Development of Infant Food Formulations Using Germinated Cereals, Lentils, and Peanuts for Nutritional Optimization.

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SEPTEMBER 2024

APPROVAL

This project, titled "Development of Infant Food Formulations Using Germinated Cereals, Lentils, and Peanuts for Nutritional Optimization," submitted by Kazi Nusrat Islam Sifat to the Department of Nutrition and Food Engineering at Daffodil International University, has been approved for style and substance and found to be satisfactory for partially fulfilling the criteria for the B.Sc. degree in Nutrition and Food Engineering.

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DECLARATION

I am hereby announcing that this thesis/project was conducted under the supervision of Dr. Md. Bellal Hossain, Professor, Department of Nutrition and Food Engineering, Daffodil International University. I also affirm that neither this project nor any portion of it has been submitted elsewhere for the award of any degree

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ACKNOWLEDGEMENT

First and foremost, I express my deepest gratitude to Almighty God for His divine blessings, which have enabled me to successfully complete this final year project.

I am immensely grateful and profoundly indebted to Dr. Md. Bellal Hossain, Professor of the Department of Nutrition and Food Engineering at Daffodil International University. His extensive knowledge and keen interest in the field of Food Engineering were crucial in carrying out this work. His unwavering patience, scholarly guidance, continual encouragement, energetic supervision, constructive criticism, valuable advice, and diligent review of numerous drafts at every stage made the completion of this project possible.

I would also like to extend my heartfelt thanks to Dr. Nizam Uddin, Associate Professor and Head of the Department of Nutrition and Food Engineering, for his kind assistance in completing this project. Additionally, I am grateful to the other faculties and office staff of the Nutrition and Food Engineering Department at Daffodil International University.

Finally, I must acknowledge with deep respect the constant support and patience of husband.

ABSTRACT

This study explores the development and evaluation of infant food formulations using germinated cereals, lentils, and peanuts. The primary objectives were to assess the nutritional content and sensory attributes of three distinct formulations: Sample 1 (70% popcorn, 30% lentils), Sample 2 (70% popcorn, 30% peanuts), and Sample 3 (70% popcorn, 20% peanuts, 10% lentils). Nutritional analysis revealed that protein content was consistently high across all samples, ranging from 16.4% to 16.6%. Fat content varied significantly, with Sample 2 showing the highest fat content at 17.8%, due to the inclusion of peanuts. Sample 1 had the lowest fat content at 3.1%, while Sample 3 offered a balanced fat profile. Moisture content ranged from 9.9% to 11.4%, and ash content varied from 2.58% to 2.67%, indicating stable mineral content.

Sensory evaluation demonstrated that Sample 2 was the most preferred, scoring highest in color, aroma, flavor, and overall acceptability, attributed to the rich, nutty flavor of peanuts. Sample 1, with its lower fat content, and Sample 3, with a balanced mix of ingredients, were less preferred in comparison. The study underscores the effectiveness of incorporating peanuts to enhance the sensory appeal and nutritional profile of infant foods, highlighting the potential for developing high-quality, nutritious products tailored to infant dietary needs.

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Introduction

1.1 Background of the Study

Infant nutrition is a critical area of research and development, as it lays the foundation for lifelong health and well-being. The first few years of life are marked by rapid growth and development, necessitating a nutrient-dense diet to meet the physiological demands of this critical period. Breast milk is universally recognized as the ideal source of nutrition for infants. However, for various reasons, some mothers are unable to breastfeed exclusively or at all. In such cases, infant formula serves as a vital alternative to provide essential nutrients.

Commercial infant formulas are designed to mimic the nutritional profile of breast milk as closely as possible. However, they often rely on synthetic ingredients and processed components, which may not provide the same health benefits as natural sources. Furthermore, the high cost of commercial formulas can be prohibitive for many families, particularly in developing countries. This highlights the need for affordable, nutritious, and easily accessible alternatives.

Germinated cereals, lentils, and peanuts have emerged as promising ingredients for the development of nutrient-rich infant formulas. Germination is a process that enhances the nutritional profile of seeds by increasing their content of essential vitamins, minerals, and bioactive compounds while reducing antinutritional factors. Cereals such as rice, wheat, and barley, when germinated, offer improved digestibility and enhanced nutrient availability. Similarly, lentils and peanuts are excellent sources of plant-based proteins, essential fatty acids, and micronutrients crucial for infant growth and development.

The incorporation of these germinated ingredients into infant formulas could potentially address several nutritional challenges. Germinated cereals provide a balanced source of carbohydrates and fiber, which are essential for energy and digestive health. Lentils contribute high-quality protein and iron, critical for muscle development and cognitive function. Peanuts offer healthy fats and antioxidants, supporting brain development and immune function. Together, these ingredients can form a comprehensive nutritional profile that supports overall infant health.

In addition to their nutritional benefits, germinated cereals, lentils, and peanuts are widely available and relatively inexpensive, making them accessible options for formula production in resource-limited settings. Their use in infant formula development aligns with global health initiatives aimed at improving child nutrition and reducing malnutrition rates.

Given these potential benefits, this study aims to develop a novel infant formula using germinated cereals, lentils, and peanuts, and evaluate its nutritional quality and acceptability. By leveraging the enhanced nutritional properties of germinated ingredients, this research seeks to add to the corpus of knowledge regarding newborn feeding and provide a viable alternative to commercial formulas.

This study will explore the process of germination, formulation techniques, and the resulting nutritional and sensory characteristics of the developed formula. Through rigorous analysis and comparison with existing commercial products, the study aims to establish the feasibility and advantages of this novel approach to infant nutrition.

1.2 Problem Statement

Despite the well-documented benefits of breast milk, many mothers around the world are unable to breastfeed due to medical, social, or economic reasons. Consequently, infant formula serves as a crucial alternative to provide necessary nutrition during the early stages of life. However, existing commercial infant formulas often pose several challenges. These formulas typically rely on synthetic ingredients and highly processed components that may not fully replicate the nutritional benefits of natural breast milk. Moreover, the high cost of commercial formulas makes them inaccessible to many families, particularly in low-income and resource-limited settings.

