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Review Article

Meat Analogue to Replace Sausage

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Abstract

This project was to prepare a soy based meat analogue containing equal or more protein than regular meat based. Soy protein concentrate prepared by coagulation of soy milk protein was dried and grinded into powder to use as the base raw material for the product. The stabilizer carboxy methyl cellulose (CMC) was added in the different variation of 1%, 1.5%, 2% and 2.5% to stabilize the emulsion formed by the oil added in the formulation. A meat like characteristic along with firmness and chewiness was developed by adding gluten to the product. Corn flour, the binder and its concentration was varied from 6%, 8%, 10% and 12% for its optimization to hold the protein together with the oil base. The desired meat-like flavor was developed adding salt and other necessary spices to the product. Sensory analysis containing 1.5% CMC with 8% binder was found best with 57.12 ± %0.22 moisture, 14.96 ± 0.002% crude fat, 12.87 ± 0.11% crude protein, 3.97 ± 0.02% crude ash and differential carbohydrate content 11.08 ± 0.18%. While for market sausage it was found to be of 63.71 ± 0.20% moisture, 16.47 ± 0.23% fat, 12.92 ± 0.18% protein, and 2.23 ± 0.04% ash and 4.66 ± 0.42% carbohydrate. The cost calculation of the product was found to be USD 0.5/100 g. with 230.433 Kcal.

Keywords: Meat Analogue; Replace; Sausage

Introduction

Meat analogues are food products that have similar texture, color, taste and form as meat. Since they are a good source of protein, they can be considered as meat substitutes. The main function of meat analogue is to replace meat in the diet, although they may also be used as bulking agents to extend real meat products. In addition to protein, meat analogues usually contain flavors, spices and wheat gluten [1]. In general, meat analogue is as a food made from non-meat, sometimes without other animal products such as dairy. It is eaten especially by vegetarians as they are made up of high protein sources like soy, wheat gluten, beans and/or nuts. Some meat analogues are based on seitan, rice, mushrooms, legumes, tempeh, or pressed tofu, with flavoring agents added to make the finished product taste like meat [2] and are generally a good source of high quality protein, providing some of the essential amino acids. Total amounts of protein will vary from product to product and brand to brand. Compared to meat, they are lower in fat and therefore lower in calories as well. Another advantage of meat analogues over meat is that they are a source of fiber because of their plant origin [3].

The quality of soy protein is highly notable and approaches the quality of meat and milk. Soy concentrates contain about 65% protein and retain most of the soybean's dietary fiber [4]. Concentrates also add texture and help foods retain moisture. Therefore, this study may be a mile stone in the new product development from soy bean, which could play a significant role for giving a safe and completely different taste, aroma, flavor and appearance in the new product having a stable shelf-life. The addition of the flavored emulsion base and meat analogue in vegetarian food products improves the texture, mouth feel, and juiciness of the resulting products [5]. Therefore, the aim of this work is to develop a new vegetarian, ready to eat meat analogue from soybean, which could provide a fair alternative product without compromising the nutritional quality to the vegetarian group in the country.

Health benefits of soybean

Protein quality refers to the percentage of protein in food that can be utilized by the body; it is usually expressed in NPU, BV or protein score. Soybean has an NPU percent of 61, and the soy protein concentrate has an NPU value of 65%. The value nearly matches up for the NPU value for chicken meat [6]. For centuries, soy has been part of a human diet. Epidemiologists were most likely the first to recognize soy's benefits to overall health when considering populations with a high intake of soy. These populations shared lower incidences in certain cancers, decreased cardiac conditions, and improvements in menopausal symptoms and osteoporosis in women [7]. Based upon a multitude of studies examining the health benefits of soy protein, the American Heart Association issued a statement that recommended soy protein foods in a diet low in saturated fat and cholesterol to promote heart health [8]. The health benefits associated with soy protein are related to the physiologically active components that are part of soy, such as protease inhibitors, phytosterols, saponins, and isoflavones [9]. Of the many active components in soy products, isoflavones have been given considerably more attention than others. Isoflavones are thought to be beneficial for cardiovascular health, possibly by lowering LDL concentrations [5,7] increasing LDL oxidation and improving vessel elasticity [10]. However, these studies have not met without conflicting results and further research is still warranted concerning the benefits of isoflavones. It is found that an average intake of 47g/day of soy protein decreased serum total cholesterol levels by an average of 9% and LDL cholesterol levels by an average of 13% [11]. Hypocholesterolemic effects were primarily noted in individuals with high baseline cholesterol levels. Another recent analysis of 30 studies in individuals with normal or mildly elevated cholesterol levels concluded that about 25 g/day of soy protein significantly lowers LDL cholesterol concentrations by about 6%. Soybeans contain a high level of phytic acid that may be an effective antioxidant and also a chelating agent. The beneficial claims for phytic acid include reducing cancer, minimizing diabetes and reduce inflammation [12].

