A STUDY ON THE PRODUCTION AND OPTIMIZATION OF CAPSICUM KETCHUP

PROJECT REPORT

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APPROVAL

This project report titled **"A Study on The Production and Optimization of Capsicum Ketchup"**, submitted by **Meharab Mosharof** to the Department of Nutrition and Food Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Nutrition and Food Engineering and approved as to its style and contents.

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I hereby declare that this project has been done by me under the supervision of **Juwel Rana, Assistant Professor,** Department of Nutrition and Food Engineering, Daffodil International University. I also declare that neither this project nor any part of this internship has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

The primary objective of this study was about the production and optimization of capsicum ketchup. The proximate composition, functional properties, microbial analysis, and sensory evaluation of unroasted, roasted, and mix-up Capsicum ketchup samples reveal significant variations. The unroasted sample had the highest moisture content (62.84%) and protein content (1.9%), but the lowest carbohydrate content (31.87%). The roasted sample, on the other hand, had the lowest moisture content (56.98%) and protein content (0.8%) but the highest carbohydrate content (39.76%). The mix-up sample exhibited intermediate values across most proximate parameters. In terms of functional properties, the roasted ketchup was the most acidic (pH 4.12) and the mix-up sample had the highest °Brix (40%), indicating it was the sweetest. Microbial analysis showed that roasting effectively reduced the microbial load, with the roasted sample having the lowest count (3.97×10^5 CFU/g). Sensory evaluation highlighted the roasted sample as the most flavorful and overall acceptable (8.45 ± 0.826 in taste and 8.15 ± 0.875 in overall acceptability), whereas the mix-up sample lagged behind in most attributes, especially in flavor (6.60 ± 0.821). Overall, roasted Capsicum ketchup shows the most promise, but a balance between functional, sensory, and microbial properties should be targeted for optimal product development.

Keyword: Capsicum ketchup, proximate analysis, sensory & microbial analysis.

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CHAPTER 1

INTRODUCTION

1.1 Background

Red pepper, scientifically known as *Capsicum annuum L.*, is a well appreciated spice that is popular among people worldwide (Vera et al., 2017). The annual output of dried red pepper in the domestic market is from 130,000 to 150,000 tons, with a production value of 1 trillion dollars (Gobie, 2019). The annual per capita intake is 4 kilograms, making it the most in the world (Goboi, 2017). Although locally produced, red pepper has a strong competitive advantage in terms of export. However, both consumption and export of red pepper mostly consist of unprocessed raw red pepper and red pepper powder. Hence, to enhance the consumption and export of red pepper, it is imperative to create processed food items with high value-added employing red pepper. In recent times, Asian cuisine has gained recognition for its health benefits.

The commercialization of traditional meals from each Asian nation is very significant in the development of goods. Thai and Korean cuisine is considered ideal for daring epicureans, although it may be challenging to replicate at home due to its distinctive fiery taste (Dedeoğlu et al., 2019). Thailand and Japan exemplify nations that have effectively globalized their cuisine traditions by emphasizing their distinctive sauces. A more efficient approach to promoting the entire culinary culture in abroad markets is to provide a diverse range of sauces and meals that are specifically designed to cater to the consumption habits of those countries (Duranova et al., 2022).

Figure 1: *Capsicum annuum L.*

Figure 2: Ketchup

Ketchup are fluid or semi-fluid condiments used to enhance the taste and appearance of foods and are renowned for their vast array of varieties (Pereira et al., 2016). Among them, condiments such as chili, tabasco, salsa, and tomato ketchup are used in a variety of foods including steak, barbecue, fish, fried chicken, hamburgers, pizza, spaghetti, and salad. Ketchup is the sauce with the highest consumption rate, not just in the United States. The present projected value of the worldwide market exceeds 300 billion dollars (Cárdenas-Castro et al., 2019).

Furthermore, hot pepper was chosen as a prominent component due to its beneficial effects on health and its ability to readily cater to the preferences of Bangladeshi customers.

1.2 Objectives

The primary objective of this study was about the production and optimization of Capsicum Ketchup.

1.2.1 Specific objectives

- To study the proximate composition of the ketchup.
- To study the sensory acceptance of the product.

CHAPTER 2

LITERATURE REVIEW

There has been an increasing focus on creating food items that provide additional value by improving customer happiness and offering health advantages. An example of such a product is chili ketchup, a widely used condiment with worldwide popularity. Historically, ketchup has been mostly derived from tomatoes, but there is a growing inclination to use several types of chili peppers to augment both taste and nutritional benefits. This phenomenon is most noticeable in areas that have a long-standing practice of growing chili peppers, such as Korea and the United States.

