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RESEARCH ARTICLE

Prevention Of Stunting In The First 450 Days Of Life (FDL) Through Fortification Of Tuna Fish Cake And Formula Programming In Supporting Indonesia's National Defense In The Health Sector

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ABSTRACT

The projection of human resource resilience in generational vulnerability is stunting, whereas health is the support of national defence. Supplementary feeding is a solution in stunting cases in Indonesia, and it is in line with the government's program to provide supplements for breastfeeding mothers.The goal of this study is to obtain tuna cake formula with sufficient RDA for breastfeeding mothers as a portion of additional food in stunting prevention in the first 450 days after giving birth. Using the design expert 7.0 pilot software design (DX 7 trial) to test the design of RSM D mixtures on tuna cake formulations (animal, vegetable and composite flour formulations). Chemically, physically, and microbiologically analyzed, as well as ligands to determine the response of composite flour containing energy, protein, vitamins (A, B12, and C), folic acid, Ca, Fe, Zn, I, Omega 3, Omega 6 and ligands and proteins.: The nutritional profile of tuna fish cake includes 505 kcal of energy, 31 g of protein, 352 ug of Vitamin A per 100 grams, 369 mg of P per 100 grams, 58.32 mcg of I per 100 grams, 3.33 mg of Zn per 100 grams, 359 ug of Cu per 100 grams, and ligan. It also satisfies the RDA criteria for safe intake. Breastfeeding moms can also eat tuna cake as part of the government's supplementing program to bolster the nation's military.

INTRODUCTION

The most crucial factor in bolstering national defence is good health; stunting can harm the country's future, particularly in human resource resilience, which is susceptible to national defence. Indonesia is the fifth-largest nation where stunting cases must be treated as soon as feasible. Malnutrition, in particular, is a primary cause of stunting. Stunting is primarily caused by persistent malnutrition, which lasts from the first 1000 days of life until the child is two years old. Risk factors for stunting exist both during pregnancy and after delivery. Prenatal variables significantly impact a child's growth and help prevent stunting (Krisnana, Widiani and Sulistiawati, 2020). It is projected that the percentage of children worldwide who are stunted will drop from 39.7% to 26.7% between 1990 and 2010 (Yang *et al.*, 2018). 11.2% of stunting occurs in the womb, 60.6% occurs between birth and two years, and 28% occurs between the ages of two and five (Anwar *et al.*, 2021). The resulting

cumulative process of dietary deficit leads to stunting, which impedes growth and development (Ilmani and Fikawati, 2023)(Muleta *et al.*, 2021).

Nutrition is essential from conception to the first two postpartum years (1000 FDL) (Likhar and Patil, 2022). Early in life, nutrition plays a critical role in a person's growth and development (Horta *et al.*, 2007). To prevent childhood malnutrition, it is imperative to provide adequate nourishment. Worldwide, inadequate nutrition has resulted in 155 million children under the age of five suffering from stunting, 47 million of whom are wasted, and 41 million of whom are fat (Dukhi, 2020)In 1000 FDL, nutritional deficits may impact mortality and morbidity. They are also linked to general health and academic achievement throughout adolescence and adulthood. (Soliman *et al.*, 2021). A zinc deficiency accounts for one per cent of stunted children (Happy Aprilitasari, 2020)(Abdollahi *et al.*, 2019). Additionally, stunted children exhibit lower IQs, language abilities, and educational achievement (Nahar *et al.*, 2020).

Enough nourishment can promote optimal growth and quick brain development, producing an intelligent future population. (Schwarzenberg and Georgieff, 2018). Protein is necessary for prenatal development, particularly for the brain (Kwilas *et al.*, 2015).

After the infant is born, early breastfeeding initiation (IMD) must be done for at least an hour to ensure proper nutrition 1000 FDL. From birth until the infant is six months old, only provide mother's milk (ASI). Breastfeeding until the child is 24 months old or older, they offer supplementary feeding (MPASI) to infants between the ages of 6 and 24 months (Likhar and Patil, 2022).

In addition to producing antibodies for newborns, IMD can decrease postpartum haemorrhage, increase milk generation, and influence whether nursing will last longer. Studies indicate that IMD is linked to a reduced risk of newborn mortality (Jiska Cohen-Mansfield, Maha Dakheel-Ali, MDb, Marcia S. Marx, PhDb, Khin Thein, MDb, and Natalie G. Regier and Waage et al., 2017).

