

DEVELOPMENT AND QUALITY EVALUATION OF READY-TO-EAT SAUSAGE FORTIFIED WITH SPINACH, MINT AND SUMAC EXTRACT POWDER

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Abstract: Ready-to-eat (RTE) meat products are popular due to their convenience, portability, and nutritional benefits. RTE sausages are still limited in the Indian market, creating an opportunity to develop a nutritious and protein-rich snack suitable for modern consumers. Natural plant-based antioxidants are widely used in food products to enhance nutritional value and improve shelf stability. Spinach (*Spinacia oleracea*) is a nutrient-rich leafy vegetable containing phytonutrients, polyphenols, and natural antioxidants. Mint provides natural pigments and antioxidant activity, while sumac (*Rhus coriaria L.*) contains bioactive compounds with antioxidant, antibacterial, and natural preservative properties. The present study aimed to develop and evaluate a ready-to-eat chicken sausage fortified with spinach, mint, and sumac extracts in six different formulations. Among them, Trial 6 showed the most desirable results, with 62% moisture, 2.36% ash, 21.9% protein, 8.4% fat, and 5.34% carbohydrate, along with a pH of 5.7. The product also demonstrated good functional properties, including 91.23% cooking yield and 72 % water holding capacity. Based on total plate count analysis at ambient temperature, the product exhibited a shelf life of 14 days. Sensory evaluation indicated good consumer acceptance with an overall score of 7.4, indicating its potential as a convenient and nutritious high-protein snack product.

Key words: Spinach Powder, Mint Powder, Sumac extract Powder, Physio-Chemical Analysis, Total Plate Count Analysis, Sensory Evaluation

I. INTRODUCTION

Meat is an important part of many diets because of its taste and nutritional content, but it spoils quickly due to lipid oxidation and microbial development, even when stored in cold temperatures. To increase safety and extended shelf life, preservation methods such as hurdle technology are used to restrict microbial growth and maintain meat quality during storage [1]. Meat products, specifically sausages, play a vital role in many diets because they assist in meeting daily nutritional requirements. They are high in protein and include various critical nutrients needed for optimum health [2]. Sausages are seen as a practical meal alternative by customers worldwide due to their widespread popularity, ease of eating, and low production costs [3]. Furthermore, these items can provide essential vitamins, minerals, and other useful bioactive ingredients that promote general wellness [4].

Spinacia oleracea, commonly known as spinach, belongs to the family *Chenopodiaceae* and is native to South-West Asia. It is widely cultivated around the world as a leafy vegetable. In traditional Indian medicine, different parts of the plant have been used for various therapeutic purposes, including as a laxative, diuretic, and carminative. Rich in vitamins A, C, E, K, B6, and B12, as well as essential minerals including magnesium, manganese, folate, and betaine, spinach is an extremely nutritious food [5].

Mint (*Mentha spicata*) is a popular herb in Indian cuisine, and it is also known for its potential to help treat a variety of common health issues [6]. Colour is an important quality attribute of mint, and it is mainly provided by natural pigments such as chlorophyll a, chlorophyll b, and carotenoids [7]. Mint extract has significant antioxidant activity, similar to that of the synthetic antioxidant butylated hydroxytoluene (BHT), according to earlier laboratory research [8].

Sumac (*Rhus coriaria L.*) is widely used in Turkey and the Middle East. Its fruits are red in colour and usually contain a single seed. The dried and ground leaves have traditionally been used as a tanning agent because of their high tannin content. Phytochemical studies have also shown that the leaves contain several bioactive compounds, including flavones, tannins, anthocyanins, and organic acids [9]. Sumac extracts have been demonstrated to have antibacterial, antioxidant, and hypoglycemic effects [10]. Sumac extract has been utilized in food applications as a natural preservative to regulate the microbiota in broiler meat, particularly raw broiler wings [11].

Thus, the purpose of this study is to create a ready-to-eat sausage enhanced with extracts from spinach, mint, and sumac and to assess the product's quality while it is vacuum-packed and kept at room temperature. The study also focuses on employing natural preservatives to increase the shelf life of fresh food.

II. MATERIALS AND METHODS

2.1 Animal -protein source

Fresh chicken breast and thigh meat were procured from the online meat retailed platform of Licious. The meat was received in vacuum-packed condition and stored under refrigerated temperature (0–4 °C).