In a research conducted by Yoo (2014), the main objective was to create a chili ketchup product that has enhanced value by using high-quality Korean chili peppers (Capsicum annuum L.). The main aim was to compare the physicochemical properties and sensory qualities of this Korean chili ketchup with American chili ketchup products, which are commonly eaten and often imported into Korea. The formulation of the Korean chili ketchup consists of 37.5% tomato paste, 14.1% Korean chili pepper, 14.8% sugar, 14.1% vinegar, 8.5% garlic, as well as herbs, plum extract, and oligosaccharide. This composition emphasizes the use of traditional Korean ingredients, renowned for their health-enhancing characteristics, notably the incorporation of Korean chili peppers, abundant in bioactive components.

The analysis of the Korean chili ketchup showed that it had a moisture content of 59.61±0.28%, crude protein content of 2.18±0.11%, crude lipid content of 1.99±0.04%, crude ash content of 9.26±0.13%, crude carbohydrate content of 26.97±0.48%, reducing sugar content of 35.19±0.97%, salt content of 3.04±0.04%, acidity of 2.22±0.01%, a pH value of 3.7±0.01, and a °Brix value of 36.3±0.14. The results suggest that Korean chili ketchup is not only high in carbs and reducing sugars, which give it its sweetness and texture, but also has a well-balanced amount of moisture, proteins, and lipids, making it a healthy choice for a condiment (Yoo, 2014).

The sensory assessment carried out in the research revealed that the Korean chili ketchup exhibited greater overall acceptance in comparison to its American equivalents. This indicates that customers responded positively to the distinctive combination of Korean chili peppers and other traditional components, maybe because of its improved taste and attractive sensory qualities. The study's results indicate the potential to substitute imported chili ketchup goods from the USA and Europe with domestically made Korean chili ketchup. This substitution might stimulate local agriculture and decrease reliance on imports (Yoo, 2014).

Furthermore, the analysis of bioactive chemicals in Korean and American chili ketchup products demonstrated that the former exhibited elevated concentrations of advantageous compounds, renowned for their many health-promoting effects, such as antioxidant characteristics. This is consistent with the larger pattern of creating functional meals that specifically target health-conscious customers. Hence, the creation of Korean chili ketchup not only enhances the worth of domestic chili pepper cultivation but also offers a more wholesome alternative to standard ketchup items now accessible on the market.

In a research conducted by Yoo (2014), a comparative investigation of bioactive components in Korean and American chili ketchups was carried out. This was followed by a sensory assessment to determine customer preferences. This research is important because it seeks to provide valuable information on the nutritional and functional advantages of chili ketchups, specifically those produced with Korean chili peppers (Capsicum annuum L.), in comparison to well-known American chili ketchup brands.

The examination of Korean chili ketchup's bioactive components shown it to be a very abundant reservoir of capsaicinoids, carotenoids, phenols, and antioxidants. The Korean chili ketchup has a total capsaicinoid content of 2.59±1.00 µg/100 g, a total carotenoid content of 33.28±1.52 µg/100 g, a total phenol content of 61.17±8.08 µg GAE/100 g, and a Vitamin C Equivalent Antioxidant Capacity (VCEAC) of 187.04±3.22 µg/100 g. The components of this product are recognized for their ability to promote health, thanks to their antioxidant and anti-inflammatory qualities. These features enhance the total nutritional value of the product (Yoo, 2014).

The research emphasizes that Korean chili ketchups had superior overall acceptance in comparison to American chili ketchups. The sensory assessment, including factors such as taste, texture, and overall flavor profile, revealed significant disparities in customer preferences, with Korean chili ketchups being the preferred choice. This discovery is especially significant since it indicates that the distinct makeup of Korean chili ketchups, which include greater levels of bioactive chemicals, may play a role in their exceptional flavor and appeal to consumers (Yoo, 2014).

This research has broader ramifications that go beyond consumer preferences. The elevated concentration of bioactive components in Korean chili ketchups highlights their potential as functional meals, providing both gastronomic pleasure and health advantages. This is in line with the worldwide trend towards health-conscious dining, as customers are progressively looking for items that provide additional nutritional benefits.

Jun and Choi (2015) performed a research to ascertain the ideal proportion of tomato sauce to chili pepper powder, with a specific emphasis on the sauce's qualitative attributes when different quantities of chili pepper powder were used. The subject has great importance within the field of food product creation, as it addresses the critical task of achieving a harmonious balance between flavor, nutritional value, and customer satisfaction.