Antinutritional factors in soybean

Among antinutritional factors present in whole soybean, the main ones are protease inhibitors - Kunitz Trypsin Inhibitor (KTI) and Bowman-Birk inhibitor (BBI), and lectins. Protease inhibitors represent 6% of the protein present in soybean seed. Approximately, 80% of the trypsin inhibition is caused by KTI, which strongly inhibits trypsin and therefore reduces food intake by diminishing their digestion and absorption. Another effect of KTI is the induction of pancreatic enzyme, hypersecretion and fast stimulation of pancreatic growth, hypertrophy and hyperplasia. Heat treatment does not completely eliminate these factors and may decrease protein solubility. Despite the efficiency of thermal treatment to reduce protease inhibitors, residual inhibition is maintained [13]. Soy flour may cause flatulence if the level ingested is sufficiently high. Flatulence is generally attributed to the fact that man does not possess the enzyme α-galactosidase, necessary for hydrolyzing the α-galactosidic linkages of raffinose and stachyose to yield readily absorbable sugars. Defatted soy flours contain 5-6% of these oligosaccharides. Conversion of defatted flakes to concentrates or isolates removes nearly all of these oligosaccharides and reduces or eliminates flatulence [14].

	Soy Flour and Grits	Concentrates	Isolate
Constituents	(On wet basis, %)		
Protein (N*5.71)	47.5-49.5	56.5-63.5	78.5-79.5
Fat	0.5-1.0	0.5-1.0	0.5-1.0
Crude fiber	2.5-3.5	2.7-3.8	0.1-0.2
Ash	5.0-6.0	5.4-6.5	3.8-4.8
Moisture	6.0-8.0	0	4.0-6.0
Carbohydrate (by diff.)	30-32	32-34	

Table 1: Composition of soy protein products.

(Endres, 2001).

Raw material and methodology

Soybean sample (*Glycine max*) was bought from the local supermarket of Kathmandu. The beans were soaked overnight and grinded the next day for extracting the soy milk. The soy milk was curdled with the addition of calcium sulfate. The precipitate so obtained was left for 3 hours then dried at 80°C in a hot air oven for next 4-6 hours. The dried soy protein concentrate was grinded in order to obtain the powdered form. The powder was kept in an air tight container till further use for product development.

Common ingredients and casing

Besides the key raw material, other common ingredients required for the preparation were weighed out as per requirement. The basic ingredients included wheat gluten, corn flour, sunflower oil, salt, sugar, and carboxymethyl cellulose.

List of equipment used in product development

Bowl chopper, Stuffer, Steamer, Casing and Grinder were used in order to mix, casing, cooking and grinding the ingredients properly.