2.2 Spice mixture

Red chilli powder and turmeric powder were obtained from an Aachi Masala vendor purchased through the local supermarket.

2.3 Plant sources

Spinach powder, mint leaf powder, and sumac powder were sourced from the vendors VM Bio Farms, Chouk, and Nature's Smith, respectively, and were selected based on the Certificate of Analysis (CoA) provided by the suppliers.

2.4 Condiments

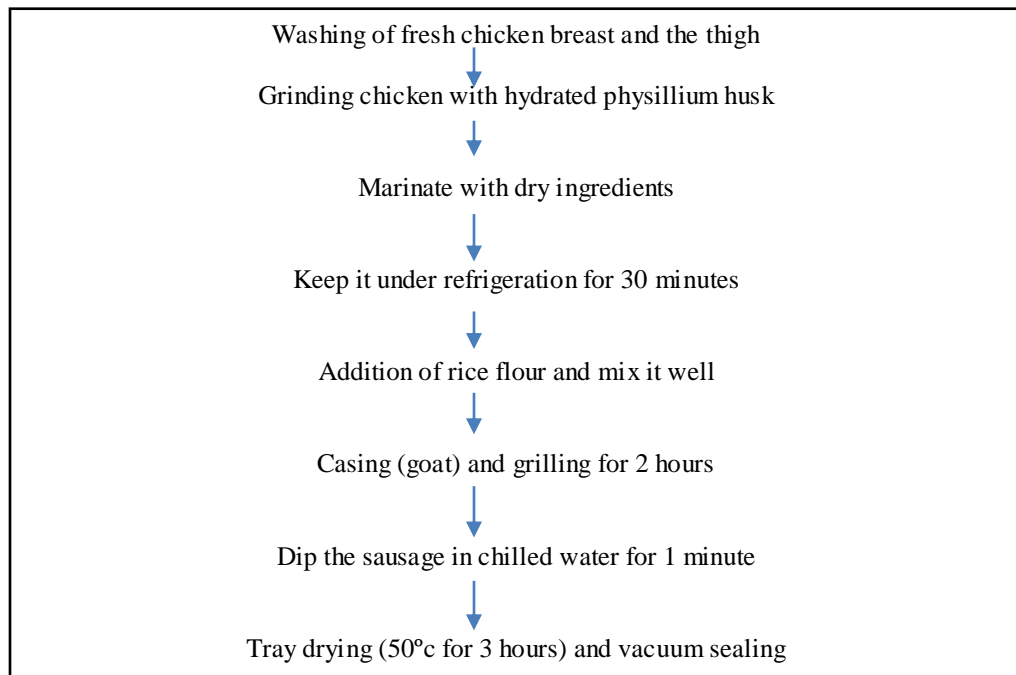
Fresh ginger and garlic were used to make the spice paste. The outer layers of ginger and garlic were removed and chopped into small bits. The chopped ginger and garlic were then combined in a grinder with the suitable blade in a 1:1 ratio to make a smooth and homogeneous condiment paste.

2.5 Iodized salt, Rice flour, Yeast extract powder, Physillium husk

Iodized salt (Tata), Yeast extract powder (Urban Platter), Rice flour (Pure & Sure) and Physillium husk (Dabur) were utilized in this study.

2.6 Formulation and preparation of Ready-To-Eat Sausage

Six compositions (T1 to T6) with various chicken sausage ingredients were prepared with a specific formula as shown in Table 1. The chicken thigh and chicken breast were washed thoroughly in water and ground with hydrated psyllium husk to obtain a uniform minced mixture. The minced meat was then marinated with dry ingredients, including red chilli powder, spinach powder, mint powder, sumac powder, salt, yeast extract powder, and turmeric powder. The mixture was kept under refrigeration for 30 minutes, after which rice flour was added and thoroughly mixed to obtain a homogeneous sausage batter. After filling natural goat casings with the prepared batter and grilling them for two hours, the sausages were dipped in cooled water for one minute. After three hours of tray drying at 50 °C, the sausages were vacuum-sealed for future storage and quality assessment.