As the addition of chili pepper powder to the tomato sauce progressed, several alterations in the food's quality were apparent. The moisture content dropped with the addition of red chili pepper powder, although the quantities of protein, fat, ash, and carbs rose. According to Jun and Choi (2015), chili pepper powder not only improves the nutritional value of the sauce but also changes its physical characteristics by decreasing its moisture content.

Additionally, the research revealed a correlation between the amount of chili pepper powder used and a reduction in pH levels. The fall in pH is most likely caused by the reduction in organic acids, which are diluted by the higher solid content resulting from the addition of chili powder. The L-value (representing brightness) and a-value (representing the red-green axis) were decreased, while the b-value (representing the yellow-blue axis) was enhanced in terms of color. The use of red chili pepper powder in the sauce alters its visual appearance by darkening it and intensifying its yellow color (Jun & Choi, 2015).

The use of red chili pepper powder enhanced the levels of lycopene and β-carotene, two carotenoids that are well recognized for their nutritional advantages, such as their antioxidant qualities. The existence of these chemicals is very significant since they contribute to the sauce's functional characteristics. In addition, the presence of red chili pepper powder resulted in an increase in the amounts of polyphenols, flavonoids, and DPPH radical scavenging activity. The findings suggest that the addition of chili pepper powder to the sauce improves its antioxidant capabilities, hence increasing its potential as a food product that promotes health (Jun & Choi, 2015).

The use of chili pepper powder had a significant impact on the texture of the sauce in sensory assessments. As the sauce got grainier, the smoothness ratings declined, suggesting a less acceptable texture. However, the graininess scores climbed. The alteration in the texture of the sauce is ascribed to the chili pepper powder's ability to absorb moisture. Although there were variations in texture, the sensory tests indicated that the sauce with 3% chili pepper powder (TC3) received the highest rating for overall acceptability when combined with pasta. On the other hand, the sauce with 2% chili pepper powder (TC2) was rated the best in overall acceptance when consumed alone. According to Jun and Choi (2015), the results indicate that adding 3% chili pepper powder achieves an ideal equilibrium by improving the taste while still appealing to consumers.

The research determines that tomato sauce with 3% red chili pepper powder provides the highest level of quality, as it combines improved nutritional characteristics with significant customer approval. This formulation has the potential to be distinctive in the competitive food industry and provides a product with enhanced health benefits as a result of the higher concentration of bioactive components.

CHAPTER 3

MATERIALS AND METHODS

3.1 Location

The study was conducted at the Department of Nutrition and Food Engineering, Daffodil International University, Ashulia, Dhaka, Bangladesh, where all the experiments, including formulation, proximate analysis, microbial analysis, and sensory assessments, were carried out. The laboratory was equipped with the necessary facilities for conducting food analysis, ensuring the accuracy and reliability of the results.

3.2 Raw Materials

The primary raw materials used for the production of Capsicum ketchup were fresh Capsicum annuum L. (chili peppers), chili, sugar, onion, garlic mint, vinegar, salt and olive oil. The capsicums and chili peppers were sourced from local market of Savar, Dhaka. All ingredients were selected based on their freshness and suitability for processing into ketchup. The chemicals and reagents used for proximate and microbial analysis were of analytical grade and sourced from reputable suppliers.

3.3 Ketchup Formulation

The formulation of Capsicum ketchup involved optimizing the ratios of tomatoes, chili peppers, and other ingredients to achieve the desired flavor, consistency, and nutritional profile. Several trial formulations were prepared with varying concentrations of chili peppers, ranging from 5% to 20% of the total formulation. The other ingredients, including sugar, vinegar, garlic, herbs, and spices, were kept constant to standardize the flavor profile. The final formulation was selected based on sensory evaluation and preliminary quality assessments.

Table 1: Ingredients of Capsicum Ketchup

Materials	Quality	Percentage
Capsicum	160g	57.55%
Onion	30g	10.79%
Chili	10g	3.60%
Garlic	20g	7.19%
Mint	10g	3.60%
Vinegar	20g	7.19%
Sugar	35g	12.58%
Salt	10g	3.60%
Olive oil	10ml	3.60%

3.4 Procedures

Firstly, capsicum, onion, green chilies, and mint were washed thoroughly. Next, capsicum and onion cut into pieces. Then, all the ingredients with olive oil were mixed. After that, the mixture was transfered into a blender and blend for 5-6 minutes, ensuring the green chilies, onion, mint, and vinegar are mixed properly. Once blended, the mixture was poured into a pan and heated it 90°C for 5-7 minutes. After heating, sugar and salt were added as required. Finally, the mixture cool let down and stored it at 4°C. Different samples (**Figure 3**) including roasted, unroasted and combination of roasted and unroasted samples were produced.