In addition to providing nourishment, exclusive breastfeeding shields babies from viral illnesses such as otitis media, gastroenteritis, diarrhoea, and acute lower respiratory tract infections (Frank *et al.*, 2019)(Branger *et al.*, 2023). The length of time that children are exclusively breastfed can lower the frequency of childhood overweight and obesity (Liu *et al.*, 2022).

Mother's milk, produced by the mammary glands, is rich in macro- and micronutrients. Babies can safely eat them because they are free of bacteria. Carbs, proteins, and lipids are the macronutrients in breast milk; vitamins and minerals are the micronutrients (calcium, magnesium, selenium, zinc, phosphorus, iron, sodium) (Yi and Kim, 2021). Many vitamins, including B6, B12, C, A, E, D, and K, are present in breast milk.(Perrella *et al.*, 2021) .

Breast milk's constituents offer well-rounded nourishment and defence against contagious diseases (Lyons *et al.*, 2020). Eighty-seven per cent of breast milk comprises water, three to five per cent of fat, 6.9 to 7.2% lactose, 0.8 to 0.9% protein, and other bioactive ingredients (Polidori *et al.*, 2022).

Breast milk's primary energy source is fat (Polidori *et al.*, 2022). Breast milk fat helps babies' immune systems, growth regulation, inflammatory response, vision, cognitive development, and motor systems. The baby's nervous system needs DHA and arachidonic acid for cell differentiation and synapse development (Basak, Mallick and Duttaroy, 2020).

Breast milk lactose hydrolyzes into glucose and galactose and increases the body's absorption of calcium. The growth of the brain is fueled by glucose. The raw material used to make galactolipids is galactose. Brain development requires cerebrosides (Gomez, 2020)(Cianciosi, Simal-Gándara and Forbes-Hernández, 2019).

Breast milk contains casein and whey protein (lactose rum). It also contains the neuroprotector and osmoregulator taurine, which is necessary for brain development (Sánchez *et al.*, 2021).

Fifty per cent of the energy required is found in breast milk. Only by receiving enough nutrients will a fetus grow to its maximum potential. Children need the lipids in breast milk for proper growth and development. Breast milk boosts the immune system and promotes both physical and mental development (Kim and Yi, 2020); when compared to non-breastfed newborns, breastfed babies' IQ can rise by 4.5 points thanks to milk(AlThuneyyan *et al.*, 2022)(Isaacs *et al.*, 2011).

The amount of nutrition needed during lactation increases by 25%, making it extremely high. The amount of protein needed rose by as much as 54%. Six to eight-month-old breastfed babies need four times as much zinc and nine times as much iron as adult males (Kemenkes RI, 2013).

The only food a newborn receives in the first six months of life is from its mother's milk. Consequently, maternal malnutrition is one of the main factors influencing fetal growth and stunting (Soliman *et al.*, 2021). Not all babies who are breastfed will grow up to be more vulnerable to chronic conditions like diabetes, heart disease, and hypertension. They may also have obesity and malnourishment (Soliman *et al.*, 2021).

The amount of food consumed has a significant impact on milk production. Through several metabolic processes, the mother's food habits can impact the composition of breast milk, particularly the amount of fatty acids and water-soluble vitamins such as vitamins A, C, B6, and B12 (Keikha *et al.*, 2021)It is critical to monitor what nursing moms consume to ensure that the milk they produce assists their children's growth and development. (Ford, Underwood and German, 2020)

Mothers must enhance the calibre of their food to boost breast milk's nutritious value (Bravi *et al.*, 2021) for the milk produced to aid in children's growth and development (Grenov *et al.*, 2020).

Given the severe effects of malnutrition on nursing mothers, PMT and the government's program to supplement lactating mothers with iron and folate should be seriously considered to enhance the nutritional status of these mothers, raise the nutritional value of their breast milk, and prevent stunting. Additionally, it will boost future human resource competitiveness and quantity.

MATERIALS AND METHODS

According to the 2004 AKG, which served as the basis for this study, pregnant and nursing moms in the 19–29 age range needed 2400 kcal of calories and 67 grams of protein per day. These tuna fish cookies contribute around 20% of the daily required energy intake (or 480 kcal) during nursing. Protein is 13.4 grams per day, vitamin A is 170 ug/100 grams, vitamin B12 is 0.56 mcg/100 grams, folic acid is 100 ug/100 grams, vitamin C is 24 mg/100 grams, calcium is 190 mg/100 grams, phosphorus is 120 mg/100 grams, iron is 6.4 mg/100 grams, zinc is 2.78 mg/100 grams, and iodine is 40 mcg/100 grams, per the RDA for this supplementary meal.