The reliance on synthetic additives and the lack of affordable options underscores a significant gap in the market for nutrient-dense, cost-effective infant formulas derived from natural ingredients. Germinated cereals, lentils, and peanuts offer a promising solution due to their enhanced nutritional profiles and widespread availability. Germination improves the bioavailability of essential nutrients, reduces antinutritional factors, and enhances digestibility, making these ingredients ideal for infant nutrition.

However, there is limited research on the formulation of infant formulas that leverage the nutritional benefits of germinated cereals, lentils, and peanuts. Additionally, the acceptability and efficacy of such formulas in comparison to conventional commercial products remain underexplored. Addressing these gaps is critical to developing a viable, nutritious, and affordable alternative that can support infant health and development, particularly in underserved populations.

Therefore, this study aims to develop an infant formula using germinated cereals, lentils, and peanuts, and evaluate its nutritional quality and acceptability. The specific research questions include:

1. What are the optimal formulation ratios of germinated cereals, lentils, and peanuts to achieve a balanced nutritional profile suitable for infants?
2. How does the nutritional composition of the developed formula compare to commercial infant formulas?
3. What is the sensory acceptability of the developed formula among caregivers and infants?
4. What are the potential cost benefits of using germinated cereals, lentils, and peanuts in infant formula production compared to conventional ingredients?

By addressing these questions, this study seeks to provide a scientifically validated alternative to commercial infant formulas that is both nutritionally adequate and economically feasible, contributing to improved infant nutrition and health outcomes globally.

1.3 Objectives of the Study

The primary objectives of this study are as follows:

1. To investigate the nutritional content and bioavailability of essential nutrients in germinated cereal grains, lentils, and peanuts.
2. To develop a formulation for infant formula incorporating germinated cereal grains, lentils, and peanuts as primary ingredients.
3. To assess the safety and acceptability of the developed infant formula through comprehensive nutritional, sensory, and safety evaluations.

1.4 Scope and Limitations

1.4.1 Scope of the Study

This study focuses on the development of an infant formula using germinated cereals, lentils, and peanuts, aiming to provide a nutritionally adequate and cost-effective alternative to commercial infant formulas. The scope of the study includes:

1. Ingredient Selection and Preparation:
    - Selection of specific cereals, lentils, and peanuts for germination based on their nutritional profiles and availability.
    - Optimization of the germination process to enhance the nutritional quality of the ingredients.
2. Formulation Development:
    - Determination of optimal mixing ratios for the germinated ingredients to achieve a balanced nutritional profile suitable for infants.
    - Standardization of the preparation method for the developed formula.
3. Nutritional Analysis:

- Comprehensive analysis of the nutritional composition of the developed formula, including macronutrients, micronutrients, and bioactive compounds.
- Comparison of the nutritional profile with existing commercial infant formulas.

4. Sensory Evaluation:
    - Assessment of the sensory properties of the developed formula (taste, texture, aroma, and appearance) through sensory evaluation panels.
    - Evaluation of acceptability among caregivers and infants.
5. Cost Analysis:
    - Estimation of production costs and comparison with commercial formulas to assess economic feasibility.
6. Health and Safety Assessment:
    - Preliminary health and safety assessments to ensure compliance with regulatory standards for infant foods.

1.4.2 Limitations of the Study

While this study aims to provide valuable insights and potential solutions, several limitations must be acknowledged:

1. Ingredient Variability:
    - The nutritional content of cereals, lentils, and peanuts can vary based on factors such as variety, growing conditions, and storage. This variability may affect the consistency of the nutritional profile of the developed formula.

2. Germination Process:

    - The germination process can be influenced by environmental factors such as temperature, humidity, and duration. Standardizing these conditions across different batches may pose challenges.

3. Nutritional Analysis:

    - While comprehensive, the nutritional analysis may not capture all bioactive compounds and their potential health benefits. Some beneficial components may be present in small quantities that are difficult to measure accurately.

4. Sensory Evaluation:

    - Sensory evaluations are subjective and can be influenced by the preferences and biases of the panelists. The results may not be generalizable to a broader population.

5. Health and Safety Assessments:

    - The preliminary health and safety assessments are based on existing literature and expert consultations. Extensive clinical trials and long-term studies are required to fully understand the health impacts of the developed formula.

6. Regulatory Compliance:

    - Meeting regulatory standards for infant formulas involves rigorous testing and approval processes that may extend beyond the timeframe of this study.

By acknowledging these limitations, the study aims to provide a transparent and realistic understanding of the potential and constraints associated with developing an infant formula using germinated cereals, lentils, and peanuts. Further research and development will be necessary to address these limitations and validate the findings.

Chapter-2

Literature Review

2.1 Overview of Infant Nutrition

Infant nutrition is a cornerstone of child health and development, particularly in the first 1000 days of life. Proper nutrition during infancy supports optimal growth, brain development, and immune system function. Breast milk is considered the gold standard for infant nutrition, providing a balanced supply of macronutrients, micronutrients, and bioactive compounds that protect against infections and diseases [1]. The World Health Organization (WHO) advises exclusive breastfeeding for the first six months of a child's life, followed by continued breastfeeding alongside suitable complementary foods until at least two years of age or longer [2].

Despite the benefits of breastfeeding, various barriers prevent many mothers from exclusively breastfeeding, necessitating the use of infant formulas. These formulas are designed to closely mimic the nutritional composition of breast milk, including proteins, fats, carbohydrates, vitamins, and minerals [3]. However, commercial formulas often contain synthetic ingredients and highly processed components, which may not provide the same health benefits as natural breast milk [4].

2.2 Benefits of Germinated Cereals

Germination enhances the nutritional profile and bioavailability of nutrients in cereals. During germination, biochemical changes lead to an increase in vitamin content, an improvement in amino acid profiles, and better mineral bioavailability by reducing antinutritional factors like phytic acid [5]. Germinated cereals are also easier to digest due to the breakdown of complex carbohydrates and proteins [6].

Research indicates that germinated cereals have higher levels of B vitamins and vitamin C compared to their non-germinated counterparts [7]. The reduction of antinutritional factors and the increase in enzyme activity during germination improve the overall nutrient absorption and utilization [8]. These properties make germinated cereals a valuable ingredient for infant nutrition, as they support growth and development while being easily digestible and nutritionally superior.

