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Standardization and Formation of Millet-based Corn Silk Choco Fudge

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Abstract:
Background: Nutritionally, corn silk is low in calories and contains vitamins such as vitamin K, as well as minerals like potassium, calcium, and magnesium. It also offers antioxidants, including flavonoids, which may contribute to its anti-inflammatory properties.
Kodo is rich in fiber, iron, calcium, and protein, making it a good dietary choice for people with diabetes or those seeking a gluten-free diet.
Oats are highly nutritious and rich in dietary fiber, protein, iron, zinc, magnesium, and antioxidants. They are known for lowering cholesterol levels and supporting heart health.

Method: First, corn silk was brushed from the Corn. A dehydration process was carried out to remove moisture from corn silk, millet, oats, and seeds. By incorporating all ingredients with the chocolate, a homogenous mixture was formed. The mixture was cast into a mold to impart a specific shape of fudge and subsequently enrobed with a chocolate coating.
Comparative study: Comparative study of Millet-based Corn Silk Choco Fudge with other fudge present in the market. This comparative study was done based on nutritional content, target audience, ingredients, packaging material used, and costing.
Result: A successful formulation for Millet-based Corn Silk Chocolate Fudge was developed through a series of trials. Sensory evolution was conducted to select the most preferred formulation. Subsequent chemical analyses revealed that the developed fudge is a good source of protein and carbohydrates, with Corn silk contributing significantly to these nutritional values.

Keywords: Corn silk, Millet, Choco Fudge, Functional food, Protein.

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1 Introduction:

This study investigates the development and characterization of a novel Millet-based Corn Silk Choco Fudge enriched with a diverse array of seeds, including pumpkin seeds, flaxseeds, and sunflower seeds. The formulation utilizes a blend of millets, including Kodo millet and oat millet, alongside corn silk. This innovative confectionery aims to enhance its nutritional profile by integrating underutilized yet nutritionally potent ingredients. Corn silk, a byproduct of corn processing, is a rich source of vitamins, particularly vitamin K, minerals such as potassium and magnesium, and antioxidants including flavonoids. Millet, a gluten-free cereal grain, is renowned for its high fiber, protein, and mineral content. The inclusion of seeds further enriches the product with essential fatty acids, vitamins, minerals, and dietary fiber. Pumpkin seeds are an excellent source of magnesium, zinc, and iron, while flaxseeds are rich in omega-3 fatty acids and lignans. Sunflower seeds contribute significantly to vitamin E and selenium content.

Additionally, the incorporation of dates adds natural sweetness and provides a valuable source of dietary fiber and antioxidants. This research aimed to leverage the synergistic nutritional benefits of these ingredients by integrating them into a palatable and appealing confectionery product – chocolate fudge. The study involved a systematic approach, encompassing ingredient selection, formulation development, sensory evaluation, and chemical analysis.

The primary objective was to create a functional food that offers a delectable treat while providing a valuable source of essential nutrients, particularly protein, fiber, antioxidants, and essential fatty acids. The findings of this research contribute to the development of innovative and nutritious confectionery products that cater to the growing demand for functional foods and provide valuable insights into the utilization of underutilized agricultural byproducts.

2 MATERIALS AND METHODS

2.1 Materials

Raw ingredients include Corn silk, Kodo millet, Oats, Chocolate, Pumpkin seeds, Sunflower seeds, flax

seeds, and Dates. Other equipment was accessible at the FPPT Lab of the MIT Art, Design, and Technology University, Pune.

The presented research is a part of B.Tech research work conducted during the years 2024 to 2025 at the School of Food Technology, MIT Art, Design and Technology University, Pune.

2.2 Preparation of the mixture

First sorting and Grading of Seeds Oats and Kodo millet were done to ensure uniformity in size and quality. Removal of any impurities such as damaged seeds and foreign materials, was done to maintain a clean and high-quality product.

Roasting of Seeds and Oats was carried out. Seeds and oats were separately roasted as they require different roasting times and temperatures. Seeds were roasted at moderate temperature around 1500C-160°C for 10-15 minutes. Oats were roasted at a slightly lower temperature of 1300C-140 °C for 8-12 minutes. Roasted seeds and oats were allowed to cool completely before further processing.

Date Paste was prepared by deseeding the dates. A food processor was used to blend the pitted dates into a smooth paste. Chocolate was melted by using microwave at 45-50oC for 5 to 10 mins.