Fig

Flowchart for Preparation of RTE sausage

1:

Ingredients	Base /100g	T1 (g)	T2 (g)	T3 (g)	T4 (g)	T5 (g)	T6 (g)
Chicken breast	39.35	31.13	31.13	31.13	31.13	31.13	31.13
chicken thigh	39.35	31.13	31.13	31.13	31.13	31.13	31.13
Red chilli powder	6.6	5.22	5.22	5.22	5.22	5.22	5.22
Ginger& garlic paste	3.3	2.61	2.61	2.61	2.61	2.61	2.61
Salt	2.0	1.61	1.61	1.61	1.61	1.61	1.61
Rice flour	0.7	0.54	0.54	0.54	0.54	0.54	0.54
Yeast extract powder	1.3	1.08	1.08	1.08	1.08	1.08	1.08
Turmeric	0.4	0.36	0.36	0.36	0.36	0.36	0.36
Physillium husk	1.6	1.35	1.35	1.35	1.35	1.35	1.35
Vegetable oil	5.5	4.48	4.48	4.48	4.48	4.48	4.48
Spinach powder	0	11.53	4.48	4.48	4.48	4.48	4.48
Mint powder	0	4.48	11.53	6.96	8.25	10.25	7.76
Sumac powder	0	4.48	4.48	9.05	7.76	5.76	8.25

Table 1: Formulations For Ready -To -Eat -Chicken Sausage

III. RESULTS AND DISCUSSION

3.1 OPTIMIZATION OF FUNCTIONAL PROPERTIES

The functional properties of ready -to -eat-sausages fortified with spinach, mint and sumac extract powder are shown in Table 2.

3.1.1 Cooking yield

Every trial of sausage was calculated using this formula and expressed as below

$$\text{Cooking yield} = \frac{\text{Wt. of cooked chicken meat sausage}}{\text{Wt. of raw chicken meat sausage}} \times 100$$

The results showed that the cooking yield was different in all the studies. It was between 89.88 percent and 92.34 percent. The cooking yield of T4 gave the best result. The cooking yield value of T5 and T6 was also good. T2 had a poor result. Overall, the results showed that adding plant extracts to chicken sausages slightly improved the cooking yield of chicken sausages. Studies on chicken meat sausages have reported similar cooking yield results, as noted by Fang et al. (2019) [12]

3.1.2 Water Holding Capacity

The water retention capacity of the chicken sausages ranged from T1 to T6. The results showed that T6 had the lowest value (72 %), indicating lower moisture retention than the other treatments and making it more suitable for increasing shelf life and quality attributes of the sausages

3.1.3 Folding Test

In this study, the folding test scores varied between 3.33 and 5.00. Huda *et al.*, (2010) [15]. The results of the folding test for chicken sausages with treatments like T1 to T6 are in Table 2. The scores for the chicken sausages were between 3 and 5. The results showed that the chicken sausages had a good volume of strengths and textures. Treatments T1 and T2 got a score of 3. The chicken sausages with T1 and T2 treatments did not have strong gel strength. The score of 4 for the chicken sausages with T3 and T4 treatments means that fairly good at folding and had a texture. The high score of 5 for the chicken sausages with T5 and T6 treatments means they were very strong and flexible. The reason for the folding test scores could be because of the ingredients used in the chicken sausages, which indicates the freshness of the meat in the sausage.

Parameters	T1	T2	T3	T4	T5	T6
Cooking yield (%)	89.88	88.32	90.12	92.34	92.19	91.23
Water Holding Capacity (%)	80.8	78.23	76	76.3	73.25	72
Folding test	3	3	4	4	5	5

Table 2: Functional Properties of Chicken Sausage

3.2 Sensory evaluation

Sensory evaluation of chicken meat sausages incorporated with spinach powder (*Spinacia oleracea*), sumac powder, and mint powder showed a gradual improvement in most sensory attributes as the level of plant powders increased. Appearance and colour scores improved across treatments, with appearance increasing from 4.0 (T1) to 7.5 (T6) and colour from 5.0 to 8.0, indicating that the natural pigments in spinach and sumac enhanced the visual quality of the sausages. Aroma and taste scores also increased from 4.0 to 7.0 and 5.0 to 7.5, respectively, suggesting that the aromatic and flavour compounds present in mint and sumac powders contributed positively to the product's flavour profile. Texture scores improved from 4.0 to 7.0, showing that the addition of spinach, sumac, and mint powders did not adversely affect the structural quality of the sausages. Overall acceptability ranged from 4.4 (T1) to 7.4 (T6), with the highest preference observed for treatments containing higher levels of plant powders, indicating better consumer acceptance. Similar sensory improvements in meat products with plant-based additives were reported by Wagh et al. (2017)[16].