Figure 3: Developed Capsicum ketchups.

3.5 Proximate Analysis

Proximate analysis was conducted to determine the nutritional composition of the Capsicum ketchup. The following methods were used:

3.5.1 Determination of Moisture Content

Moisture content was determined by moisture analyzer at 120°C (AOAC, 2016).

3.5.2 Determination of Ash Content

Ash content was determined by incinerating a known weight of the sample in a muffle furnace at 550°C until a white ash was obtained (AOAC, 2016). The ash content was expressed as a percentage of the original sample weight.

$$Ash\ Content(\%)\frac{Weight\ of\ Ash}{Original\ Sample\ Weight} \times 100$$

3.5.3 Determination of Crude Fat Content by Soxhlet Method

Crude fat content was determined using the Soxhlet extraction method. A known weight of the dried sample was extracted with petroleum ether in a Soxhlet apparatus for 6 hours (AOAC, 2016). The solvent was then evaporated, and the remaining fat was weighed. The fat content was expressed as a percentage of the sample weight.

$$Fat\ Content(\%) = \frac{Weight\ of\ Extracted\ Fat}{Original\ Sample\ Weight} \times 100$$

3.5.4 Determination of Protein Content by Kjeldahl Method

Protein content was determined using the Kjeldahl method (AOAC, 2016). The sample was digested with concentrated sulfuric acid in the presence of a catalyst, converting the nitrogen in the sample to ammonium sulfate. The digest was then neutralized with sodium hydroxide, and the liberated ammonia was distilled into a boric acid solution. The ammonia was titrated with standard hydrochloric acid to determine the nitrogen content, which was then converted to protein content using a conversion factor of 6.25.

$$Nitrogen\ content(\%) = \frac{V_1 \times N \times 14.07 \times 100}{W_s}$$

$$Protein\ Content(\%) = Nitrogen\ Content(\%) \times Conversion\ Factor$$

Here, V_1; volume of NaOH, N; normality of NaOH, W_s; weight of sample in grams

3.5.5 Determination of Carbohydrates

Carbohydrate content was determined by difference, subtracting the sum of the percentages of moisture, ash, protein, and fat from 100% (AOAC, 2016).

$$Carbohydrates(\%) = 100 - (Moisture + Ash + Fat + Protein + Fiber)$$

3.5.6 Determination of pH

The pH of the Capsicum ketchup was measured using a calibrated digital pH meter (AOAC, 2016). A sample of the ketchup was homogenized, and the pH was recorded at room temperature.

3.6 Microbial Analysis

Microbial analysis was conducted to ensure the safety and quality of the Capsicum ketchup. Total plate count (TPC) was determined using the pour plate method on Plate Count Agar (PCA) according to Mumtaz et al. (2018). The samples were serially diluted in sterile saline, plated, and incubated at 37°C for 48 hours. Colonies were counted, and the results were expressed as colony-forming units per gram (CFU/g).

3.7 Sensory Assessments

Sensory assessments were conducted to evaluate the organoleptic properties of the Capsicum ketchup, including color, aroma, taste, texture, and overall acceptability (Witono et al., 2014). A panel of trained sensory evaluators was asked to rate the samples using a 9-point hedonic scale, where 1 indicated "dislike extremely" and 9 indicated "like extremely." The sensory data were analyzed statistically to identify the formulation with the highest consumer preference.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Results

The proximate composition (**Table 2**) of Capsicum ketchup varies significantly across unroasted, roasted, and mix-up samples. The unroasted ketchup exhibits the highest moisture content at 62.84%, while the roasted variant has the lowest at 56.98%. Ash content is slightly higher in the unroasted ketchup (1.38%) compared to the roasted (1.12%) and mix-up (1.21%) samples. Protein content is most prominent in the unroasted ketchup at 1.9%, with the roasted sample showing the least at 0.8%. Fat content remains relatively consistent across all samples, with the unroasted version slightly higher at 2.01% compared to the roasted (1.34%) and mix-up (1.92%). Carbohydrate content is most elevated in the roasted sample, reaching 39.76%, followed by the mix-up (37.26%) and unroasted (31.87%) samples.

Table 2: Proximate composition of Capsicum ketchup.