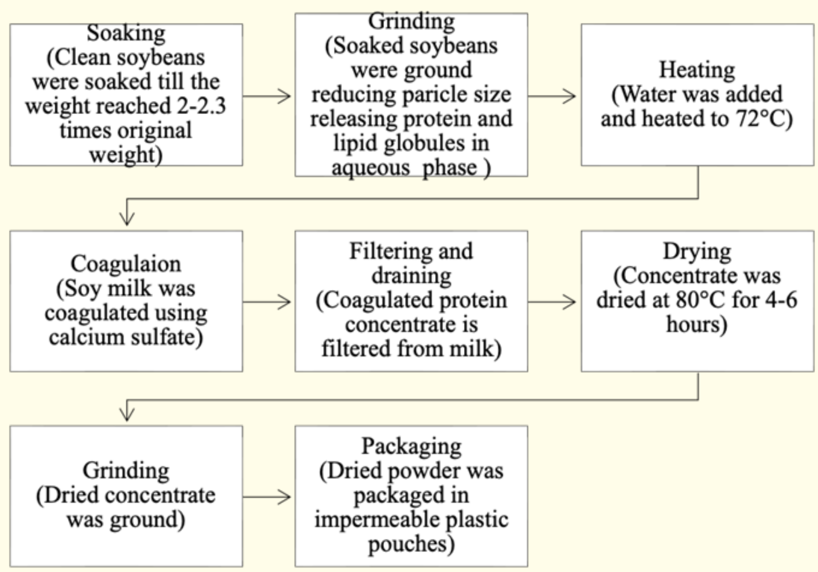

Figure 1: Preparation of soy protein concentrate powder.

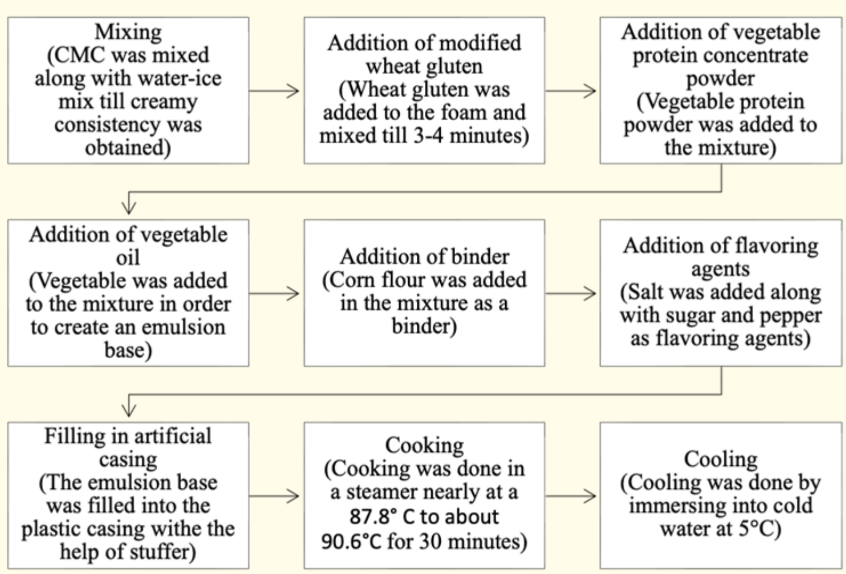

Figure 2: Flow-chart for preparation of vegetarian sausage.

Vegetarian sausage formulation

The product was based on soy protein concentrate. The first set of formulations was based on the variations in the proportions of the CMC powder. A set of variations in the CMC proportion were prepared. The percentage narrowed down to set of four fractions, namely, 1%, 1.5%, 2% and 2.5%. The second set of formulations varied on the basis of the amount of the binder used in the preparation of the product. The amounts of the binder were varied in the proportions of 6%, 8%, 10% and 12%.

Analysis of physiochemical parameters and microbiological quality

The proximate composition specifically moisture, crude fat, crude ash, crude protein, and carbohydrate was analyzed.

Sample preparation for sensory analysis

The sausage samples were shallow fried, cut into thin slices, and kept along with the entire uncooked sausage. The panelists judged the product on the scale of 1 to 9, 1 being the extremely disliked and 9 being the extremely like one, as per the Hedonic Rating test [15].

Statistical Analysis

The experiment was conducted in triplicate per sample. The data were analyzed by SPSS programming at 5% level of significance using one-way analysis of variance. The means were compared using LSD and the best treatment was selected using SPSS 16.

Results

Proximate Composition of soy protein powder

The proximate composition of dried soy protein powder has been presented in the table below

Parameters (%)	Soy protein powder
Moisture	3.81
Ash[a]	5.05
Fat[a]	23.10
Protein[a]	55.24
Carbohydrate[a]	12.80

Table 2: Proximate Composition of the raw material.

