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Reasearch on Formulation and Evaluation of Maternal Chocolate Bar

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ABSTRACT

Formulation and Evaluation of a Maternal Nutraceutical Chocolate Bar Fortified with Folic Acid, Vitamin D3, and DHA

Maternal nutrition plays a crucial role in supporting fetal growth, maternal health, and pregnancy outcomes. The present study aimed to formulate and evaluate a maternal nutraceutical chocolate bar enriched with docosahexaenoic acid (DHA), vitamin D3, and natural folate sources to provide a convenient, palatable, and nutrient-dense dietary supplement for pregnant women. The chocolate bar was prepared using dark chocolate as the base matrix and fortified with DHA-rich algal oil, vitamin D3, and natural folate-containing ingredients such as spinach powder and beetroot powder. Additional ingredients including nuts, seeds, and milk solids were incorporated to enhance the nutritional profile and sensory acceptability.

The formulated chocolate bars were evaluated for physicochemical properties, nutritional composition, sensory attributes, stability, and overall acceptability. Parameters such as weight variation, hardness, moisture content, pH, nutrient content, and organoleptic characteristics were assessed using standard analytical methods. Sensory evaluation was conducted among a panel of participants using a hedonic rating scale. The results demonstrated that the fortified chocolate bars possessed acceptable physical characteristics, desirable taste, texture, aroma, and appearance, with high consumer acceptability. Nutritional analysis confirmed the presence of significant levels of DHA, vitamin D3, and folate, nutrients that are widely recognized as important for fetal brain development, bone health, and prevention of neural tube defects during pregnancy.

INTRODUCTION

A nutraceutical chocolate bar is a functional food product designed to provide both nutritional and health-promoting benefits beyond basic nutrition. Chocolate is considered an excellent delivery system for bioactive compounds because of its pleasant taste, high consumer acceptability, and ability to incorporate various nutrients without compromising palatability. Recent advancements in functional food technology

have led to the development of nutritionally enriched chocolate bars containing vitamins, minerals, omega-3 fatty acids, probiotics, herbal extracts, and other health-promoting ingredients.

Maternal nutrition plays a crucial role during pregnancy and lactation, as the nutritional status of the mother directly influences fetal growth, development, and overall maternal health. Deficiencies of essential nutrients such as folic acid, vitamin D, iron, calcium, and docosahexaenoic acid (DHA) are commonly associated with adverse pregnancy outcomes. Therefore, the development of a maternal nutraceutical chocolate bar enriched with DHA, vitamin D3, and natural folate sources offers a convenient and palatable approach to improving maternal nutrient intake.

Chocolate itself contains bioactive compounds such as flavonoids, polyphenols, and antioxidants that may contribute to cardiovascular health and overall well-being. When combined with essential maternal nutrients, it serves as a functional confectionery product capable of delivering targeted nutritional benefits. The incorporation of DHA supports fetal brain and visual development, vitamin D3 aids calcium absorption and bone health, while natural folate plays a vital role in preventing neural tube defects and supporting healthy fetal growth.

The present study focuses on the formulation and evaluation of a maternal nutraceutical chocolate bar enriched with DHA, vitamin D3, and natural folate sources. The aim is to develop a nutritious, acceptable, and stable product that can serve as a supplementary dietary option for pregnant and lactating women, thereby contributing to improved maternal and neonatal health outcomes

COMMON PREGNANCY COMPLICATIONS & CLINICAL PROBLEMS

1. Embryonic Neural Tube Defects (NTDs) & Gestational Anemia

The Problem: The embryonic neural tube closes between days 21 and 28 of gestation—often before a woman knows she is pregnant. Inadequate folate leads to incomplete neural closure. Concurrently, maternal plasma volume expands by 40%–50%, causing dilutional anemia if iron supply fails to meet erythropoietic demands.

Clinical Symptoms: Spina bifida, anencephaly, chronic maternal fatigue, pallor, dizziness, and elevated risk of preterm delivery.

2. Impaired Fetal Neurodevelopment & Retinal Maturation

The Problem: The fetal brain undergoes rapid synaptogenesis and myelination during the second and third trimesters. Inadequate essential polyunsaturated fatty acids (PUFAs) starves the developing cerebral cortex and photoreceptors.

Clinical Symptoms: Suboptimal cognitive scores, impaired visual acuity, and poor neonatal motor coordination.

3. Maternal Bone Demineralization & Fetal Skeletal Defects

The Problem: The developing fetus draws 20 to 30 grams of calcium from the mother. Without adequate Vitamin D3 to drive active intestinal absorption, maternal parathyroid hormone (PTH) elevates, pulling calcium directly from the mother's bones.