Samples	Moisture%	Ash%	Protein%	Fat%	CHO%
Unroasted	62.84%	1.38%	1.9%	2.01%	31.87%
Roasted	56.98%	1.12%	0.8%	1.34%	39.76%
Mix-up	58.41%	1.21%	1.2%	1.92%	37.26%

Regarding functional properties (**Table 3**), the pH levels differ, with the roasted sample being the most acidic (pH 4.12), while the mix-up sample has the highest pH (4.87). The °Brix value, indicating sugar content, is highest in the mix-up ketchup at 40%, making it the sweetest, followed by the roasted (32%) and unroasted (25%) variants.

Table 3: Functional properties of Capsicum ketchup

Samples	pH	°Brix
Unroasted	4.83	25
Roasted	4.12	32
Mix-up	4.87	40

Microbial analysis (**Table 4**) reveals that the unroasted ketchup has the highest microbial load at 4.9×10^5 CFU/g, while the roasted sample has the lowest at 3.97×10^5 CFU/g.

Table 4: Microbial analysis of Capsicum ketchup

Samples	CFU/g
Unroasted	4.9×10^5

Roasted	3.97×10^5
Mix-up	4.10×10^5

The sensory evaluation results (**Table 5**) reveal interesting variations among the three samples across the attributes of appearance, taste, flavor, texture, and overall acceptability. Unroasted shows a balanced performance with consistently favorable scores in all categories. Its appearance (7.55 ± 0.605) and flavor (7.45 ± 0.887) are particularly well-received, although its taste (7.15 ± 0.745) and texture (7.25 ± 0.910) are rated slightly lower. The overall acceptability (7.35 ± 0.587) reflects that the sample is generally well-liked, though there is room for improvement in taste and texture. Roasted stands out for its taste, receiving the highest score in this category (8.45 ± 0.826), which indicates that it was the most flavorful and enjoyable in terms of taste among the samples. Its overall acceptability (8.15 ± 0.875) is also high, driven by its strong performance in taste and texture (7.70 ± 0.923). However, the appearance (7.50 ± 1.05) has a higher standard deviation, suggesting more variability in how participants perceived its visual appeal. Mix-up, on the other hand, scores the lowest across most attributes, with a particularly low rating in flavor (6.60 ± 0.821). This sample's appearance (7.00 ± 0.973), texture (6.75 ± 0.851), and overall acceptability (6.75 ± 0.910) also trail behind the other two samples. These results suggest that Mix-up may require improvements, particularly in its flavor and texture, to enhance its overall appeal.

Table 5: Sensory evaluation of Capsicum ketchup

Samples	Appearance	Taste	Flavor	Texture	Overall Acceptability
Unroasted	7.55±0.605	7.15±0.745	7.45±0.887	7.25±0.910	7.35±0.587
Roasted	7.50±1.05	8.45±0.826	7.50±0.761	7.70±0.923	8.15±0.875
Mix-up	7.00±0.973	7.25±0.639	6.60±0.821	6.75±0.851	6.75±0.910

Mean±Standard deviation

4.2 Discussion

The proximate composition of Capsicum ketchup in this study shows a range of values across unroasted, roasted, and mix-up samples, and these results can be compared with findings from existing literature. The moisture content in our samples ranged from 56.98% in roasted samples to 62.84% in unroasted samples. These values are comparable to the moisture content reported by Yoo (2014) for Korean chili ketchup, which was 59.61%. The lower moisture content observed in roasted samples is consistent with the expected moisture loss due to the heat applied during roasting. Regarding ash content, our study found values between 1.12% and 1.38%, which are lower than the 9.26% reported by Yoo (2014). This difference may be attributed to variations in the raw materials or the concentration of mineral-rich ingredients used in the ketchup formulations.

The protein content in our ketchup samples was highest in unroasted samples (1.9%) and lowest in roasted samples (0.8%). Yoo (2014) reported a protein content of 2.18% for Korean chili ketchup, indicating that our roasted samples might have undergone protein denaturation due to the roasting process, leading to lower protein levels. In terms of fat content, our study found values ranging from 1.34% in roasted samples to 2.01% in unroasted samples, which closely align with Yoo's (2014) reported fat content of 1.99%. The slight reduction in fat content in roasted samples could be due to fat loss during roasting.

The carbohydrate content in our ketchup samples was higher than the 26.97% reported by Yoo (2014), with our values ranging from 31.87% to 39.76%. This increase in carbohydrate content, particularly in roasted samples, could be due to the concentration effect as moisture content decreases during the roasting process. For functional properties, our study's pH values ranged from 4.12 in roasted samples to 4.87 in mix-up samples, which are slightly higher than the pH of 3.7 reported by Yoo (2014). This difference may be due to variations in ingredient composition, particularly the acidity contributed by vinegar and tomatoes. The °Brix values in our study ranged from 25 in unroasted samples to 40 in mix-up samples, with higher °Brix observed in roasted and mix-up samples likely due to sugar concentration effects as moisture content decreases.