This research focuses on cookie composition, making both vegetable and animal flour. The composite flour optimization method was created using the D-optimal RSM mix design and the Design Expert 7.0 trial software (DX 7 trial). The lower and upper bounds for any food ingredient that uses the composite flour formula can be found based on the nutritional value of the constituents. Composite flour is influenced by the following responses: energy, protein, calcium, iron, zinc, iodine, folic acid, vitamin A, vitamin B12, vitamin C, and omega three and omega 6. To create a flour formula with the best nutritious content and a superior taste that nursing moms may tolerate, this research chose 20 composite flours. Once the standard recipe has been determined, incorporate 40 grams of composite flour into the tuna fish cake recipe. After that, the tuna cookies' ligand quality and physical, chemical, and microbiological properties were examined. Data were tallied and subjected to a descriptive analysis.

RESULT

The nutritious value of the cookies that nursing moms will get is one of the main factors determining the program's effectiveness. The following describes the laboratory's chemical, physical, and microbiological examination of tuna cookies:

Physical Properties of Tuna Cookies

Round pieces with the flavour, appearance, colour, and perfume of standard cookies and SNI01 - 2891 - 1992, BUTIR1.2, as shown in Table.1, are the physical characteristics of tuna fish cookies.

Table.1 Physical characteristics of cookies

Parameter	Cookies tuna
Smell	Normal
Test	Normal
Colour	Normal

The Nutritional Content Of Tuna Cookies

Table.2 displays the nutritional analysis of tuna cookies in terms of water, ash, protein, fat, carbs, crude fibre, and energy:

Table.2 Proximate Analysis of Cookies tuna

Parameter	Cookies tuna
Water (%)	7.16
Ash (%)	4.22
Protein (%)	29.4
Fat (%)	24.2
Carbohydrate (%)	35
Crude fibre (%)	0
Energy(kKal/100 gram)	475

Table.3 analyses other nutrients found in conventional and tuna cookies, including energy, protein, calcium, iron, zinc, phosphorus, copper, iodine, omega three and omega 6, vitamin A, vitamin C, vitamin B12, and folic acid.

Table. 3 Energy and nutritional content of Cookies tuna

Nutrients*	Cookies tuna	Standard Cookies (20%RDA for Pregnant Women)
Energy (kkal)	505	480
Protein (g)	31	13,4
Vit. An (ug/100gr)	352	170
Vit. B12 (mcg/100mg)	0,33	0,56
Folic Acid (ug/100mg)	<25	100
Vit. C (mg/100/gram)	<0,07	24
Calcium(mg/100gram)	123	190
Phosphor(mg100gr)	369	120
Iron (mg/100gram)	3,52	6,4
Zinc (mg/100gram)	3,33	2,78
Iodium (mcg/100gram)	58,32	40
Cuprum (mg/100gram)	359	

Ligands

Table. 4. displays the ligand component found in tuna fish biscuits.

Table. 4 Ligand component in Cookies tuna

Parameter	Cookies tuna	Metode
Histidine	9396,175 mg/kg	HPLC
Methionine	6071,15 mg/kg	HPLC
Sistin	2058,135 mg/kg	HPLC

Microbiological Analysis

Table.5 displays the results of the microbiological study of the tuna cookies:

This study aims to develop a cookie formulation that, by considering the interactions between micronutrients, satisfies the nutritional demands of nursing moms and may be utilized as an additional meal program for them.

Table 5. Microbial contamination in Cookies tuna

Microbial Contamination	Cookies tuna	FDA Standard
Total plate number 350C 48 hours	3.0 X 10^2	Max. 1 X 10^6 (ISO 4833:2003(E)
Coliform	9,2	Max.20 (BAM 2002 Chapter 4)
E.coli	<3	<3 (BAM 2002 Chapter 4)
Mould	3	Max. 1.0 X 10^2
Khamir	<10	SNI 01-2897-1992

DISCUSSION

Physical Properties of Tuna Cookies

Round pieces with flavour, appearance, colour, and aroma that meet Indonesian national cookie criteria are the physical characteristics of tuna fish cookies.