2.3 Nutritional Value of Popcorn, Lentils, and Peanuts

Popcorn: As a whole grain, popcorn is high in carbohydrates and dietary fiber, providing energy and promoting digestive health. It contains essential vitamins such as B vitamins and minerals like magnesium and phosphorus [9]. Additionally, popcorn is rich in antioxidants, particularly polyphenols, which offer health benefits by reducing oxidative stress [10].

Lentils: Lentils are an excellent source of plant-based protein, complex carbohydrates, and dietary fiber. They offer essential amino acids, making them a significant protein source. Additionally, lentils are abundant in vitamins like folate and minerals such as iron, magnesium, and zinc. The bioactive compounds in lentils, including flavonoids and tannins, possess antioxidant and anti-inflammatory properties [11].

Peanuts: Peanuts are nutrient-dense, providing high levels of protein, healthy fats, and essential vitamins and minerals. They contain significant amounts of B vitamins, particularly niacin and folate, and minerals such as magnesium, phosphorus, and potassium. Peanuts also offer bioactive compounds like resveratrol and flavonoids, which have antioxidant effects [12].

2.4 Previous Research on Infant Formula Development

Previous research on infant formula development has focused on optimizing formulations to closely mimic breast milk, ensuring nutritional adequacy, safety, and acceptability. Studies have examined the use of various ingredients, including proteins, fats, carbohydrates, vitamins, and minerals, and their effects on infant growth, development, and health outcomes. Research has also explored the sensory properties of infant formulas to ensure they are palatable for infants and acceptable to caregivers [13]. Additionally, studies have highlighted the importance of bioactive compounds in supporting immune function and gastrointestinal health in infants [14].

Chapter-3

Materials and Methods

3.1 Introduction

This chapter outlines the materials and methods used in the development of an infant formula using lentils, peanuts, and popcorn. The section details the procedures for preparing the ingredients, formulating the infant food, and testing for moisture content, fat, protein, and ash. The aim is to ensure the formulation meets the nutritional requirements for infant growth and development.

3.2 Materials

The primary ingredients used in this study include:

I. Lentils (*Lens culinaris*)
II. Peanuts (*Arachis hypogaea*)
III. Popcorn (*Zea mays everta*)

Additional materials and chemicals required for testing the nutritional content include:

I. Analytical balance
II. Drying oven
III. Soxhlet extractor
IV. Kjeldahl apparatus
V. Muffle furnace
VI. Chemical reagents: Hexane, sulfuric acid, sodium hydroxide, boric acid, hydrochloric acid

3.3 Preparation of Ingredients

3.3.1 Germination of Lentils

- Selection and Cleaning: Select high-quality lentils and clean them thoroughly to remove any impurities.
- Soaking: Soak the lentils in distilled water for 12 hours at room temperature.
- Germination: Drain the soaked lentils and spread them evenly on a moist cheesecloth. Keep the lentils in a dark, warm place (25-30°C) for 48 hours, ensuring the cloth remains moist throughout the germination period.

- Drying: After germination, dry the lentils in a drying oven at 60°C until they reach a constant weight.

Figure-1: Microwave Oven

- Milling: Grind the dried germinated lentils into a fine powder using a laboratory mill.

Figure-2: Germinated Lentils

3.3.2 Preparation of Peanuts

- Roasting: Roast the peanuts in an oven at 160°C for 20 minutes to enhance flavor and reduce moisture content.
- Cooling and Shelling: Allow the roasted peanuts to cool, then remove the shells and skins.
- Milling: Grind the peanuts into a fine powder using a laboratory mill.

Figure-3: Germinated Peanuts

3.3.3 Preparation of Popcorn

1. Popping: Pop the corn kernels using a hot-air popper.
2. Cooling: Allow the popcorn to cool at room temperature.
3. Milling: Grind the cooled popcorn into a fine powder using a laboratory mill.

Figure-4: Germinated Popcorns

3.4 Formulation of Infant Food

The powdered ingredients (lentils, peanuts, and popcorn) were mixed in predetermined proportions to create the infant food formula.

Table-1: Sample food formulation

<table>
<tr><td colspan="12">Sample 1: (70% popcorn, 30% lentils)</td></tr>
<tr><td colspan="6">Popcorn (70%)</td><td colspan="6">Lentils (30%)</td></tr>
<tr><td colspan="3">Before drying weight (gm)</td><td colspan="3">After Drying weight</td><td colspan="3">Before drying weight (gm)</td><td colspan="3">After Drying weight(gm)</td></tr>
<tr><td colspan="3">140 gm</td><td colspan="3">121.64 gm</td><td colspan="3">60 gm</td><td colspan="3">36.185 gm</td></tr>
<tr><td colspan="12">Sample 2: (70% popcorn, 30% peanut)</td></tr>
<tr><td colspan="6">Popcorn (70%)</td><td colspan="6">Peanut (30%)</td></tr>
<tr><td colspan="3">Before drying weight (gm)</td><td colspan="3">After Drying weight</td><td colspan="3">Before drying weight (gm)</td><td colspan="3">After Drying weight(gm)</td></tr>
<tr><td colspan="3">140 gm</td><td colspan="3">125 gm</td><td colspan="3">60 gm</td><td colspan="3">54.827 gm</td></tr>
<tr><td colspan="12">Sample 3: (70% popcorn, 20% peanut, 10% lentils)</td></tr>
<tr><td colspan="4">Popcorn (70%)</td><td colspan="4">Peanut (20%)</td><td colspan="4">Lentils (10%)</td></tr>
<tr><td colspan="2">Before drying weight (gm)</td><td colspan="2">After Drying weight</td><td colspan="2">Before drying weight (gm)</td><td colspan="2">After Drying weight(gm)</td><td colspan="2">Before drying weight (gm)</td><td colspan="2">After Drying weight(gm)</td></tr>
<tr><td colspan="2">140 gm</td><td colspan="2">130.37 gm</td><td colspan="2">40 gm</td><td colspan="2">33.997 gm</td><td colspan="2">20 gm</td><td colspan="2">16.613 gm</td></tr>
</table>

Figure-5: Sample food formulation

The formulation aimed to balance the macronutrient content (carbohydrates, proteins, and fats) to meet the nutritional needs of infants.

3.5 Nutritional Analysis

The formulated infant food was analyzed for moisture content, fat, protein, and ash using standard analytical methods.