Finally, the microbial analysis in our study showed that the microbial load ranged from 3.97×10^5 CFU/g in roasted samples to 4.9×10^5 CFU/g in unroasted samples. While Yoo (2014) did not provide specific CFU/g values, our results align with the general expectation that heat treatment, such as roasting, reduces microbial load.

Sensory evaluation is a crucial method used to assess the acceptability of food products based on human senses such as taste, appearance, flavor, and texture. In this study, the sensory evaluation of three samples was conducted, and the results show notable differences in these sensory attributes.

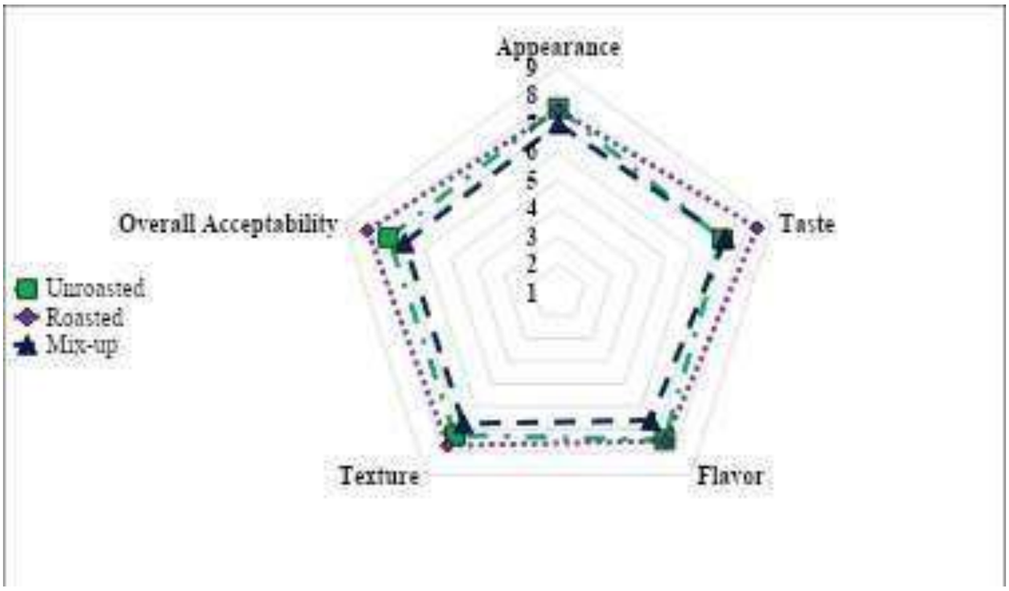

Figure 2: Sensory preference of different Capsicum ketchups

Unroasted demonstrated a balanced sensory profile, with high scores across all categories. Its appearance (7.55 ± 0.605) and flavor (7.45 ± 0.887) were particularly appreciated, indicating that this sample had an appealing look and a pleasing flavor. However, the taste (7.15 ± 0.745) and texture (7.25 ± 0.910) were rated slightly lower, showing room for improvement in these areas. The overall acceptability (7.35 ± 0.587) suggests that despite minor shortcomings in taste and texture, the product was generally well-received. Studies have shown that appearance plays a critical role in consumer acceptance, as it provides the first impression of the product's quality (Singh-Ackbarali & Maharaj, 2014).

Roasted stood out for its taste, achieving the highest score (8.45 ± 0.826) among all samples, which reflects that the sample was the most flavorful and well-liked in terms of taste. The texture (7.70 ± 0.923) and overall acceptability (8.15 ± 0.875) also received high ratings, indicating strong consumer preference for this product. However, the appearance (7.50 ± 1.05) had a larger standard deviation, suggesting some variability in how participants perceived the visual appeal of the sample. Research suggests that variability in sensory attributes like appearance can significantly influence consumer expectations and satisfaction (Lawless & Heymann, 2010).

Mix-up received the lowest ratings across most attributes, with flavor (6.60 ± 0.821) being the weakest. Appearance (7.00 ± 0.973), texture (6.75 ± 0.851), and overall acceptability (6.75 ± 0.910) were also lower compared to the other samples. These results suggest that Sample 3 requires significant improvements, particularly in flavor and texture, to enhance consumer acceptance. Poor flavor has been identified as a key factor that can lead to reduced overall acceptability, as flavor directly influences taste and consumer enjoyment (Stone et al., 2012).

