

DEVELOPMENT OF A HIGH-ENERGY NUTRIENT-DENSE MEAL AS SUPPLEMENTARY FUNCTIONAL FOOD FOR IMPROVING PROBLEM OF STUNTED AND UNDER-NOURISHED CHILDREN

Ida Idayu Muhamad

School of Chemical and Energy Engineering, Faculty of Engineering,
Universiti Teknologi Malaysia, 81300 Johor Bahru, Johor.
IJN- UTM Cardioeng. Centre, Institute of Human Centered Engineering,
Faculty of Engineering, Universiti Teknologi Malaysia, 81300 Johor Bahru, Johor.
Email: idaidayu@utm.my

Dayang Norulfairuz Abang Zaidel

School of Chemical and Energy Engineering, Faculty of Engineering,
Universiti Teknologi Malaysia, 81300 Johor Bahru, Johor.
Email: dnorulfairul@utm.my

Yanti Maslina Mohd Jusoh

School of Chemical and Energy Engineering, Faculty of Engineering,
Universiti Teknologi Malaysia, 81300 Johor Bahru, Johor.
Email: yantimaslina@utm.my

Norhayati Pa'e

School of Chemical and Energy Engineering, Faculty of Engineering,
Universiti Teknologi Malaysia, 81300 Johor Bahru, Johor.
Email: hayatipae-pd@utm.my

Zulkifli Khair

School of Human Resource Development and Psychology,
Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia, 81300 Johor Bahru, Johor.
Email: zulkiflih@utm.my

Hairudin Abdul Majid

School of Computing, Faculty of Engineering,
Universiti Teknologi Malaysia, 81300 Johor Bahru, Johor.
Email: hairudin@utm.my

ABSTRACT

Poverty, obesity and lifestyles are the most associated factors of vitamin D deficiency among urban-living children in Malaysia. These children are among many whom are neglected by the society. Vitamin D is necessary for calcium absorption from food to ensure healthy bones and teeth. Vitamin D deficiency can cause soft and brittle bones disease known as rickets in children and osteomalacia in adults. Based on previous research, lack of nutritional knowledge among parents can contribute to nutrition deficiencies in children. To overcome this issue, nutritional education and awareness campaign among parents are needed. Besides campaign, the development of supplementary functional food which can provide crucial nutrients and energy that can assist in brain and body growth seems beneficial. This article reports the outcomes of a multi-disciplinary research program established for solving these issues. The program contained five integrated studies in development of High Energy Nutrient Dense (HEN-D) bar for stunted and undernourished children. The studies involved were socio-economic impact on children's healthy food intake, the formulation and up-scaling of HEN-D process, development of new packaging material for extending HEN-D shelf-life and finally the development of a web-based system for effective HEN-D bar manufacturing and distribution to the target groups. This web-based system also serves as a platform for crowd-funding activity. The outcome of socio-economic study reveals that family socio-economic status influences the nutritional knowledge of the parents. The result from this study indicated the need for a supplementary functional food. In correlation to this, HEN-D bar enriched with vitamin D and DHA for stunting prevention was successfully formulated according to Malaysia's Recommended Nutrient Intakes for children, and its processing procedures were also established. A new packaging film made of starch incorporated with 2 % thymol can assist in retaining the freshness of HEN-D bar for 12 months. A system for tracking demand, supply, manufacturing and distribution of HEN-D and, also perform crowd-funding, were successfully developed based on Kanban Methodology. This report shows the significance of multi-disciplinary knowledge and effort in solving issues within the society.

Keywords: High Energy, Nutrient Dense, Supplementary Functional Food, Vitamin D, Stunted.

INTRODUCTION

The Global Nutrition Report (2020) found that Malaysia is off course to meet the targets for stunting (low height-for-age) among under-five children. This report supports UNICEF's finding on children living in low-cost housing area in Kuala Lumpur had

higher poverty and malnutrition rates compared to the national average. According to UNICEF (2018), the percentage of children who suffer impaired growth and development was approximately 22 %, which is two times higher than the national average, at that time. Ironically, IPH (2016) reported that Malaysia's stunting prevalence was at 20.7 %, and which was higher than Ghana (18.8 %), Mexico (12.4 %) and even Gaza (7.4 %). The stunting issue among Malaysian children has been first covered by mainstream media in 2012 via 'More obese, stunted Malaysian children' (New Straits Times, 2012).