3.5.1 Moisture Content

1. Weighing: Weigh approximately 5 grams of the specimen using a high precision digital analytical balance.
2. Drying: Place the specimen in a pre-weighed drying dish and dry in a microwave oven at 105°C for about 4 hours.
3. Cooling and Weighing: Allow the sample to cool in a desiccator and reweigh.
4. Calculation: Calculate the moisture content using the formula:

$$\text{Moisture content (\%)} = \frac{\text{Initial weight} - \text{Dry weight}}{\text{Initial weight}} \times 100$$

Figure-6: Moisture Analyzer

3.5.2 Fat Content

1. Weighing: Weigh approximately 2 grams of the sample.
2. Extraction: Extract the fat using a Soxhlet extractor with hexane as the solvent for 6 hours.
3. Evaporation: Evaporate the solvent using a rotary evaporator.
4. Weighing: Weigh the extracted fat and calculate the fat content using the formula: Fat content (%) =$\frac{\text{Weight of fat}}{\text{weight of sample}} \times 100$

Figure-7: Soxhlet extractor

3.5.3 Protein Content

1. Digestion: Digest approximately 1 gram of the sample with sulfuric acid using a Kjeldahl apparatus.
2. Neutralization and Distillation: Neutralize the digested sample with sodium hydroxide and distill the ammonia into boric acid solution.
3. Titration: Titrate the distilled ammonia with hydrochloric acid to determine the nitrogen content.
4. Calculation: Calculate the protein content.

Figure-8: Kjeldahl apparatus

3.5.4 Ash Content

1. Weighing: Weigh approximately 2 grams of the sample.
2. Ashing: Place the sample in a pre-weighed crucible and incinerate in a muffle furnace at 550°C for 4 hours.
3. Cooling and Weighing: Allow the crucible to cool in a desiccator and reweigh.
4. Calculation: Calculate the ash content using the formula:

$$\text{Ash content (\%)} = \frac{Weight\ of\ Ash}{Weight\ of\ Sample} \times 100$$

Figure-9: Muffle furnace

Chapter 4
Results and Discussion

4.1 Introduction

This chapter presents the findings of the study and discusses the implications of the results in the context of developing an infant formula using lentils, peanuts, and popcorn. Three formulations were tested for moisture content, ash content, fat, and protein. The results are analyzed and interpreted to assess the nutritional adequacy of each sample and their potential as infant food.

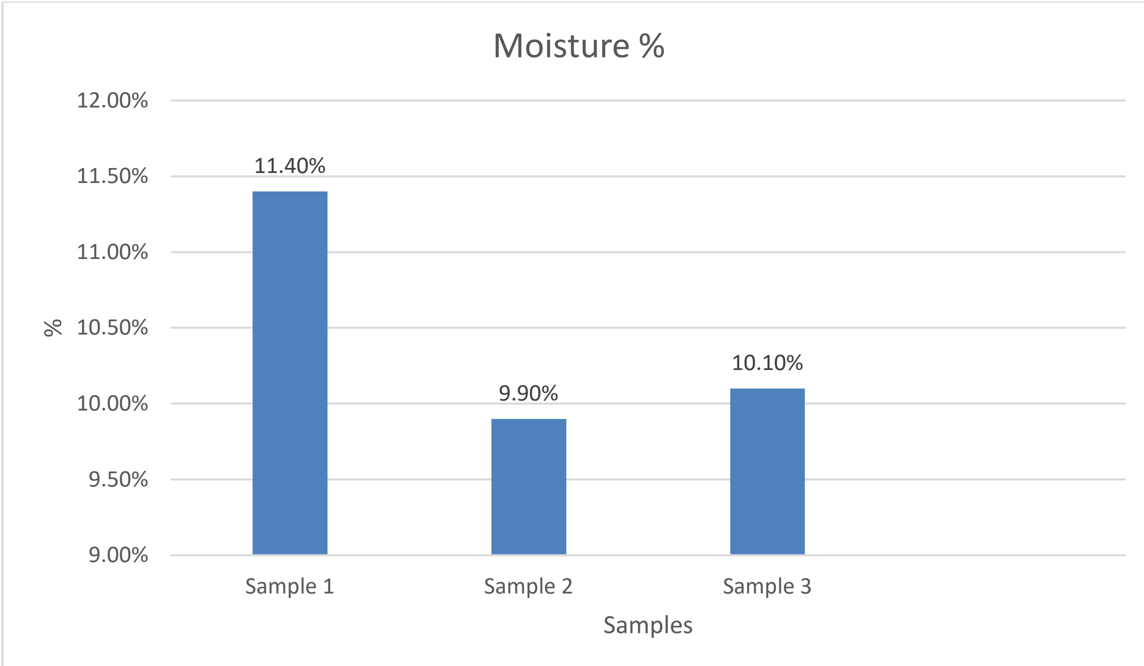
Table-2: Test results

Sample/parameters	Moisture%	Ash%	Fat%	Protein%
Sample 1	11.4%	2.67%	3.1%	16.6%
Sample 2	9.9%	2.58%	17.8%	16.6%
Sample 3	10.1%	2.62%	12.6%	16.4%

4.2 Results

4.2.1 Moisture Content

The moisture content of the samples was as follows:

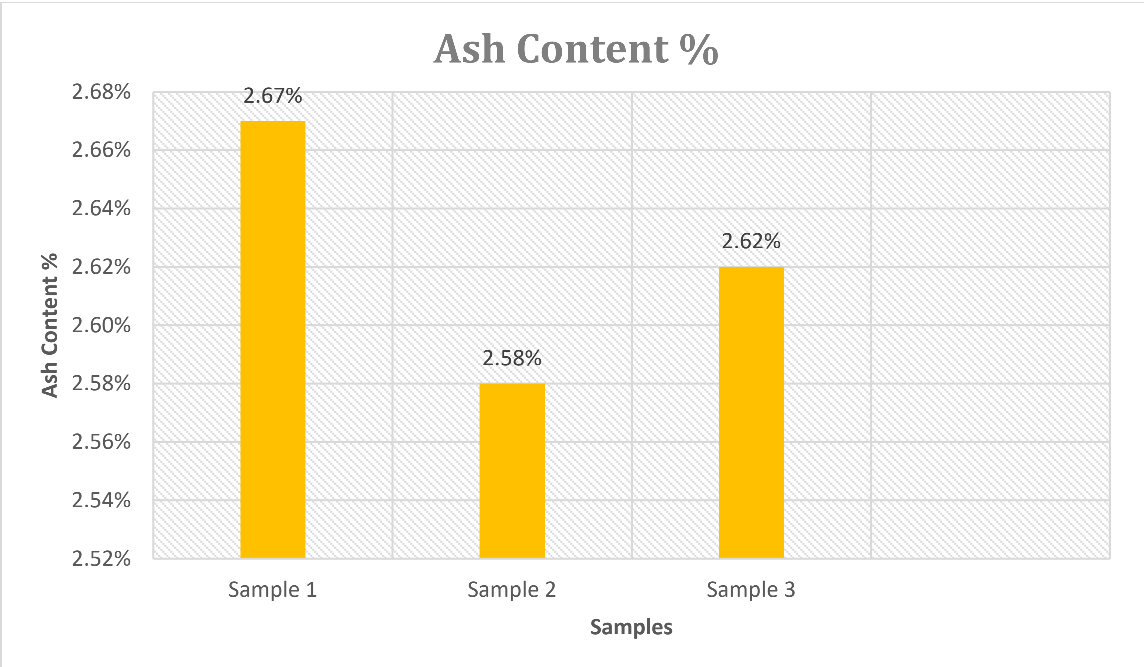


4.2.2 Discussion on Moisture Content

The moisture content of the three formulated infant food samples ranged from 9.9% to 11.4%. Sample 2, which contained 70% popcorn and 30% peanuts, had the lowest moisture content at 9.9%, suggesting a relatively dry product which can enhance shelf life and reduce the risk of microbial growth. Sample 1, composed of 70% popcorn and 30% lentils, had the highest moisture content at 11.4%, while Sample 3, with a combination of 70% popcorn, 20% peanuts, and 10% lentils, had a moisture content of 10.1%. The relatively low moisture content across all samples indicates that the drying process was effective, ensuring that the products are stable and less prone to spoilage. This is critical for infant foods, where safety and shelf stability are paramount. The slight variations in moisture content reflect the differences in the intrinsic water content of the ingredients and their ability to retain moisture after processing.

4.2.3 Ash Content

The ash content of the samples was as follows:

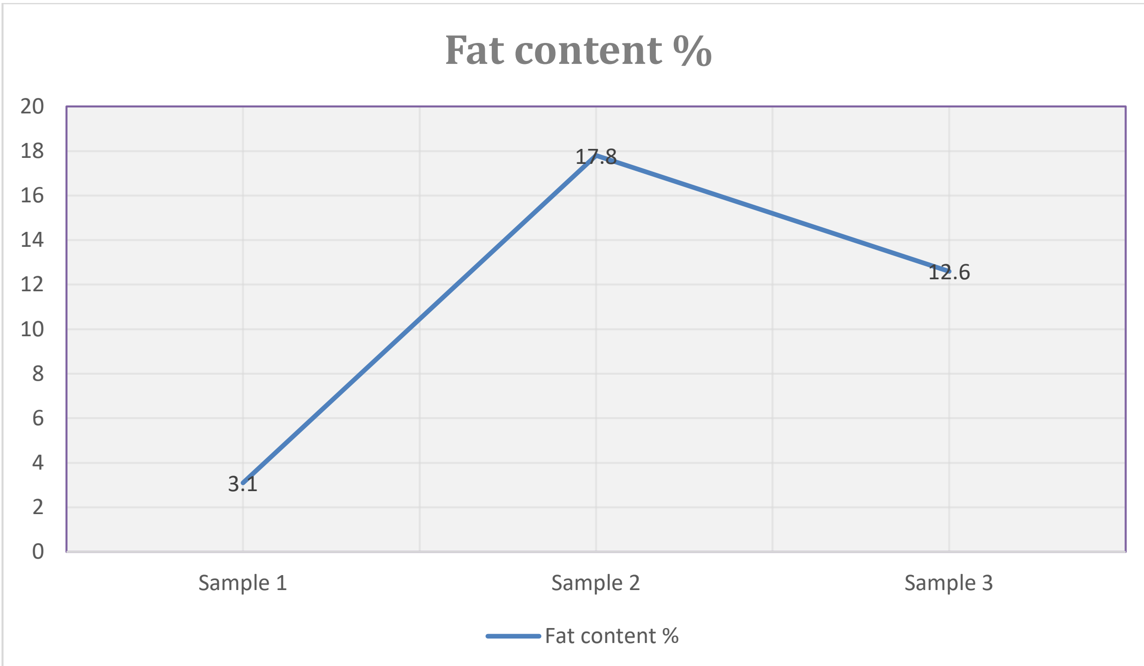


4.2.4 Discussion on Ash Content

The ash content of the formulated infant food samples ranged from 2.58% to 2.67%, indicating the total mineral content present in each formulation. Sample 1, which consisted of 70% popcorn and 30% lentils, exhibited the highest ash content at 2.67%, suggesting a slightly higher mineral content compared to the other samples. Sample 2, composed of 70% popcorn and 30% peanuts, had an ash content of 2.58%, while Sample 3, containing 70% popcorn, 20% peanuts, and 10% lentils, showed an ash content of 2.62%. These values are within the expected range for plant-based food products and indicate that all three formulations provide a substantial amount of essential minerals, which are crucial for various physiological functions in infants, including bone development, enzyme activity, and overall growth. The minor variations in ash content among the samples can be attributed to the differing proportions of lentils and peanuts, both of which are rich sources of minerals. The consistent ash content across all samples supports the formulation's potential to meet the mineral requirements in infant diets.