Roasted outperformed the others, especially in taste and overall acceptability, while Sample 1 exhibited a well-balanced sensory profile. Mix-up, however, underperformed in several areas, indicating the need for further development. Understanding consumer sensory preferences is essential for developing food products that meet market demands (Kemp, Hollowood, & Hort, 2018).

CHAPTER 5

CONCLUSION

5.1 Conclusion

The analysis of the Capsicum ketchup samples “unroasted”, “roasted”, and “mix-up” revealed differences in their proximate composition, functional properties, microbial stability, and sensory attributes. The roasted sample appeared as the most favorable in terms of taste and overall acceptability, indicating that the roasting process positively impacts consumer acceptance. Alternatively, the mix-up sample underperformed in key sensory categories, particularly in flavor and texture, indicating the need for improvement in these areas. The microbial analysis showed that roasting had reduced microbial load compared to other samples. Each sample displayed unique nutritional characteristics, with the unroasted ketchup containing higher protein levels but lacking in sensory appeal compared to the roasted sample. Overall, while the roasted ketchup achieved the highest sensory scores, but there is potential for optimizing nutritional value, sensory qualities, and microbial safety.

5.2 Recommendations

The roasted sample demonstrated superior taste and overall acceptability, making it a standout product. Therefore, it is recommended to focus on refining the roasting process to enhance sensory attributes like appearance, which showed some variability among participants. Additionally, the mix-up sample, which scored lower in flavor and texture, could benefit from flavor enhancement strategies, such as adjusting seasoning or processing techniques, to improve its overall appeal. Although the roasted sample showed the lowest microbial load, continued research into preservation methods, such as optimizing packaging, could help extend the shelf life and ensure microbial safety for all variants. Furthermore, while the unroasted sample had the highest protein content, future product development should aim to retain this nutritional advantage while simultaneously improving sensory properties like taste and texture. Overall, the focus should be on achieving a balance between nutritional value, sensory appeal, and microbial stability to optimize the quality and marketability of Capsicum ketchup products.

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APPENDICES

Appendix 1: Sensory datasheet

ID	Appearance	Taste	Flavor	Texture	Overall Acceptability
Unroasted	7	6	7	7	7
Unroasted	8	7	7	8	7
Unroasted	7	6	7	8	8
Unroasted	7	7	8	7	7
Unroasted	8	7	9	7	7
Unroasted	7	8	6	8	8
Unroasted	9	8	9	7	8
Unroasted	8	7	9	8	8
Unroasted	8	6	7	7	7
Unroasted	7	7	8	7	7
Unroasted	8	6	7	6	7
Unroasted	7	8	7	6	7
Unroasted	8	7	7	6	7
Unroasted	7	8	6	9	8
Unroasted	7	8	7	7	7
Unroasted	7	8	7	9	8
Unroasted	8	7	8	6	6
Unroasted	7	8	8	7	7
Unroasted	8	7	7	8	8
Unroasted	8	7	8	7	8
Roasted	7	9	8	8	8
Roasted	9	9	8	8	9
Roasted	7	8	8	6	6
Roasted	9	6	7	9	9
Roasted	8	7	7	8	9
Roasted	6	8	6	7	7
Roasted	9	8	8	9	9
Roasted	9	9	8	7	9
Roasted	7	9	7	7	8
Roasted	8	8	7	8	8
Roasted	8	8	7	8	8
Roasted	8	9	8	7	8
Roasted	7	9	8	8	8
Roasted	7	9	9	7	8
Roasted	7	9	8	6	9
Roasted	6	9	7	7	7
Roasted	6	9	6	8	8
Roasted	6	9	8	9	9
Roasted	8	8	8	9	7
Roasted	8	9	7	8	9
Mix-up	6	7	6	7	6
Mix-up	7	6	7	6	6
Mix-up	9	7	6	9	8
Mix-up	6	7	6	7	6
Mix-up	9	7	6	7	8
Mix-up	7	8	6	6	6
Mix-up	8	7	7	6	7
Mix-up	8	7	6	6	6
Mix-up	7	7	8	6	7
Mix-up	7	7	6	6	6
Mix-up	6	7	6	7	6
Mix-up	6	7	6	6	6
Mix-up	6	7	6	6	6
Mix-up	6	7	7	6	6
Mix-up	7	7	6	7	7
Mix-up	6	7	7	7	7
Mix-up	7	8	7	7	7
Mix-up	7	8	7	8	8
Mix-up	8	9	9	7	9
Mix-up	7	8	7	8	7

Appendix 2: Synopsis

A STUDY ON THE PRODUCTION AND OPTIMIZATION OF CAPSICUM KETCHUP

Meharab Mosharof (Id: 201-34-245)

1. **Project title:** A Study on the Production and Optimization of Capsicum Ketchup.