The nutritional content of tuna cookies

The comparatively high energy content of tuna cookies (505 kcal) surpasses the recommended daily allowance (RDA) for nursing moms (> 480 kcal). Pregnancy weight and energy consumption are related to the growth and development of the fetus, particularly in undernourished mothers (Marshall *et al.*, 2022a)(Najpaverova *et al.*, 2020).

Tuna cookies have a comparatively high protein content (31 grams), which is more than the recommended daily allowance (RDA) for nursing moms (> 13.4 grams). Because this cookie has a sufficient amount of protein, nursing mothers can consume it. Both plant and animal proteins provide this protein. Protein is necessary for prenatal development, particularly for the brain (Mousa, Naqash and Lim, 2019). During lactation, protein needs rise to 54% (Binder *et al.*, 2023). Six to eight-month-old breastfed babies need four times as much zinc and nine times as much iron as adult males (Aprilya Sirait and Achadi, 2020).

Tuna cookies include 27.2% of their calories from carbohydrates. The baby's primary energy source for meeting its glucose requirements is carbohydrates (Kalhan and Kiliç, 1999). Additionally, the qualities of the food, such as its taste, colour, and texture, are primarily determined by the presence of carbohydrates. The primary energy source for the baby's brain to meet its glucose needs is carbohydrates (Kalhan and Kiliç, 1999).

Thirty-one per cent of tuna cookies are made of fat. Fat has a savoury flavour, and fat is what gives cookies their flavour and texture. Additionally, fat aids in the central nervous system's development and growth, which helps the body absorb vitamins A, D, E, and K(Youness *et al.*, 2022).

Tuna cookies contain 2.99% omega 6 and 0.28% omega 3, suitable for brain health (Bahagat *et al.*, 2019). Additionally, omega-3 components impact children's cognitive development and contribute to the growth and development of the brain (Dinicolantonio and Keefe, 2020). The body needs omega-3 fatty acids but cannot produce them independently (Mukhametov *et al.*, 2022).

Tuna cookies have a comparatively high vitamin A content (352 ug/100 grams), which is more than the recommended daily allowance (RDA) for nursing women (> 170 ug/100 grams). Antioxidant vitamin A promotes the growth and differentiation of cells and tissues (Takahashi *et al.*, 2022). To restore normal RBP and transferrin synthesis, vitamin A can enhance iron absorption, make iron storage useable for erythropoiesis, and lessen the severity of infection (Takahashi *et al.*, 2022).

Vitamin C in tuna fish cookies is less than the recommended daily allowance for expectant mothers (< 17 mg). Vitamin C deficiency during pregnancy will lead to abnormalities in the fetal brain's metabolism (Tveden-Nyborg, 2021).

Vitamin B12 in tuna cookies (<0.56 mcg / 100 grams) does not meet the recommended daily allowance for breastfeeding women. One metabolic coenzyme producing haemoglobin is vitamin B12 (Krzywański *et al.*, 2020). Deficits in vitamin B12 can result in metabolic, haematological, and neurological conditions (Ozyurek *et al.*, 2021). A higher incidence of type 2 diabetes mellitus was discovered in a study including pregnant vegetarians who were deficient in vitamin B12 (Madhu, 2020).

The amount of folic acid in tuna cookies is insufficient to satisfy the recommended daily allowance for breastfeeding moms (<120 ug / 100 grams). Therefore, cookie consumption must be combined with the government's iron folate supplementation program to meet the nutritional needs of nursing women. Folic acid aids in gene regulation, expression, DNA replication, and the methylation cycle (Abbasi *et al.*, 2018). Folic acid is required for nucleotide synthesis, DNA integrity, and brain development(Naninck, Stijger and Brouwer-Brolsma, 2019).

The micronutrient content of tuna cookies falls short of nursing moms' recommended daily allowance (<190 mg/100gr). Ca aids in the formation of teeth and bones (Nedoklan *et al.*, 2021).