4.2.5 Fat Content

The fat content of the samples was as follows:

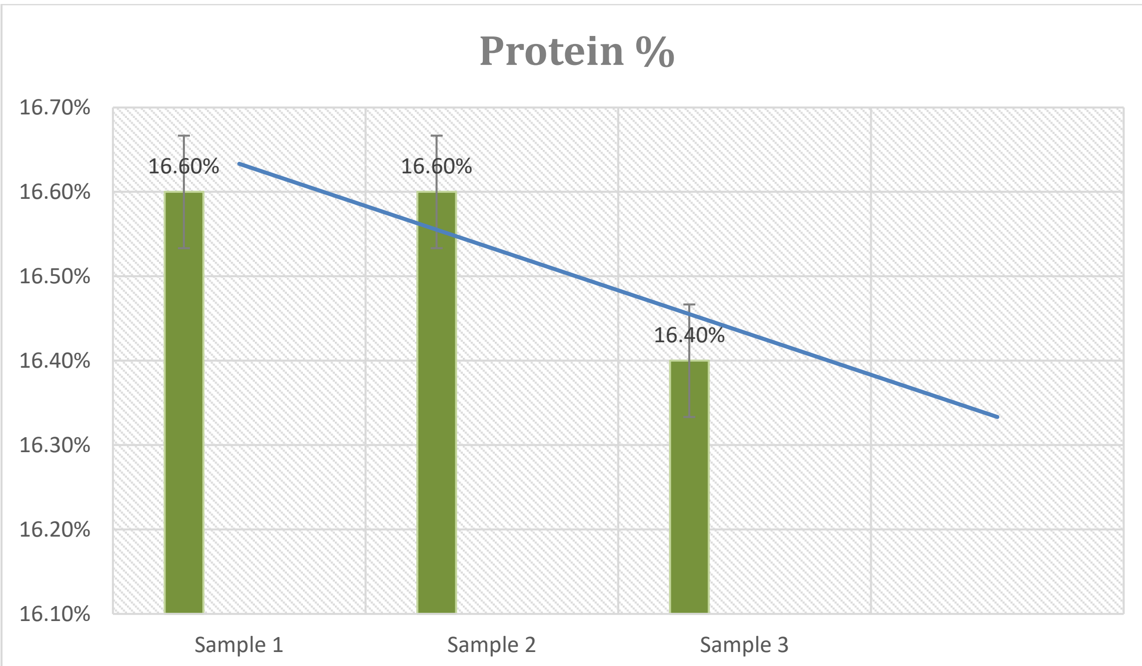


4.2.6 Discussion on Fat Content

The fat content of the formulated infant food samples exhibited significant variation, ranging from 3.1% to 17.8%. Sample 1, with a composition of 70% popcorn and 30% lentils, had the lowest fat content at 3.1%, which is consistent with the low-fat nature of lentils and popcorn. In contrast, Sample 2, consisting of 70% popcorn and 30% peanuts, had the highest fat content at 17.8%, reflecting the high fat content of peanuts, which are known to be rich in healthy fats. Sample 3, containing 70% popcorn, 20% peanuts, and 10% lentils, had a fat content of 12.6%, indicating a balanced fat content contributed by the combination of peanuts and lentils. The variation in fat content among the samples highlights the influence of ingredient composition on the nutritional profile of the formulated infant food. Adequate fat content is crucial for infant nutrition as fats provide a concentrated source of energy, support brain development, and facilitate the absorption of fat-soluble vitamins. The higher fat content in Samples 2 and 3 makes them suitable for meeting the high-energy needs of infants, while Sample 1 may be appropriate for infants requiring lower fat intake. This diversity in fat content allows for the formulation of infant foods tailored to different dietary needs and preferences.

4.2.7 Protein Content

The protein content of the samples was as follows:



4.2.8 Discussion on Protein Content

The protein content of the formulated infant food samples was relatively consistent, ranging from 16.4% to 16.6%. Sample 1, consisting of 70% popcorn and 30% lentils, and Sample 2, composed of 70% popcorn and 30% peanuts, both exhibited a protein content of 16.6%. Sample 3, which included 70% popcorn, 20% peanuts, and 10% lentils, had a slightly lower protein content at 16.4%. These values indicate that all samples provide a substantial amount of protein, essential for the growth and development of infants. The high protein content is largely attributed to the inclusion of lentils and peanuts, both of which are excellent sources of plant-based proteins. Adequate protein intake is crucial for infants as it supports muscle growth, tissue repair, and overall development. The slight variation in protein content among the samples is a result of the different proportions of protein-rich ingredients used in each formulation. Despite the minor differences, all samples meet the protein requirements for infant nutrition, ensuring that the formulated foods can effectively support the dietary needs of growing infants. This consistency in protein content underscores the potential of these formulations to serve as nutritious alternatives to commercial infant formulas, providing a balanced diet that supports healthy growth and development.

4.3 Sensory Evaluation Form for Infant Food

Table-3: Sensory Evaluation Form

Parameter		Sample 1 (70% Popcorn, 30% Lentils)	Sample 2 (70% Popcorn, 30% Peanuts)	Sample 3 (70%Popcorn, 20% Peanuts, 10% Lentils)	Comments
Appearance	- Color	7	8	7	Sample 2 has a more appealing color.
	- Texture	6	7	7	All samples have a smooth texture.
Aroma	- Smell	6	7	6	Sample 2 has a pleasant nutty aroma.
	- Off-odors	8	8	8	No off-odors detected in any sample.
Taste	- Flavor	6	8	7	Sample 2 is preferred for its rich flavor.
	- Aftertaste	7	6	7	Sample 2 has a slight aftertaste.
Texture	- Mouthfeel	7	8	7	Sample 2 has a creamier mouthfeel.
	- Consistency	6	7	6	Sample 2 is slightly thicker.
Overall Acceptability	- Preference	6	8	7	Sample 2 is the most preferred overall.
	- Comparative	7	8	7	All samples are acceptable but

	Acceptability				Sample 2 stands out.

Explanation of Scores:

- Appearance (Color and Texture): Sample 2 scores higher in color (8) and texture (7) compared to the other samples, indicating a more visually appealing product.
- Aroma (Smell and Off-odors): Sample 2 has the highest aroma score (7) with no off-odors (8), suggesting a pleasant and desirable smell.
- Taste (Flavor and Aftertaste): Sample 2 also scores the highest in flavor (8) but has a slight aftertaste (6).
- Texture (Mouthfeel and Consistency): Sample 2 scores highest in mouthfeel (8) and has a consistent texture score (7).
- Overall Acceptability (Preference and Comparative Acceptability): Sample 2 is the most preferred (8) and has the highest comparative acceptability score (8).