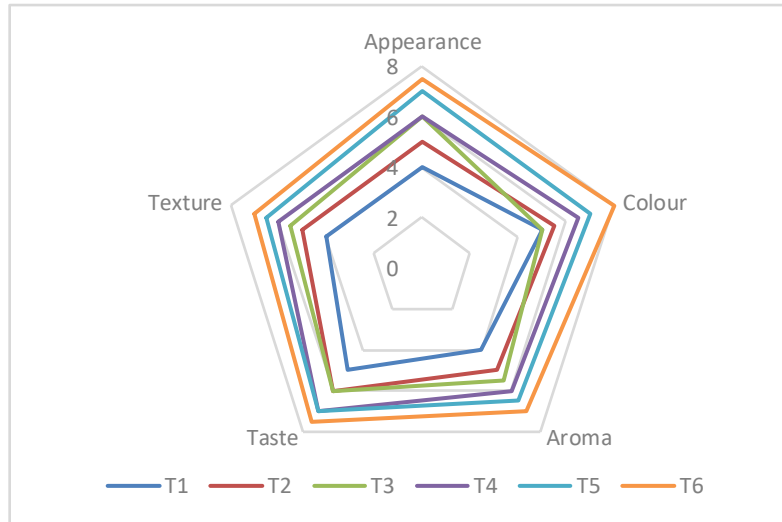


Fig: 2 Sensory Evaluation of RTE Chicken Sausage

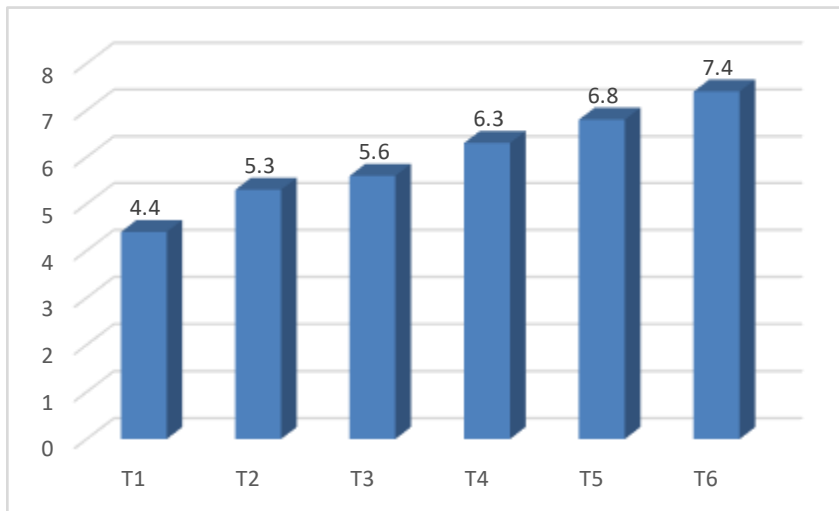


Fig: 3 Overall Acceptability of RTE Chicken Sausage

3.3 Optimization of Physio-Chemical Properties

From Table 3, the proximate analysis of the physio-chemical properties in six trials showed that the nutrition changes in the sample. The amount of moisture in the food gradually decreases from 66 to 67% in the T1-T2 to 62 % in T6. Thus the meat used as a filler for sausage undergoes gelatinization, which increases the volume of the dough [17]. The ash content was influenced by the ingredients [18]. The amount of ash content indicates the mineral richness in the sample ranges between 2.73% -2.36 %. The protein in the food increased from 15.1 % (T1) to 21.9 % (T6), which means the food became more nutritious [19]. On the other hand the fat in the food decreased from 10.6 % to 8.4 % [20]. The carbohydrate values range between 2.83 and 6.35 %. There was no clear pattern [21] The pH of the food decreased slowly from 6.3 to 5.6, which means the food became more acidic across all six trials.[22]

