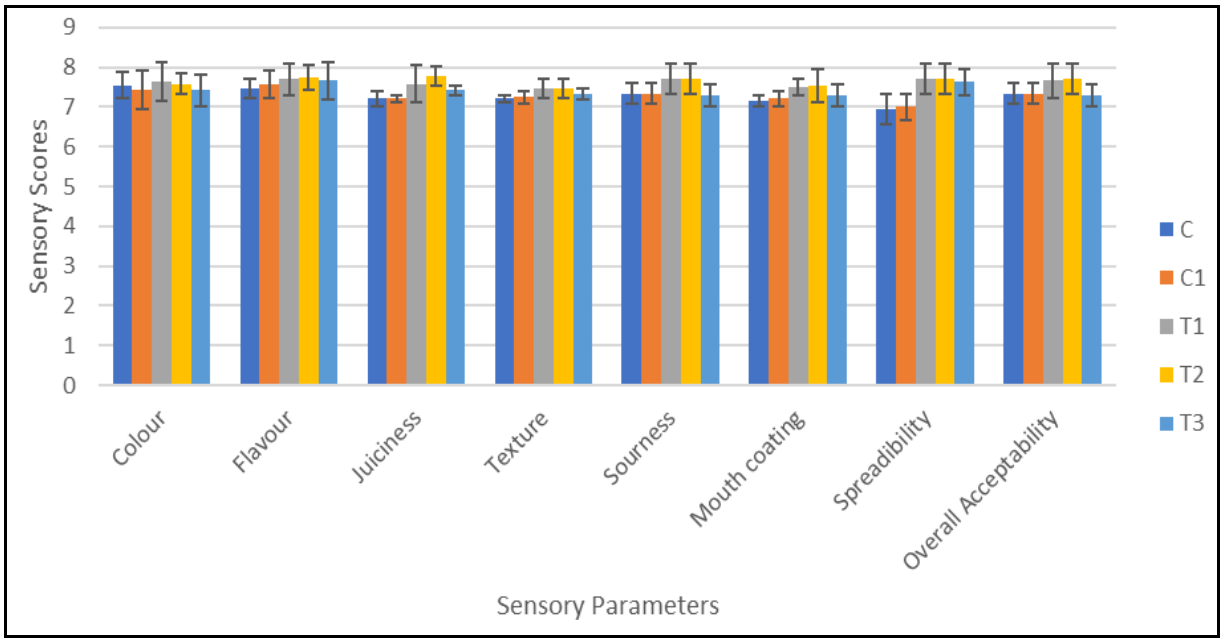

Fig 1: Sensory evaluation of the developed product on 8 point hedonic scale

Cost economics

Production cost of chicken meat spread was estimated by keeping in view the different types of costs involved in a small scale meat processing plant. A total of 300 working days were presumed in an annual calendar, with a capacity to produce 50 kg product per day. To process this much of meat it would take around Rs. 92460 as an initial major capital investment (Table 3). Taking into the account of formulation, the rate for meat per kg varied in different treatments (Table 4). Detailed breakup of the cost regarding raw materials, labour charges, power utility and other charges is presented in Table 04 and 05. To calculate the final yield of products weight of all the ingredients and product yield have been taken into consideration. The final cost of chicken meat spread estimated per kg ranged as Rs 396.20, 413.70, 376.29, 338.35 and 307.43 in C, C_1, T_1, T_2 and T_3 respectively (Table 5). The cost economics came to be lowest for T_3 and highest for C.

Table 3: Major capital investment with cost and annual depreciation for production of 50 kg of chicken meat spread per day

Sr. No.	Items	Particulars	Qty.	Estimated cost (Rs)	Rate of (%) depreciation	Annual depreciation (Rs)
1	Weighing balance	10 kg	1	5000	10	500
2	Cup sealing machine	--	1	4000	10	400
3	Stainless steel patila	40 lit	2	2200	10	220
4	Stainless steel spoons	Big	6	480	10	48
5	Stainless steel trays	Big	4	800	10	80
6	Stainless steel buckets	20 lit.	2	1500	10	150
7	Chopping knives	--	2	300	10	30
8	Chopping board	--	1	100	10	10
9	Tub plastic	--	2	400	20	80
10	Refrigerator	300 lit	1	35000	10	3500
11	Cooking vessel	25 lit	1	2000	10	200
12	Cooking cans	5 lit	5	2500	10	250
13	Measuring vessels	1 lit	2	100	10	10
14	Electric mixer	--	1	8000	10	800
15	Electric meat mincer	--	1	25000	10	2500
16	LPG connection (DBC)	--	1	3000	--	
17	Burner brass	--	2	2000	10	200
18	Lighter electronic	--	1	80	10	8
	Total:			92460		8986