Khazanah Research Institute (2014) found that many Malaysians are unable to afford nutritionally adequate diet. JCI-JSC (2019) argued that stunting is not really associated to 'Malaysian' genetic, but the major role of this issue is the lack of awareness and knowledge on nutrition and health. Indeed, nutrition insecurity is a phenomenal condition in this country. A report by UNICEF in 2018 has stated that children who were living in the low-cost housing area in Kuala Lumpur did not meet the recommended daily intake of vitamin D, 15mcg/day (600 IU/day). People who are experiencing vitamin D deficiency may develop soft and brittle bones, a condition known as rickets in children and osteomalacia in adults. Vitamin D is essential for calcium absorption from food to develop strong and healthy bones and teeth. One of the most effective interventions to overcome the vitamin D deficiency issue is the development of specially formulated functional food that can provide vitamin D, DHA and other nutrients for energy and healthy brain and bone development.

WHO Multicentre Growth Reference Study Group (2006) found that children's growth was not related to genetics and ethnicity, and were more influenced by nutrition, environment and healthcare differences. In recent literature, Ssentongo et al. (2021) found that prevalence of stunting among children 0-59 months in low-and middle-income countries between 2006 and 2018 was 29.1%. Most probably, Mohd. Shariff (1998) is the first report on stunting among children in Malaysia who stated that approximately 50% of the school children (6-10-year-old) among low-income family in Kuala Lumpur were stunted. Mohd. Sharif and Ang (2001) found that 65.7% of low-income households in Kuala Lumpur experienced some kind of food insecurity, while 27.0% fell into the Child Hunger category. NHMS (IPH, 2016) reported the prevalence of stunting among children under 5-year-old was 20.7%. A focus study in Putrajaya showed the prevalence of stunting among children under 5-year-old was 25.5% (Ahmad et al., 2021) which was associated with various factors such as poor awareness or education and low household income.

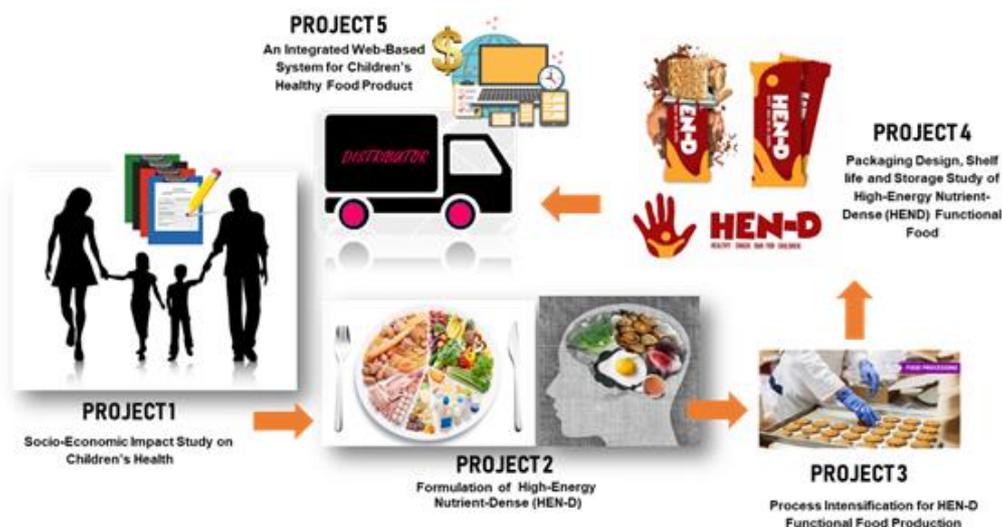
One of the most practical ways for urban-living children in having the supplementary functional food (SFF) is a concept of ready-to-eat, and on-the-go handy nutritious meal for that does not require reheating or cooking prior to its consumption. In this study, SFF is designed for undernourished children that are living in the urban area and can be consumed directly in its ready-to-eat form. The work has been carried out in designing specialty food as SFF starting from formulating the ingredients that would supply needed nutrients, provide energy and brain booster, promote growth, protect body and immune system, and importantly also satisfy the taste. Susilastuti *et al.* (2021) suggested SSF to be formulate using local sources. However, to better provide the nutrients needed, knowledge of processing techniques is needed for enrichment and fortification of nutrients by substitution or adding other food ingredients.