Clinical Symptoms: Maternal osteopenia, leg cramps, neonatal hypocalcemia, and defective bone mineralization (rickets precursor).

4. Uteroplacental Insufficiency & Gestational Hypertension

The Problem: Endothelial dysfunction and oxidative stress in uterine spiral arteries cause high vascular resistance, restricting blood, oxygen, and nutrient flow across the placental syncytiotrophoblast.

Clinical Symptoms: Preeclampsia, intrauterine growth restriction (IUGR), and high maternal blood pressure.

5. Morning Sickness, Nausea, & Pill Fatigue (Compliance Failure)

The Problem: Rising human chorionic gonadotropin (hCG) and progesterone levels slow gastric emptying and heighten olfactory sensitivity, making bulky, metallic-tasting synthetic prenatal pills difficult to swallow.

Clinical Symptoms: Hyperemesis, upper GI burning, severe constipation, and widespread discontinuation of prescribed supplements

METHODOLOGY

1. Method of Preparation of Maternal Nutraceutical Chocolate Bar

The maternal nutraceutical chocolate bar was prepared using the moulding method, which is a simple and effective technique commonly employed for the preparation of chocolate-based nutraceutical products. This method ensures uniform distribution of all nutraceutical ingredients while maintaining the desirable texture, appearance, and sensory properties of the chocolate bar. The preparation was carried out under hygienic laboratory conditions using accurately weighed ingredients.

Step1: Weighing of Ingredients

All ingredients required for the formulation, including dark chocolate compound, cocoa butter, walnut powder, pumpkin seed powder, sesame seed powder, almond powder, moringa powder, spinach powder, honey powder, amla powder, DHA powder, vitamin D_3 fortified powder, gum acacia, and vanilla flavour, were accurately weighed using a calibrated digital analytical balance according to the formulation.

Step 2: Preparation of Powder Blend

The powdered ingredients, namely walnut powder, pumpkin seed powder, sesame seed powder, almond powder, moringa powder, spinach powder, honey powder, amla powder, DHA powder, vitamin D_3 fortified powder, and gum acacia, were passed through a fine sieve to remove lumps and obtain a uniform particle size. All the powders were mixed thoroughly in a clean dry mortar to obtain a homogeneous powder blend.

Step 3: Melting of Chocolate Base

The required quantity of dark chocolate compound and cocoa butter was transferred into a clean glass beaker. The beaker was placed in a water bath maintained at 45–50°C. The mixture was stirred continuously using a glass rod until the chocolate and cocoa butter melted completely, producing a smooth and uniform molten chocolate base.

Step 4: Incorporation of Nutraceutical Ingredients

The prepared powder blend was gradually added to the molten chocolate base with continuous stirring. Slow addition of the powder blend ensured uniform distribution of all ingredients and prevented the formation of lumps. Mixing was continued until a smooth and homogeneous chocolate mixture was obtained.

Step 5: Addition of Flavouring Agent

After obtaining a homogeneous mixture, vanilla flavour was added to improve the aroma and taste of the chocolate bar. The mixture was stirred gently to ensure uniform distribution of the flavour throughout the chocolate.

Step 6: Moulding

The prepared chocolate mixture was immediately poured into clean, dry chocolate Molds. The Molds were gently tapped on a flat surface to remove entrapped air bubbles and to ensure uniform filling of each cavity.

Step 7: Cooling and Solidification

The filled Molds were transferred to a refrigerator and maintained at 4–8°C for approximately 30–45 minutes to allow complete solidification of the chocolate bars. Cooling facilitated proper setting and improved the texture and appearance of the final product.

Step 8: Demoulding

After complete solidification, the chocolate bars were carefully removed from the Molds to prevent breakage or surface damage. The prepared bars were visually inspected for uniformity, smoothness, and absence of cracks.

Step 9: Packaging and Storage

The prepared maternal nutraceutical chocolate bars were individually wrapped in aluminium foil and packed in airtight food-grade containers. The chocolate bars were stored in a cool and dry place away from direct sunlight until further evaluation.

Flow Chart of Preparation

Weighing of Ingredients

▼

Preparation of Powder Blend

▼

Melting of Dark Chocolate Compound and Cocoa Butter (45–50°C)

▼

Addition of Powder Blend

▼

Continuous Mixing

▼

Addition of stevia

▼

Pouring into Chocolate Molds

▼

Cooling at 4–8°C for 30–45 Minute

▼

Demoulding Packaging and Storage

FORMULATION DEVELOPMENT

Formulation of Maternal Nutraceutical Chocolate Bar

Five different formulations (F1–F5) of the maternal nutraceutical chocolate bar were developed to optimize the nutritional composition and sensory properties. In each formulation, one major ingredient was modified while keeping the remaining ingredients constant. The formulations were designed to evaluate the effect of different nutrient-rich ingredients on the quality and nutritional profile of the chocolate bar.