[a] means the data are in dry basis.

As shown in the table, dried soybean protein concentrate powder had a moisture content of 3.81%, ash 5.05%, fat 23.10%, protein 55.24% and carbohydrate, calculated by difference, 12.80%. Due to lack of standards for the raw material, the comparison could not be made. However, the data were compared with the proximate analysis of tofu on dry basis, as the product was made from drying the tofu itself.

Product optimization

For the optimization of CMC, it was used as an emulsifier in the vegetarian sausage in different concentrations of 1%, 1.5%, 2% and 2.5%, and sensory evaluation was carried out by using 9 point hedonic rating scale for selecting the best CMC proportion.

Statistical analyses of sensory evaluation score for vegetarian sausage with CMC variation

Effect on product color

The mean sensory score of the prepared product sample based on color attribute is shown in the figure 3.

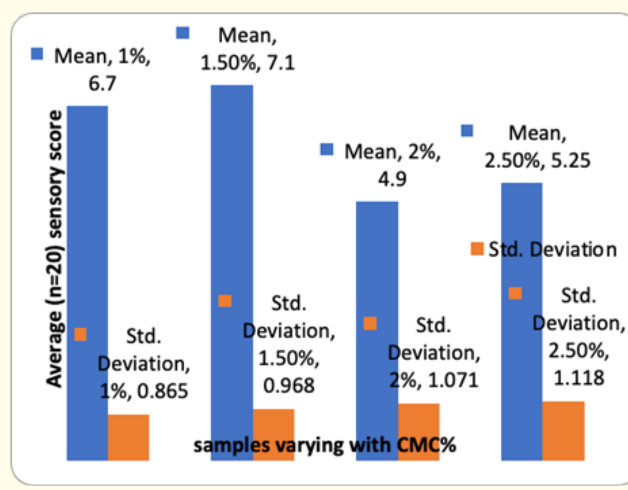

Figure 3: Statistical analyses for color attribute.

The average mean score obtained by the sample for color attribute was higher for the composition containing 1.5% CMC, which was 7.1, with standard deviation of 0.968 whilst the least mean score was for the composition containing 2% CMC with a value of 4.9, with standard deviation of 1.071.

From one way ANOVA, the effects on sensory score based upon variation in CMC % for color attribute were significantly different ($p < 0.05$). Since, any two samples were significantly different among four samples, multiple comparisons were done using the same statistical tool to find individual difference among the samples.

Effect on taste of product

The mean sensory score of the prepared product sample based on taste attribute is shown in the figure 4.

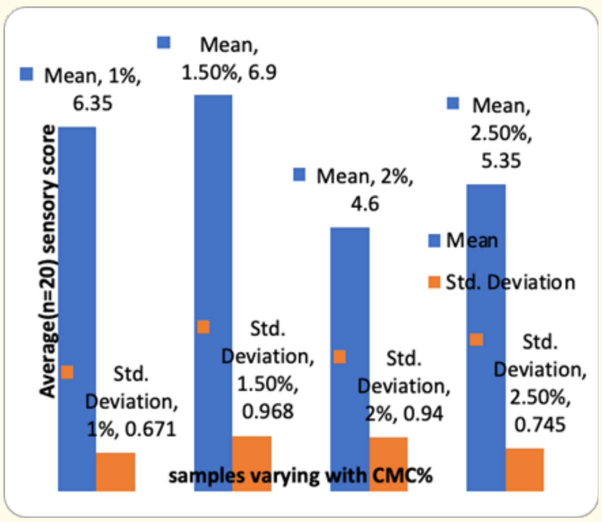

Figure 4: Statistical analyses for taste attribute.

The highest average score for taste attribute was for the sample containing 1.5% CMC, i.e., 6.9, with standard deviation of 0.968. The least mean score, 4.9, with standard deviation of 0.94 was for the composition containing 2% CMC.

Since, $p < 0.05$, one way ANOVA showed the taste attribute was significantly different with the variation in CMC concentration. So, at least two samples were significantly different among four samples, and multiple comparisons were done using the same statistical tool to find individual difference among the samples.