Parameters	T1	T2	T3	T4	T5	T6
Moisture	66 %	67 %	66 %	63 %	64 %	62 %
Ash	2.73 %	2.67 %	2.63 %	2.53 %	2.39 %	2.36 %
Protein	15.1 %	17.2 %	18.3 %	18.82 %	19.76 %	21.9 %
Fat	10.6 %	10.3 %	9.6 %	9.3 %	8.7 %	8.4 %
Carbohydrate	5.57 %	2.83 %	3.47 %	6.35 %	5.15 %	5.34%
pH	6.3	6.2	6.1	5.8	5.6	5.7

Table :3 Physio-Chemical Properties of RTE chicken sausage

3.4 Microbial Analysis

The quality attributes of sausages could deteriorate due to lipid oxidation, induced the rapid microbial growth. This can cause public health hazards and economic crises due to meat spoilage and food poisoning. Hence, the incorporation of spinach, mint, sumac extract powder into sausage formulation to serves both antioxidant and antimicrobial properties useful for preserving meat quality [24][25]. Based on Table 4, the samples are increased from a range of 4.7-8 10^4 log CFU/g during the ambient storage period. From the trial 1 to trial 6, the microbial count decreased from 4.7-4.48 10^4 log CFU/g during 0th and 7th days of the storage period. On day 14 of storage, only trial 5 and trial 6 were to 4.4 -4.5 10^4 log CFU/g, which are under the permissible limit. However, the count increased on the 21st day and was not under the permissible limit.[23]

TOTAL PLATE COUNT (10^4 log CFU /g)						
Storage days	T1	T2	T3	T4	T5	T6
P+0	4.7	4.5	3.8	3.2	3	2.8
P+7	4.8	4.65	4.55	4.45	4	4.48
P+14	8.9	7.9	6.3	5	4.4	4.5
P+21	20	16	11	8.9	7.1	8

Table: 4 Total Plate count for RTE chicken sausage

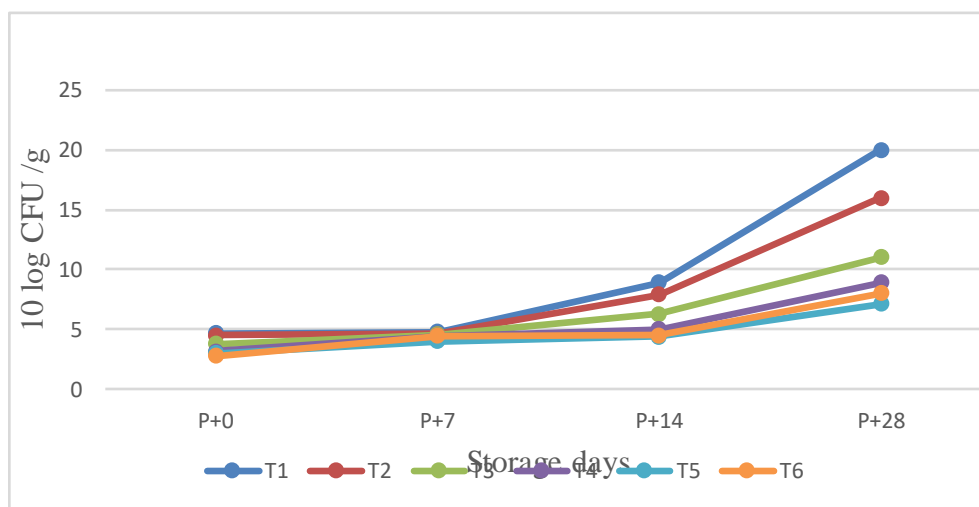


Fig: 4 Changes on TPC In RTE Chicken Sausage

IV. CONCLUSION

This study successfully developed a nutritious, high-protein, ready-to-eat chicken sausage by incorporating natural plant-based extracts. Among the six formulations tested, Trial 6 (T6) emerged as the most effective and acceptable version. T6 achieved the highest protein content at 21.9% and the lowest fat content at 8.4%. It demonstrated excellent moisture retention with a water holding capacity of 80.8% and achieved a maximum score of 5 in folding tests, indicating high structural strength and flexibility. The addition of plant powders improved the visual and flavour profile, with T6 receiving the highest overall acceptability score of 7.4. By utilizing the natural antioxidant and antimicrobial properties of spinach, mint, and sumac, the product maintained a permissible microbial count for up to 14 days at ambient temperature. This formulation provides a healthy, shelf-stable, and consumer-accepted snack for the modern market.

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