Roasted seeds and oats were ground finely by using food processing equipment such as a grinder.

The finely powdered seeds and coarsely ground oats were combined with prepared date paste preservatives such as sodium benzoate and added up to 0.1% in the mixture to extend its shelf life. Melted chocolate was gradually added to the mixture, the mixture was stirred thoroughly to ensure evenly incorporation of all the ingredients. The chocolate acts as a binding agent and provides a smooth, rich texture to the mixture.

The below figure shows the contestants of the prepared mixture.

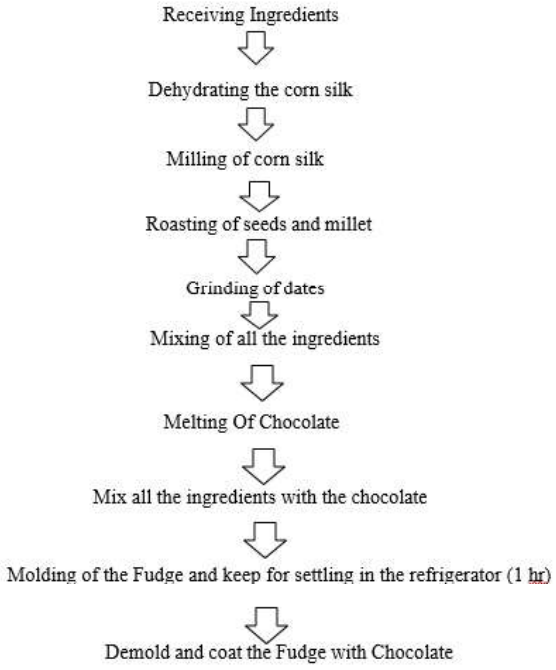
Fig 1: Mixture of seeds millet and corn silk

Shaping the Fudge

Once the mixture had achieved a homogenous consistency, it was divided into portions of 12gm and shaped into the desired size. Molds were used to shape the fudge into squares or rectangles. It was ensured that the shape of the fudge was compact and uniform.

The shaped fudge was evenly coated with melted chocolate. The fudge was kept in the freezer at 3oC for 1 hour 30 minutes.

Figure 2 shows the coated Choco fudge.



In total, three trials were conducted with different formulations, which gave different results.
Various problems were also faced in this trial. A few of these problems were uneven coating and a gummy mouth feel.
The following is Table 1, which shows the formulation done for the 25gm fudge sample.
Table 1: Formulation for Millet-based Corn Silk Choco Fudge

3 Formulation and trials

Ingredients.	Control	Sample 1	Sample 2	Sample 3
Chocolate	7	7	7	7
Kodo	4.25	2.12	6.37	4.23
oats	4.25	6.37	2.12	4.23
Sunflower seeds	3.1	3.1	3.1	3.1
Pumpkin seeds	3.1	3.1	3.1	3.1
Flax seeds	1.25	1.25	1.25	1.25
Dates	2.02	2.02	2.02	2.02
Corn silk	-	0.04	0.04	0.04