Table 4: Detailed break up of product cost for the manufacture of chicken meat spread

Sr. No.	Component	Rate per kg (Rs)	Requirement (per annum)	Expenditure (per annum)				
				C	C_1	T_1	T_2	T_3
A)	Manufacturing cost							
a)	Direct product cost							
I	**Raw material**							
1	Deboned meat (For C) 86% of whole meat	325	12900	4192500				
2	Deboned meat (for C_1) 86% of whole meat	325	12900		4192500			
3	Deboned meat (for T_1) 76% of whole meat	325	11400			3705000		
4	Deboned meat (for T_2) 66% of whole meat	325	9900				3217500	
5	Deboned meat (for T_3) 56% of whole meat	325	8400					2730000
6	Sorghum flour(T_1)	90	300			27,000		
7	Sorghum flour(T_2)	90	600				54,000	
8	Sorghum flour(T_3)	90	900					81,000
9	Common salt	25	300	7,500	7,500	7,500	7,500	7,500
10	Spice mix	915	450	4,11,750	4,11,750	4,11,750	4,11,750	4,11,750
11	Refined Vegetable Oil	140	900	126000	126000	126000	126000	126000
12	Condiments	80	450	36,000	36,000	36,000	36,000	36000
13	*Lactobacillus acidophilus* (1 million CFU/g) 5 billion CFU @ Rs 10	10	30000		3,00,000	3,00,000	3,00,000	300000
14	Printed cups (Capacity - 200 gms)	0.50/pack	75000 cups	37,500	37,500	37,500	37,500	37,500
	Sub Total (I)			4811250	5111250	46,50,750	4190250	3729750
II	Operating labour and supervision							
1	Skilled Labour		9000/ month		Two		2,16,000	
	Sub-total (II)						2,16,000	
III.	Power and utility							
1	Power		6/KWH		5340		32,040	
2	Water		2/100 lit		150000		3000	
	Sub-total (III)						35,040	
IV	Maintenance/Laboratory charges		1000/ month				12,000	

V	Cleaning material (detergent)	80/kg.	300	24,000
	Sub-total (a) = I+II+III+IV+V)			
	For C			50,98,290
	For C_1			53,98,290
	For T_1			49,37,790
	For T_2			44,77,290
	For T_3			40,16,790
b)	Fixed charges			
1	Rent for building	3000/month		36,000
2	Depreciation on capital investment (10%)			8,986
3	Insurance and taxes @ 4% of capital investment			3698
	Sub-total (b) =			48,684
	Sub-total A = a+b			
	For C			51,46,974
	For C_1			54,46,974
	For T_1			49,86,474
	For T_2			45,25,974
	For T_3			40,65,474

Table 5: Cost of chicken meat spread (Rs/kg)

B	General expenses Interest on investment @ 15% per annum			13,869	
c)	Product cost (A+B)				
	For C			51,60,843	
	For C_1			54,60,843	
	For T_1			50,00,343	
	For T_2			45,39,843	
	For T_3			40,79,343	
		Total raw material (kg)	Cooking Yield (%)	Final product (kg)	Cost/kg
	Product cost per kg for C	15000.00	86.84	13026.00	396.20
	Product cost per kg for C_1	15000.00	88.00	13200.00	413.70
	Product cost per kg for T_1	15000.00	88.59	13288.50	376.29
	Product cost per Kg for T_2	15000.00	89.45	13417.50	338.35
	Product cost per kg for T_3	15000.00	88.46	13269.00	307.43

Conclusions

The sensory parameters revealed that T_2 was having best acceptably among the panelist and the production cost of chicken meat spread was estimated by keeping in view the different types of costs involved in a small scale meat processing plant. Taking into the account of formulation percent, the rate of ingredients, product cooking yield etc. the final cost of chicken spread calculated per kg was Rs. 396.20, 413.70, 376.29, 338.35 and 307.43 in C, C_1, T_1, T_2 and T_3 respectively. The cost economics came to be lowest for T_3 and highest for C.

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