Effect on tenderness of product

The mean sensory score of the prepared product sample based on tenderness attribute is shown in the figure 5.

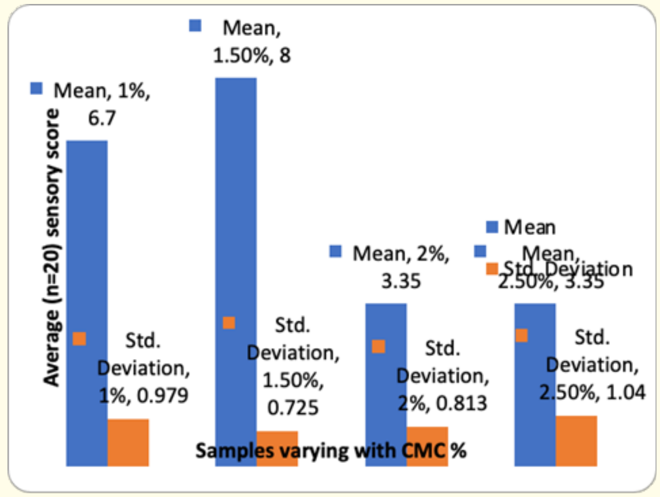

Figure 5: Statistical analyses for tenderness attribute.

The sample containing 1.5% CMC showed the highest mean score 8 for tenderness, with standard deviation of 0.725. Likewise, the least score was same, i.e., 3.35 for the two samples of composition containing 2% and 2.5% CMC, with standard deviation of 0.813 and 1.04, respectively.

From one way ANOVA, it was found that upon variation in CMC content, taste of products were significantly different ($p < 0.05$). It's the conclusion that among these four samples at least any two samples are significantly different.

Effect on juiciness of product

The mean sensory score of the prepared product sample based on juiciness attribute is shown in the figure 6.

The above figure 4 shows that the mean score was higher for product containing 1.5% CMC, and was equal to 8.15 ± 0.587. The products containing 2% and 2.5% CMC obtained least mean score.

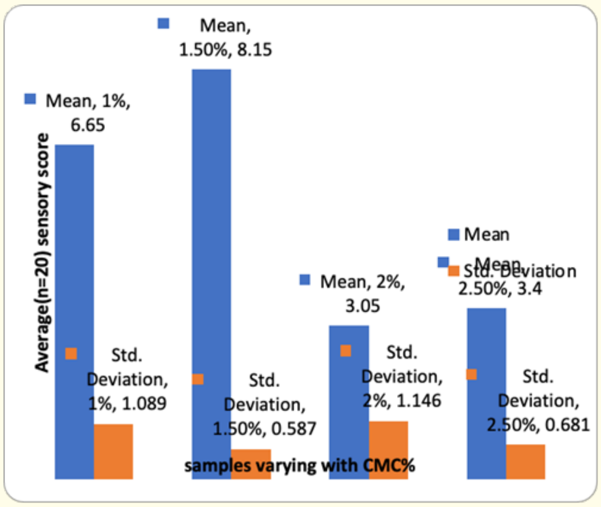

Figure 6: Statistical analyses for juiciness attribute.

From one way ANOVA, the effects on sensory score based upon variation in CMC % for juiciness attribute were significantly different, as p-value was found to be less than 0.05. This result describes that among these four samples at least any two samples were significantly different.

Effect on overall acceptability of product

The mean sensory score of the prepared product sample based on overall acceptability is shown in the figure 7.