3.1 Sensory evaluation

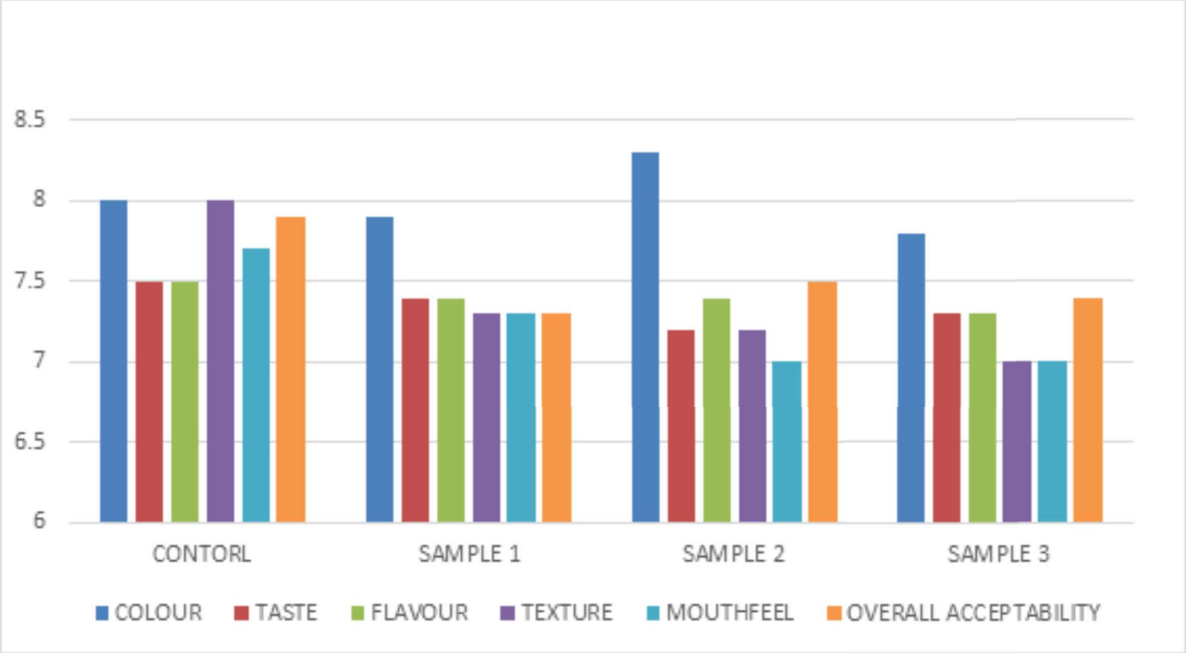
The sensory assessment of the Millet-based Corn Silk Choco Fudge was carried out using a nine-point hedonic scale (from dislike extremely to like extremely in merit order) method. The following table shows the result of the sensory evaluation.

Table 2: Sensory evaluation result

Sample	Colour	Taste	Flavour	Texture	Mouthfeel	Overall acceptability
CONTORL	8	7.5	7.5	8	7.7	7.9
SAMPLE 1	7.9	7.4	7.4	7.3	7.3	7.3
SAMPLE 2	8.3	7.2	7.4	7.2	7	7.5
SAMPLE 3	7.8	7.3	7.3	7	7	7.4
MEAN	8	7.35	7.4	7.375	7.25	7.525
MEDIAN	7.95	7.35	7.4	7.25	7.15	7.45
standard deviation	0.216025	0.129099	0.08165	0.434933	0.331662	0.262996

ANOVA	P-value
Control and Sample 1	0.571311
Control and sample 2	0.727218
Control and sample 3	0.317694

The below figure shows a graphic representation that the panel shows likens the sample 2. The texture and overall acceptance of sample 2 are more compared to any other samples.
Fig 3: Graphic representation of sensory evaluation



4 Chemical analysis
Various tests were conducted to determine the chemical composition of the millet-based corn silk chocolate fudge. Factors such as protein, fat, moisture, and minerals were tested. The following are the results.
4.1 Protein Content
The Kjeldahl method is a widely used laboratory technique for determining the protein content in food, animal feed, and other materials. It works by measuring the nitrogen content in a sample, as nitrogen is a key component of amino acids, which are the building blocks of proteins. The process involves three main steps: digestion, neutralization, and titration. The titer value was recorded, and the percentage of nitrogen in the sample was calculated using the following formula.

$$\text{Nitrogen (\%)} = \frac{(\text{Sample titer} - \text{Blank titer}) \times \text{Normality of HCl} \times 14 \times 100}{\text{Weight of sample} \times 1000}$$

4.2 Fat Content
Fat extraction is the process of isolating fats (lipids) from a sample, commonly done to determine the fat content in materials like food, plants, or animal tissues. Soxhlet extraction is one of the most widely used methods for this, particularly in food science and chemistry. It effectively extracts fats from solid samples, such as plant materials or foods. The fat percentage was calculated as follows:

$$\text{Fat (\%)} = \frac{W3 - W1}{W2} \times 100$$

Where
W1 - Initial weight of the empty flask
W2 - Sample weight
W3 - Final weight of flask + fat
4.3 Carbohydrates
Carbohydrate extraction methods are used to isolate carbohydrates from different types of materials. The goal is to break down the cell walls or other structural components to release the carbohydrates for further analysis.

$$\text{Carbohydrate content in 100 mg of sample} = \frac{\text{mg of glucose} \times 100}{\text{The volume of the test sample}}$$

4.4 Ash Content
Ash content refers to the inorganic residue left after a sample has been burned at a high temperature, typically around 550°C. This method is commonly used in food science, agriculture, and materials science to determine the amount of minerals present in a sample.