Tuna cookies have a comparatively high zinc content (3.33 mg/100 grams), which meets nursing women's recommended daily allowance (> 2.7 mg/100 grams). Zinc is a cofactor of numerous enzymes, including those that produce albumin, albumin, transferrin (which transports iron and zinc into the blood and distributes them throughout the bone marrow and other blood-forming tissues), heme (aminolevulinic acid dehydratase), and retinol-binding protein (which releases and facilitates the liver's ability to reuse stored iron) (Wolfgang, 2013)(Marshall *et al.*, 2022b). Children's growth can be impeded by caloric consumption, protein, QPM (Quality Protein Maize), zinc insufficiency, and a vegetarian diet without supplements (Gunaratna, Moges and Groote, 2019). A zinc deficit that occurs during pregnancy and lactation may result in permanent brain damage (Gunaratna, Moges and Groote, 2019). A zinc deficiency accounts for one per cent of stunted children (Berawi *et al.*, 2019). Compared to adult men, children aged 6 to 8 months require four times as much zinc.(Berawi *et al.*, 2019).

Given that tuna cookies have a relatively high iodine content (58.32 mcg / 100 grams), they meet the recommended daily allowance for breastfeeding moms (> 40 ugs) and help prevent iodine insufficiency. The production of proteins and thyroid hormones benefits from iodine. The primary sources of iodine are seafood, including shrimp and tuna (Sprague, Chau and Givens, 2022). To

prevent mental retardation and brain damage, iodine is essential. To create thyroid hormones vital for brain development, iodine is required (Delshad, 2018).

Tuna cookies have 359 Ug of Cu per 100 grams. In addition to being a neurotransmitter and helping to mature neuropeptides, copper (Cu) also functions as a cofactor for several copper-bound proteins and enzymes that neutralize free radicals (Delshad, 2018).

The RDA for breastfeeding moms (<6.4 mg) is not met by the Fe component of tuna cookies. Therefore, cookie consumption must be combined with the government's iron folate supplementation program to meet the nutritional needs of nursing women. Because haemoglobin serves as a channel for transferring multiple electrons among cells and facilitating the activity of numerous enzymes, iron is helpful for hematopoiesis, nucleic acid metabolism, and oxygen carriers throughout the body (Vogt *et al.*, 2021). Since the brain is an oxidative organ that uses glucose as its primary energy source, glucose homeostasis will be disturbed if an iron deficit arises. Dopamine and norepinephrine are neurotransmitters crucial for motor control, sleep cycles, physical activity, learning, and memory. Iron deficiency also alters the neurotransmitter dopamine and increases the metabolism of norepinephrine.

Furthermore, low iron levels might lead to poor gamma-aminobutyric acid (GABA) breakdown (Guo *et al.*, 2020). Six to eight-month-old breastfed newborns require nine times as much iron as adult males (Guo *et al.*, 2020). Red blood cells are produced insufficiently when severe iron shortages meet the body's physiological requirements (Kumar *et al.*, 2022). Iron deficiency during fetal development also affects the postpartum brain and behavioural development (Kumar *et al.*, 2022). Iron is necessary for nerve myelination, neurogenesis, and the differentiation of fetal brain cells during pregnancy (Kumar *et al.*, 2022).

For nursing moms, the phosphorus content of tuna cookies meets their RDA (> 120 mg). Maternal nutrition before delivery impacts the child's linear development and the likelihood of stunting in 1000 FDL (Lukman *et al.*, 2021). Pregnancy-related malnutrition can lead to further problems like anaemia, pre-eclampsia, haemorrhage, etc (Todd *et al.*, 2019).

Ligands

Lingands are used in tuna biscuits to lessen the interactions between micronutrients. Ligands like histidine can alter the zinc absorption pathway in the food matrix; non-heme iron does not affect this process (Maares and Haase, 2020).

Microbiological Analysis

For tuna fish cookies to be safe to eat, the microbiological standards for assessing sanitation and hygiene must match the FDA cookie specifications. Because tuna cookies meet the FDA's microbiological criteria for cookies, they are safe to eat.

Breastfeeding moms can avoid stunting by giving their children tuna fish biscuits. Stunting is a significant issue for the Indonesian government because it makes it challenging to develop competent human resources for future national security and health projections.

CONCLUSION

Breastfeeding moms can also eat tuna cake as part of the government's supplementing program to bolster the nation's military.

AUTHORS' CONTRIBUTIONS

Each author has contributed to the research and writing of this article as follows Arfiyanti: Conceptualization, Methodology, Software, Data curation, Writing- Original draft preparation,

Visualization, and Investigation. Arif Rachman: Supervision, Software, Validation, Writing- Reviewing and Editing, and Funding Acquisition.

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