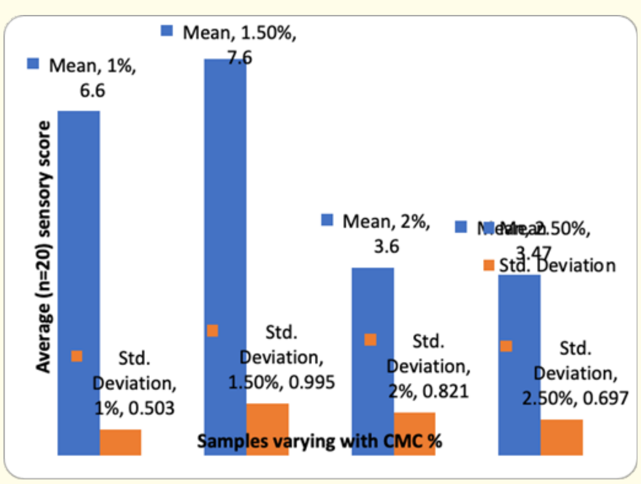

Figure 7: Statistical analyses for overall acceptability.

The figure shows that the average mean score obtained by the sample for overall acceptability attribute is higher for the composition containing 1.5% CMC. The mean score was 7.6, with standard deviation of 0.995. Likewise, the least mean score was 3.47 for the composition containing 2.5% CMC, with standard deviation of 0.697.

From one way ANOVA, the effects on sensory score based upon variation in CMC % for overall acceptability attribute were significantly different since p-value was found to be less than 0.05. This result showed that among these four samples at least any two samples were significantly different.

Binder optimization in vegetarian sausage formulation

Corn flour was used as a binder in different concentrations of 6%, 8%, 10% and 12% with 1.5% CMC, which was found to be the best content by the sensory analysis.

Statistical analyses of sensory evaluation for vegetarian sausage with binder variation

Effect on color of product

The mean sensory score of the prepared product sample based on color attribute is shown in the figure 8.

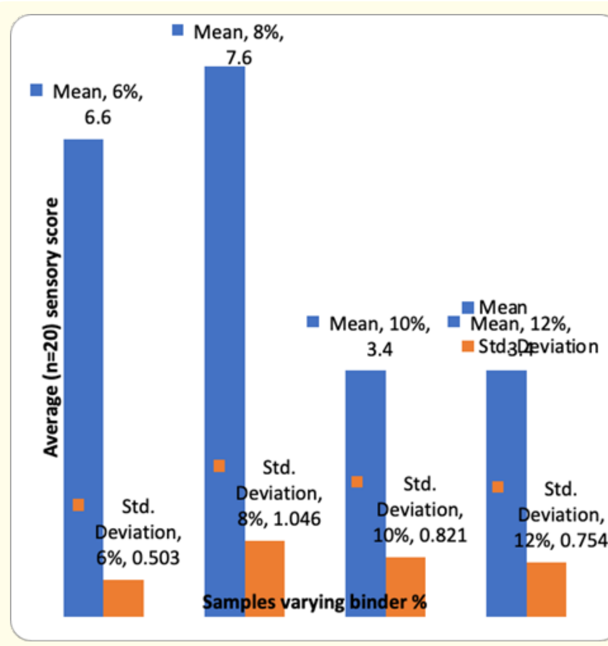

Figure 8: Statistical analyses for color attribute.

The average score for color attribute was higher for the product containing 8% binder, i.e., 7.6 ± 1.046. Likewise, the least mean score was obtained for the composition containing 10% and 12% binder content with a value of 3.9, with standard deviation of 0.821 and 0.754, respectively.

From one way ANOVA, the effects on sensory score based upon variation in binder content for color attribute were not significantly different ($p > 0.05$). It implied that no effect was found on the color of the product due to increase or decrease of the addition of corn flour.

Effect on taste of product

The mean sensory score of the prepared product sample based on taste attribute is shown in the figure 9.

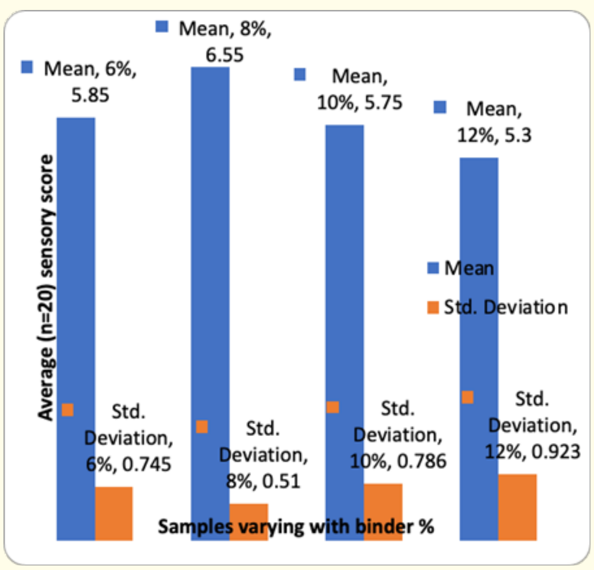

Figure 9: Statistical analyses for taste attribute.