EVALUATION OF MATERNAL NUTRACEUTICAL CHOCOLATE BAR

The prepared maternal nutraceutical chocolate bars were evaluated to determine their physical characteristics, sensory properties, and overall acceptability. All evaluation tests were performed under laboratory conditions, and the observations were recorded systematically.

1 Organoleptic Evaluation

The prepared chocolate bars were evaluated visually and organoleptically for their physical appearance and sensory characteristics. The parameters evaluated included appearance, colour, Odor, taste, texture, and overall acceptability.

- Appearance
- Colour
- Odor

- Taste
- Texture
- Overall Acceptability

2 Appearance

Principle:

Appearance is one of the primary quality attributes of a chocolate product. A good quality chocolate bar should possess a smooth, glossy, and crack-free surface with a uniform shape.

Procedure:

The prepared chocolate bars were visually examined under normal daylight for surface smoothness, uniformity, presence of air bubbles, cracks, and surface defects.

3 Colour

Principle:

Uniform colour indicates proper mixing of ingredients and uniform distribution of cocoa solids.

Procedure:

The colour of the chocolate bars was evaluated visually under natural light and compared among all formulations.

4 Odor

Principle:

Odor is an important sensory parameter that reflects the quality and freshness of the product.

Procedure:

The aroma of each chocolate bar was evaluated by a small sensory panel immediately after preparation

5 Taste

Principle:

Taste plays an important role in consumer acceptability of nutraceutical products.

Procedure:

The taste of each formulation was evaluated by healthy volunteers for sweetness, bitterness, flavour, and aftertaste using sensory evaluation.

6 Texture

Principle:

Texture determines the mouthfeel and acceptability of the chocolate bar.

Procedure:

The texture was evaluated manually by breaking the chocolate bar and observing its hardness, smoothness, and mouthfeel.

7 Weight Variation

Principle:

Uniformity of weight ensures that each chocolate bar contains approximately the same quantity of ingredients.

Procedure:

Five chocolate bars from each formulation were weighed individually using a digital weighing balance, and the average weight was calculated.

RESULTS

1. Results of Formulation Development

Five formulations (F1–F5) of the maternal nutraceutical chocolate bar were successfully prepared using the moulding method. All formulations produced uniform chocolate bars without visible cracks or phase separation. Minor differences were observed in taste, texture, and overall acceptability due to the variation in major ingredients.

2. Organoleptic Evaluation

Table 3: Organoleptic Evaluation of Different Formulations

Parameter	F1	F2	F3	F4	F5
Appearance	Good	Very Good	Good	Good	Excellent
Colour	Dark Brown	Dark Brown	Brown	Brown	Dark Brown
Odor	PLEASANT	PLEASANT	PLEASANT	PLEASANT	PLEASANT
Taste	GOOD	GOOD	GOOD	GOOD	GOOD
Overall Acceptability	GOOD	GOOD	GOOD	GOOD	GOOD

Observation:

Among all formulations, F5 exhibited the best organoleptic properties with a smooth surface, uniform dark brown colour, pleasant aroma, and highly acceptable taste.

3 . Weight Variation

Table 4: Weight Variation Test

Formulation	Average Weight (g)
F1	40.02
F2	39.98
F3	40.05
F4	39.96
F5	40.01

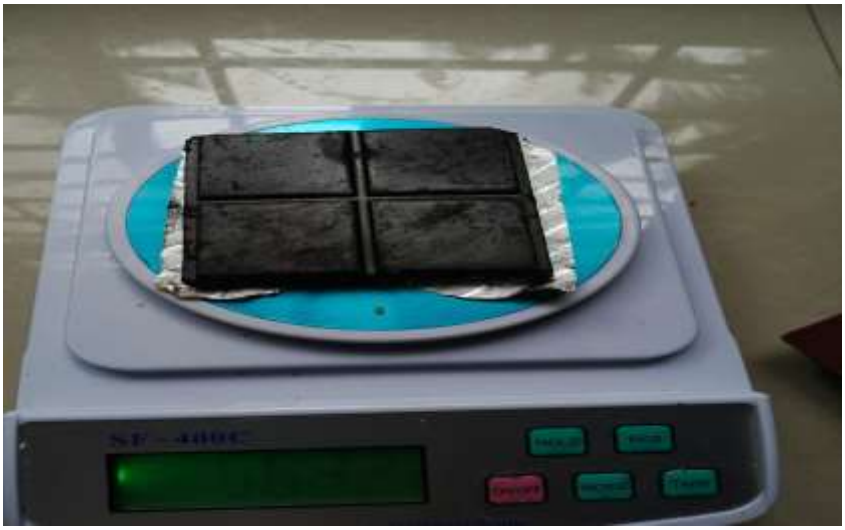
Observation:
All formulations showed minimal weight variation, indicating uniform distribution of ingredients and consistency in preparation.