The ash content is often used as a proxy for evaluating the total mineral content of foods, feed, and other organic materials. The percent total ash was calculated as follows:

Ash content (%) = $\frac{W3 - W1}{W2}$

Where
W1 – Initial weight of crucible
W2 – Sample weight
W3 – Final weight of the crucible

4.5 Determination of Energy Value Procedure:
Energy value = (Carbohydrate + Protein) x 4 + Fat x 9.
The following table shows the result of the chemical analysis
Table 3: Result of chemical analysis

Sr.no	Test Parameters	Result	Units	Test method
1	Protein	7.38	g/100g	Kjeldahl method
2	Fat	26.23	g/100g	Jonner-fat- extraction method
3	Carbohydrates	60.26	g/100g	Gerber method
4	Energy value	506.63	Kcal/100g	Gerber method
5	Moisture	3.57	g/100g	Ash
6	Total Ash	2.56	g/100g	Muffle furnace

5 Comparative study
To evaluate its market potential, a comparative analysis was conducted against existing commercial fudge products manufactured by established brands such as Dr. Oetker India Pvt. Ltd., House of Candy (Candy House India Pvt. Ltd.), and Moddy's Chocolates (Udhagamandalam). The comparison includes proximate nutritional values, ingredient composition, pricing, and target demographics. Table 4.1 , table 4.2 , table 4.3 and table 4.4 shows the comparative study.
Table 4.1: Nutritional Comparison

Parameter	Millet-Based Corn silk Choco fudge	Moddy's Chocolate Fudge	House of Candy Fudge
Energy (kcal)	506.63	381	420
Protein (g)	7.38	2.38	2.1
Fat (g)	26.23	9.52	13
Carbohydrates (g)			

Product	Primary Ingredients
Millet-Based Fudge	Kodo millet, Oats, corn silk, cocoa powder, dates, seeds
Moddy's Chocolate Fudge	Sugar, butter, condensed milk, cocoa, vanilla (traditional recipe-based)
House of Candy Fudge	Sugar, glucose syrup, palm/coconut oil, skimmed milk powder, cocoa powder, emulsifiers, artificial flavorings

Product	Age Group	Primary Target Audience
Millet-Based Fudge	15–45	Health-conscious individuals, gym -goers, diabetic/pre-diabetic groups, clean-eating audience
Moddy's Chocolate Fudge	All ages	Families, gift shoppers, dessert lovers
House of Candy Fudge	5–30	Kids, teens, and sweet-lovers seeking high -sugar confectionery

Product	Packaging Material	Cost per 100g
Millet-Based fudge	PET zip lock bag and wrapping paper	Rs 118 / 100g
Moddy's Chocolate Fudge	Foil wraps and tetra packs	Rs 220/100g
House of Candy fudge	PET, aluminum foil	Rs 186/100g

Result and Discussion

Raw ingredients such as corn silk, oats, and millet were used in the preparation of millet-based Corn silk Choco fudge. Precautions were taken so that the protein contained in corn silk wouldn't be desaturated. Various millets, such as finger millet and foxtail millet, were tried to combine in the fudge. Kodo millet was selected to be used in the fudge because of its binding and crunchy characteristics. Seeds were involved in the fudge to enhance the nutritional profile. Figure 4 shows the mixture prepared for making fudge.

While preparing Fudge various trials were taken to standardize the formation of fudge. In these trials, various problems were faced such as gumminess and chewiness these problems were faced because of improper consistency of dates in the fudge.

A chemical analysis of fudge was done to check its nutritional profile. The Millet-based corn silk choco fudge was found to be high in carbohydrates and energy as well as it is a good source of energy.

6.1 Conclusion

This study successfully developed a novel Millet-based Corn Silk Choco Fudge formulation. The incorporation of corn silk, a rich source of vitamins and antioxidants, along with the inherent nutritional benefits of millet and oats, resulted in a functional food with enhanced protein and carbohydrate content. Sensory evaluation guided the selection of the most preferred formulation, demonstrating the acceptability of this innovative confectionery. The developed fudge offers a promising avenue for incorporating underutilized agricultural byproducts like corn silk into palatable and nutritious food products, promoting a balanced and healthy diet.

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