The average score obtained for taste attribute of sample was higher for the composition containing 8% binder, 6.55 ± 0.51. Likewise, the least mean score was obtained for the composition containing 12% binder content with a value of 5.3 ± 0.923.

From one way ANOVA, the effects on sensory score based upon variation in binder concentration for taste attribute were significantly different ($p < 0.05$). So, among four samples of products, any two samples were significantly different.

Effect on tenderness of product

The mean sensory score of the prepared product sample based on tenderness attribute is shown in the figure 10.

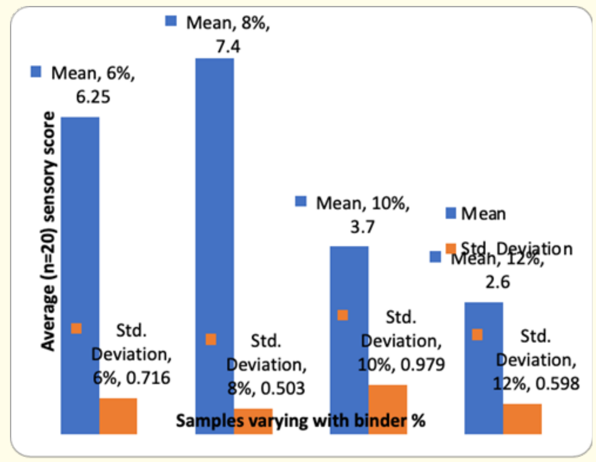

Figure 10: Statistical analyses for tenderness attribute.

The mean score obtained by the sample for tenderness attribute was higher for the composition containing 8% binder, with the value of 7.4 ± 0.503. Likewise, the least mean score was for the composition containing 12% binder content with a value of 2.6 ± 0.598.

From one way ANOVA, the effects on sensory score based upon variation in the concentration of binder for taste attribute were significantly different, since p-value was less than 0.05. Hence, among these four samples any two samples were significantly different.

Effect on juiciness of product

The mean sensory score of the prepared product sample based on juiciness attribute is shown in the figure 11.

The average score obtained for tenderness attribute was highest for the sample of composition containing 8% binder, with a value of 7.7 ± 0.571. The tenderness was decreased with an increase in the corn flour. The least score was obtained by the product containing 12% corn flour, which were 2.8 with standard deviation of 0.696.

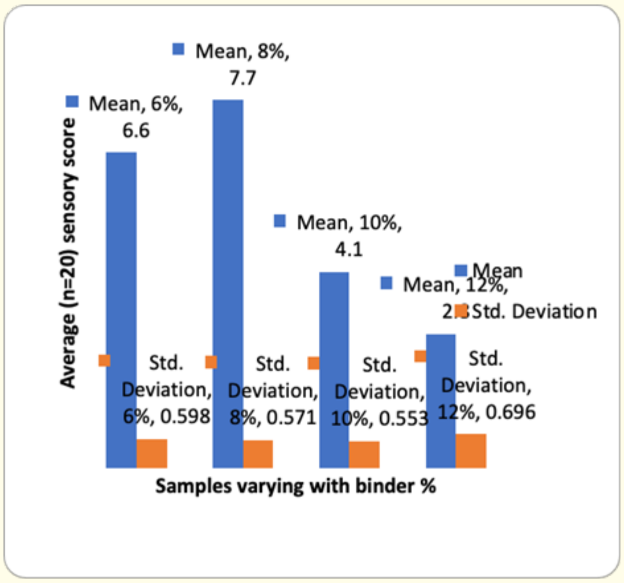

Figure 11: Statistical analyses for juiciness attribute.