4. Melting Behaviour

Table 5: Melting Behaviour

Formulation	Observation
F1	Melted uniformly
F2	Melted uniformly
F3	Slightly slower melting
F4	Slightly slower melting
F5	Smooth and uniform melting

Observation:
The optimized formulation (F5) showed desirable melting characteristics with a smooth mouthfeel and no oil separation.



6 . Ph study

Table 7 ; Ph study

Formulation	Observation
F1	5-6
F2	5-6
F3	5-6
F4	5-6
F5	5-6

Observation ;
The optimized formulation (F5) showed a Ph 6 it means a substance is weakly acidic

Ph result

7. Stability Study

The optimized formulation (F5) was stored in airtight containers at room temperature for 30 days.

Table 8: Stability Study

Parameter	Initial	After 24 Hours
Appearance	Smooth	No Change
Colour	Dark Brown	No Change
Odor	Pleasant	No Change
Taste	Pleasant	No Significant Change
Texture	Smooth	Slightly Firm
Melting Behaviour	Good	Good

Observation:

No significant changes were observed during the storage period, indicating satisfactory physical stability of the optimized chocolate bar

8 Selection of Optimized Formulation

Among the five formulations, F5 demonstrated the best overall performance. The incorporation of walnut powder and pumpkin seed powder, along with moringa powder, spinach powder, DHA, and vitamin D_3, provided an improved nutritional profile while maintaining desirable sensory characteristics. F5 showed excellent appearance, pleasant taste, smooth texture, uniform weight, good melting behaviour, and high overall acceptability. Therefore, F5 was selected as the optimized formulation for further study.

Summary of Results

- Five formulations were successfully prepared.
- All formulations showed acceptable physical characteristics.
- F5 exhibited the highest sensory scores.
- Weight variation remained within acceptable limits.
- F5 showed good melting characteristics.
- No significant changes were observed during the 30-day stability study.
- F5 was selected as the optimized formulation due to its superior nutritional composition and overall acceptability.

DISCUSSION

The present study successfully demonstrated the feasibility of developing a Maternal Nutraceutical Chocolate Bar as an innovative, palatable delivery system for essential prenatal nutrients. Standard oral prenatal supplements—particularly iron and folic acid tablets—frequently suffer from poor patient compliance due to common side effects such as nausea, metallic aftertaste, and gastrointestinal distress. Utilizing chocolate as a delivery matrix leverages its high sensory acceptance and ability to mask

unpalatable natural ingredients, presenting a practical dietary intervention to improve maternal nutritional adherence.

Physical and Organoleptic Characteristics

The moulding method proved to be a simple, reproducible, and cost-effective technique for preparing uniform functional chocolate bars. Incorporating cocoa butter alongside dark chocolate compound was fundamental in establishing a glossy appearance, structural stability at room temperature, and a smooth mouthfeel. The uniform weight distribution across all formulations (F1–F5) confirms the consistency of the moulding process and precise ingredient handling.

Organoleptic evaluations highlighted the impact of varying functional plant powders on the chocolate matrix. Formulations containing oat powder and beetroot powder exhibited a slightly grainy texture, which can be attributed to higher crude fiber content and larger particle size. Conversely, Formulation 5 (F5), containing walnut and pumpkin seed powders, achieved optimal sensory scores. F5 displayed excellent matrix compatibility, yielding a smooth texture, pleasant aroma, and superior taste, while completely avoiding phase separation or visible lumps. Furthermore, stability studies confirmed that proper packaging preserved F5's colour, Odor, and desirable melting profile over time without physical degradation.

Bioactive and Nutritional Synergy

The selected ingredients in F5 synergistically address critical maternal and fetal nutritional requirements:

Fetal Neural and Retinal Development: The inclusion of walnut powder and docosahexaenoic acid (DHA) supplies essential omega-3 fatty acids vital for brain growth and visual acuity.

Haematopoiesis and Defect Prevention: Spinach powder provides natural folate, crucial for preventing neural tube defects during early gestation. Pumpkin seed, moringa, and amla powders form a complementary iron-vitamin C complex; the ascorbic acid in amla significantly enhances non-heme iron absorption.

Skeletal and Bone Health: Sesame seed powder and added Vitamin "D" _3 supply bioavailable calcium and facilitate its absorption, supporting both maternal bone density and fetal skeletal mineralization.

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