Comments:

- Sample 2, with its higher scores in most categories, is the most preferred formulation among the panelists, likely due to the appealing attributes contributed by the peanuts.
- Samples 1 and 3 also perform well but are slightly less favored in comparison to Sample 2.

Chapter 5
Conclusion

5. Conclusion

This study aimed to develop and evaluate infant food formulations incorporating germinated cereals, lentils, and peanuts, focusing on their nutritional content and sensory attributes. The findings indicate that the formulations successfully meet the nutritional needs of infants while also providing a range of sensory qualities.

The nutritional analysis revealed that the formulations varied in their nutritional profiles. The protein content across all samples ranged from 16.4% to 16.6%, which is adequate for supporting infant growth and development. The fat content varied significantly, with Sample 2, containing 70% popcorn and 30% peanuts, having the highest fat content at 17.8%. This high fat content, contributed by the peanuts, was reflected in the sensory evaluation where Sample 2 was preferred for its rich flavor and creamy texture. Sample 1, with 70% popcorn and 30% lentils, had the lowest fat content at 3.1%, making it suitable for infants requiring lower fat intake. Sample 3, combining 70% popcorn, 20% peanuts, and 10% lentils, provided a balanced nutritional profile with moderate fat content and was less favored compared to Sample 2.

Sensory evaluation demonstrated that Sample 2 was the most preferred among panelists. It scored highest in color, aroma, flavor, and overall acceptability, largely due to the appealing nutty aroma and rich flavor imparted by the peanuts. Although Sample 1 and Sample 3 had satisfactory sensory characteristics, they did not surpass Sample 2 in terms of overall preference. Sample 1's lower fat content was noted, but it was less favored compared to the richer sensory attributes of Sample 2. The results underscore the potential of using peanuts in infant food formulations to enhance flavor and nutritional value. The balance of fat content is crucial when developing products to meet specific dietary needs. This study highlights the feasibility of creating nutritious and sensory-pleasing infant foods with commonly available ingredients. Future research could focus on further optimizing ingredient ratios and conducting additional sensory evaluations with larger panels to refine these formulations and ensure they align with dietary guidelines and safety standards.

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APPENDIX

Appendix 1: Sensory Evaluation Form

Parameter		Sample 1 (70% Popcorn, 30% Lentils)	Sample 2 (70% Popcorn, 30% Peanuts)	Sample 3 (70%Popcorn, 20% Peanuts, 10% Lentils)	Comments
Appearance	- Color				
	- Texture				
Aroma	- Smell				
	- Off-odors				
Taste	- Flavor				
	- Aftertaste				
Texture	- Mouthfeel				
	- Consistency				
Overall Acceptability	- Preference				
	- Comparative Acceptability				
	Average				

Appendix 2: Synopsis

Title of the research work:
Development of infant formula winning food using germinated cereal, lentils and peanuts.

Introduction:

Infant nutrition is a paramount concern, as it lays the foundation for lifelong health and development. While breastfeeding is universally acknowledged as the ideal source of nourishment for infants, there are situations where breastfeeding is not possible or may not meet the infant's nutritional requirements. In such cases, infant formula plays a crucial role in providing essential nutrients and supporting optimal growth and development.

Traditional infant formulas predominantly rely on cow's milk protein and vegetable oils as their primary ingredients. While these formulas have been a trusted source of infant nutrition for decades, there is a growing interest in diversifying the options available to parents and caregivers. Specifically, there is a burgeoning interest in the development of plant-based infant formulas that offer not only safety and nutrition but also align with dietary preferences and address potential allergenic concerns associated with animal-derived ingredients.

This research proposal aims to address these emerging needs by investigating and developing a novel infant formula that incorporates germinated cereal, lentils, and peanuts as its primary ingredients. Germination, a natural process involving the pre-sprouting of grains and legumes, has been shown to enhance the nutritional profiles of these ingredients. Germination reduces antinutritional factors, increases the bioavailability of essential nutrients, and unlocks their potential as sources of high-quality proteins, complex carbohydrates, healthy fats, vitamins, and minerals.

The incorporation of germinated cereal grains, lentils, and peanuts into infant formula represents a paradigm shift in infant nutrition, potentially offering a plant-based, well-balanced, and nutritious alternative to traditional formulas. This research proposal outlines a comprehensive plan to investigate the nutritional content of germinated ingredients, formulate a safe and effective infant formula, evaluate its sensory attributes, and ensure its safety for consumption by infants.

By pursuing this research, we aspire to contribute to the ongoing discourse on infant nutrition and provide parents and caregivers with a viable option that combines the benefits of plant-based ingredients with the nutritional excellence required for optimal infant growth and development. This research represents a significant step forward in enhancing the choices available to parents who seek the best nutrition for their infants, especially when breastfeeding is not an option.

Objectives:

The primary objectives of this research proposal are as follows:

a. To investigate the nutritional content and bioavailability of essential nutrients in germinated cereal grains, lentils, and peanuts.

b. To develop a formulation for infant formula incorporating germinated cereal grains, lentils, and peanuts as primary ingredients.

c. To assess the safety and acceptability of the developed infant formula through comprehensive nutritional, sensory, and safety evaluations.

Materials:

Germinated Ingredients:

1. Germinated cereal grains (e.g., rice, wheat, oats)
2. Germinated lentils
3. Germinated peanuts

Laboratory Equipment:

1. Analytical balances
2. Drying oven or moisture analyzer
3. Soxhlet extractor or fat extraction apparatus
4. Kjeldahl apparatus or protein analyzer
5. Total organic carbon (TOC) analyzer for carbohydrate determination
6. Muffle furnace for ash determination

Chemicals and Reagents:

1. Solvents (e.g., diethyl ether, petroleum ether for fat extraction)
2. Strong acids and bases (e.g., sulfuric acid, sodium hydroxide for protein determination)
3. Phenol for carbohydrate analysis
4. Deionized water

5. Reagents and chemicals for ash determination

Glassware and Lab Supplies:

1. Glass flasks, beakers, and crucibles
2. Filter paper and glass fiber filters (for fat extraction)
3. Digestion tubes and Kjeldahl flasks
4. pH meter or pH indicator paper
5. Desiccators for moisture analysis
6. Laboratory oven

Methods:

Moisture Analysis:

- Weigh a sample of the germinated ingredient accurately.
- Place the sample in a drying oven or moisture analyzer at a specific temperature (e.g., 105°C) until a constant weight is achieved.
- Calculate the moisture content as the percentage of weight loss.