2. **Introduction:**
   Capsicum (Capsicum spp.), also called as pepper, is a main vegetable and spice crop originated in the American tropics and today cultivated all over the world for fresh, dried, and processing products.

   Capsicum ketchup, also known as bell pepper ketchup or pepper sauce, is a delicious and flavorful condiment made from ripe, sweet capsicums (bell peppers). Capsicum ketchup is a versatile accompaniment, perfect for enhancing the taste of various dishes, from sandwiches and burgers to grilled meats and roasted vegetables. Its vibrant color and zesty taste make it a favorite among food enthusiasts, adding a burst of flavor to any meal. Whether used as a dipping sauce, marinade, or a topping, capsicum ketchup is a delightful addition to any culinary creation, elevating the overall dining experience with its distinctive taste profile.

   In 2017-18, Bangladesh produced just over 7 tons of capsicum. This increased slightly to 11 tons in 2018-19. However, in the fiscal year 2020-21, capsicum production saw a significant rise. According to the Bangladesh Bureau of Statistics (BBS), the country cultivated capsicum on 54 acres and produced 177 tons in FY21, compared to 13.4 acres and 39 tons in FY20 according to the Department of Agricultural Extension (DEA).

   In Bangladesh, the local farmers have successfully met the demands for capsicum, with the market size ranging between 5-6 crore. This achievement is notable, considering the challenges faced by the country in producing capsicum. One of the primary reasons for not resorting to imports is Bangladesh's inability to match the high demands internally. Additionally, the expensive import duty on capsicum further discourages the country from relying on imports to bridge the gap between demand and supply.

3. **Objective:**
   The specific objectives of this study are:

   1. To develop a high-quality sauce with a rich, balanced flavor profile.
   2. To source fresh and organic ingredients to enhance the sauce's quality.
   3. To create a unique and versatile recipe that appeals to a wide audience.
   4. To develop a sauce that caters to specific dietary needs, such as vegan, gluten free or low-sodium options.

5. **Materials:**

   Capsicum, Garlic, Green Chilli, Onion, Mint, Vinegar, Sugar, Salt, Olive oil, Black Pepper Powder, Oregano

6. **Methods:**

i. **Preparation of ketchup:** Firstly, wash the capsicum, onion, green chilies, and mint thoroughly. Next, cut the capsicum and onion into pieces. Then, mix all the ingredients with olive oil. After that, transfer the mixture into a blender and blend for 5-6 minutes, ensuring the green chilies, onion, mint, and vinegar are mixed properly. Once blended, pour the mixture into a pan and heat it to 90°C for 5-7 minutes. After heating, add sugar and salt as required. Finally, let the mixture cool down and store it for later use. Different samples including roasted, unroasted and combination of roasted and unroasted samples will be produced.

ii. **Proximate composition Analysis:** Protein, fat, carbohydrate, moisture and ash will be analyzed.

iii. **Antioxidant Assessment:** Total phenolic content, Total Flavonoid Content and antioxidant activity will be analyzed.

iv. **Microbial Analysis:** A month long study will be conducted to analyze the shelf life of the products.

v. **Consumer Acceptance:** A well-structured survey form will provide to the consumer and get their feedback.

7. **Place of the study:**

   Laboratory of Department of Nutrition and Food Engineering, Daffodil International University

8. **Period of the study:**

Major Activities	**Duration (months)**					
	July	**August**	**September**	**October**	**November**	**December**
Literature review						
Experimental Design						
Lab Experiment						
Proximate and Microbial Analysis						
Data analysis						
Report writing						

9. Supervision:

Supervisor: Mr. Juwel Rana, Assistant Professor, Department of Nutrition and Food Engineering, Daffodil International University.

10. Expected outcome:

To develop capsicum ketchup, focusing on its flavor profile, shelf stability, and potential health benefits. The expected outcome is to create a high-quality, flavorful sauce with a balanced heat level, ensuring its appeal to consumers. Additionally, the research aims to establish optimal storage conditions, enhancing the sauce's shelf life and preserving its quality. By addressing these aspects, the thesis contributes valuable insights for the culinary industry, offering a delicious and enduring capsicum sauce for widespread enjoyment.

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Juwel 24.12.24

Signature of Supervisor: ________________

A STUDY ON THE PRODUCTION AND OPTIMIZATION OF CAPSICUM KETCHUP

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