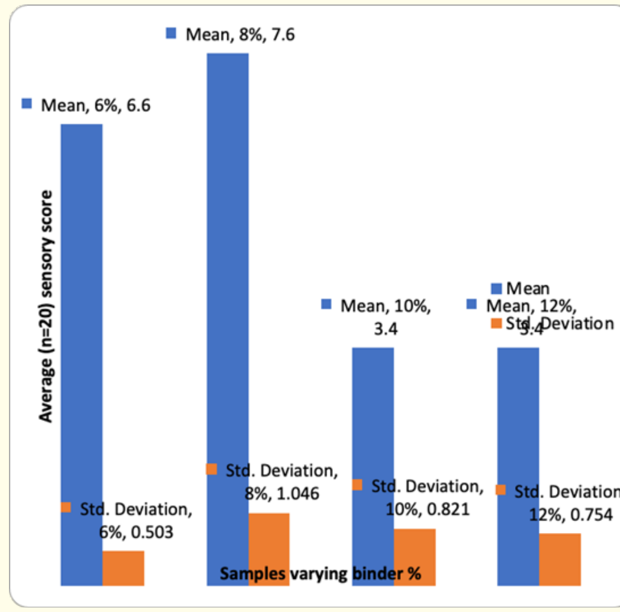

Figure 12: Statistical analyses for overall acceptability of a product.

One way ANOVA showed a significant difference among the samples. When the data were subjected to multiple comparison tests, they showed that the difference were among every sample varying in corn flour.

Effect on overall acceptability of product

The mean sensory score of the prepared product sample based on overall acceptability is shown in the figure 12.

The sample containing 8% binder has the highest the average score, 7.6 ± 1.046, for tenderness, and had the lower the acceptability among the varieties. From ANOVA, there was seen a significance difference among the samples as the p-value was less than 0.05. As per the multiple comparison tests, there was no significant difference between the samples containing 6% and 8% corn flour, whereas the samples containing 10% and 12% were very much different from each other and rest of samples.

The moisture content of the vegetarian sausage was found to be 57.12 ± %0.22, fat 14.96 ± 0.002%, protein 12.87 ± 0.11%, ash 3.97 ± 0.02%, and carbohydrate 11.09 ± 0.18%. While for market meat sausage, the proximate analysis showed the moisture of 63.71 ± 0.20%, fat 16.47 ± 0.23%, protein 12.92 ± 0.18%, ash 2.23 ± 0.04%, and carbohydrate 4.66 ± 0.42%. The moisture content of vegetarian sausage was found to be lower than the market meat sausage. This might be due to completely dryness of the soy protein concentrate powder. Likewise, the prepared vegetarian sausage had low fat than meat sausage, which could be due to the use of extra animal fat in the production of meat sausage, and the manufacturing of the vegetarian sausage completely relied only upon the vegetable oil added and the fat contained in the raw material itself. The ash content of vegetarian sausage was found to be slightly higher than the meat sausage. Since, the raw material used in the vegetarian sausage is plant based, the ash content might have risen. The carbohydrate content, calculated by difference, was found to be much higher than the control product. The use of CMC and high percentage of binder might have resulted in the increment in total.

Calorific value of the final product

The calorific value of the product, prior to cooking, was found to be 230.433 Cal per 100 g of the sample.

Cost calculation of the final product

The total cost of the final product, including 10% overhead costs along with 10% profit margin was totaled to be USD 0.5 per 100g of the sample.

Conclusion

Vegetarian sausage so prepared from soy protein concentrate powder was analyzed where sensory analysis showed that among the various formulations, the sausage prepared with 1.5% CMC and 8% binder with 16% soy protein concentrate powder was found to be superior. The product was developed using locally available materials, and preparation was simple and easy with low cost of USD 0.10/ 100 g vegetarian sausage. Prepared vegetarian sausage was shown to have nearly equal quantity of protein to that of meat based sausage. Therefore, it can be used as a substitute to meat sausage for the vegetarian groups.

Conflict of Interest

The author declares there is no any conflict of interest exists.

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