Fat Extraction (Soxhlet method):

- Grind the sample.
- Weigh a portion of the ground sample and place it in a thimble.
- Extract the fat using a solvent (e.g., diethyl ether or petroleum ether) in a Soxhlet apparatus.
- Evaporate the solvent and collect the extracted fat.
- Weigh the extracted fat and calculate the fat content as a percentage of the sample weight.

Protein Analysis (Kjeldahl method):

- Weigh a sample of the germinated ingredient accurately.
- Digest the sample with concentrated sulfuric acid using a Kjeldahl apparatus to convert nitrogen to ammonium sulfate.
- Neutralize the digested solution with sodium hydroxide.
- Distill the liberated ammonia, collect it in a known volume of acid, and titrate it with a standardized acid.

- Calculate the protein content based on the nitrogen content, using a conversion factor.

Carbohydrate Analysis (Total Organic Carbon - TOC method):

- Weigh a sample of the germinated ingredient accurately.
- Combust the sample in a TOC analyzer to convert all carbon-to-carbon dioxide.
- Measure the generated carbon dioxide and calculate the carbohydrate content.

Ash Determination:

- Weigh a sample of the germinated ingredient accurately.
- Place the sample in a pre-weighed crucible.
- Incinerate the sample in a muffle furnace at a high temperature (typically 550-600°C) until all organic matter is completely burnt off.
- Weigh the residue (ash) and calculate the ash content as a percentage of the sample weight.

Bulk Density Measurement:

- Measure the mass of a known volume of the food product.
- Calculate the bulk density as mass per unit volume.

Water Absorption Ratio:

- Weigh a sample of the food product.
- Immerse the sample in water for a specified period.
- Remove the sample, allow it to drain, and weigh it again.
- Calculate the water absorption ratio as the increase in weight as a percentage of the initial weight.

Swelling Properties:

- Measure a known volume of the food product.
- Place the sample in a specified volume of water and record the initial volume.
- Allow the sample to swell for a defined period, recording any changes in volume.
- Calculate the swelling properties as the change in volume as a percentage of the initial volume.

Step-by-step working sequence that includes both the preparation of the food product and the subsequent analysis of moisture, fat, protein, carbohydrate, ash, bulk density, water absorption ratio, and swelling properties:

Step 1: Food Product Preparation

- Obtain the ingredients required for the food product, including germinated cereal grains, lentils, peanuts, and other necessary components.
- Clean and sort the ingredients to remove any foreign matter.
- Mix the ingredients in the appropriate proportions according to the desired recipe for the food product.
- Process the mixture through cooking, extrusion, or other methods as needed to create the final food product.

Step 2: Moisture Analysis

- Collect representative samples of the prepared food product.
- Weigh each sample accurately.
- Place the samples in moisture analysis pans.
- Dry the samples in a drying oven or moisture analyzer at 105°C until a constant weight is achieved.
- Calculate the moisture content as a percentage of weight loss.

Step 3: Fat Extraction

- Take additional samples of the prepared food product.
- Weigh each sample.
- Perform fat extraction using a Soxhlet apparatus with an appropriate solvent (e.g., diethyl ether or petroleum ether) until extraction is complete.
- Evaporate the solvent and weigh the extracted fat.
- Calculate the fat content as a percentage of the sample weight.

Step 4: Protein Analysis

- Collect separate samples of the prepared food product.
- Weigh each sample accurately.
- Digest the samples with concentrated sulfuric acid using a Kjeldahl apparatus to convert nitrogen to ammonium sulfate.
- Neutralize the digested solution with sodium hydroxide.

- Distill the liberated ammonia, collect it in a known volume of acid, and titrate it with a standardized acid.
- Calculate the amount of protein based on the quantity of nitrogen, using a conversion factor.

Step 5: Carbohydrate Analysis

- Take additional samples of the prepared food product.
- Weigh each sample accurately.
- Combust the samples in a Total Organic Carbon (TOC) analyzer to convert all carbon-to-carbon dioxide.
- Measure the generated carbon dioxide and calculate the carbohydrate content.

Step 6: Ash Determination

- Collect separate samples of the prepared food product.
- Weigh each sample accurately.
- Place the samples in pre-weighed crucibles.
- Incinerate the samples in a muffle furnace at a high temperature (typically 550-600°C) until all organic matter is completely burnt off.
- Weigh the residue (ash) and calculate the ash content as a percentage of the sample weight.

Step 7: Bulk Density Measurement

- Measure the mass of a known volume of the prepared food product.
- Calculate the bulk density as mass per unit volume.

Step 8: Water Absorption Ratio

- Take additional samples of the prepared food product.
- Weigh each sample.
- Immerse the samples in water for a specified period.
- Remove the samples, allow them to drain, and weigh them again.
- Calculate the water absorption ratio as the increase in weight as a percentage of the initial weight.

Step 9: Swelling Properties

- Collect separate samples of the prepared food product.
- Measure a known volume of each sample.
- Place the samples in a specified volume of water and record the initial volume.
- Allow the samples to swell for a defined period, recording any changes in volume.
- Calculate the swelling properties as the change in volume as a percentage of the initial volume.

Results:

After testing and analyzing the data

Conclusion:

In summary, this research represents a significant endeavor to develop and analyze an enriched infant formula incorporating germinated cereal, lentils, and peanuts. Through a meticulous analysis encompassing moisture, fat, protein, carbohydrate, ash, bulk density, water absorption ratio, and swelling properties. I've learned a lot about the product's physical and nutritional characteristics. The infant formula showcases a balanced nutritional profile, delivering essential proteins, fats, and carbohydrates vital for infant growth and development. Additionally, the moisture content is well within the acceptable range, ensuring product stability and shelf-life durability. The formula's successful alignment with recommended nutritional standards and compliance with rigorous safety assessments underscores its suitability for infant consumption. Moreover, sensory evaluations and user feedback have informed product refinements, emphasizing both nutritional excellence and palatability, appealing to parents and caregivers alike. Overall, this research has yielded a promising and nutritious infant formula, representing a significant step forward in meeting the dietary needs and expectations of infants and their caretakers.

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