In addition, it is compulsory to ensure the integrity of the SFF is maintained throughout the SFF program against relevant factors that may reduce the quality. Food packaging is functioned to maintain the quality and safety of food products during storage and transport and to extend their shelf life by preventing impacts from unfavourable factors or conditions, such as spoilage microorganisms, chemical contaminants, oxygen, moisture, light, and external force. The development of active packaging is one approaches that can be done to extend the shelf life. This is due to the formulation of active packaging systems with controlled migration of natural antioxidants and/or antimicrobial compounds to foodstuff might result in prolonged shelf life and preservation of quality of the product. (Siddique et al., 2021).

A successful SFF program need to manufacture sufficient stock of product throughout the specified period. Majority of current manufacturing industries do not have a system that will help in managing their stock systematically. With the limited size of storage, they need to continuously fulfil all the demands and at the same time maintain the lowest possible level of inventory. The problem also arouses when the quantity of production does not meet their daily target number. The quantity of raw materials used should be aligned with the quantity of the finished products. Company should be able to track on the supply of raw materials and distribution of finished products within the completion period. Therefore, inventory control system is needed to overcome all of these problems (Angel et al., 2014).

Vitamin D is essential for calcium absorption from food to gain strong and healthy bones and teeth. The UNICEF (2018) highlighted some relevant solutions such as executing policies that promote the easy access towards nutritious food; a strict regulation of food sold at schools and taxes on sugar-sweetened beverages. Hence, development of functional food that provide energy which is also healthy and could boost the brain and growth development is important. Characteristics of potential target populations were considered in determining the nutrient composition of the supplementary functional food (SFF). Efficient distribution of healthy food products among the children should be improved and awareness among parents as well as funding from public and private sectors in healthy food should be emphasized and promoted to improve health and growth development among children. Therefore, the ultimate aim of this research program was to provide a solution to the stunting and undernourished issues in Malaysian children as these two conditions can lead to serious health issues. To achieved the objective, this research program was designed to contain five integrated studies which were the study on the socio-economic impact and nutritional knowledge of parent towards stunting, the formulation of HEN-D and up-scaling the production, development of new packaging material for extending HEN-D shelf-life and finally the development of a web-based system for effective HEN-D bar manufacturing and distribution to the target groups. This web-based system also serves as a platform for crowd-funding activity. Multi-disciplinary knowledge and effort in solving these issues are highly required. Figure 1 is the summary of the overall five projects that were performed for developing this supplementary functional food for improving stunting and undernourishment in children.

Figure 1: Flow of the research program (five integrated projects)



METHODOLOGY

Study on Socio-Economic Impact on Health of Children

This quantitative study was conducted via descriptive and regression methods. Data collection was done via Google Form questionnaire which has been distributed through social media, WhatsApp group and Facebook, by using convenience sampling method. The convenience sampling method can assist researchers obtain research findings more easily and quickly, and in addition, this method can prevent bias (Cooper and Schindler, 2011). The sampling population was the parents of children below six-year-old, and this requirement was explicitly mentioned at the introduction part of the questionnaire.

The questionnaire was adapted from Mohd. Shariff (1998) and this document was initially used to study the growth determinants of children from low-income households in Kuala Lumpur. The research instrument consists of three sections: Part A: Demographic Information of Parents/Guardians; Part B: Children's Growth Status; and Part C: Parent Nutritional Knowledge. The collected data was analysed using statistical software, Statistical Packages for the Social Scientist (SPSS) Version 20.0. Linear regression was used to measure the degree of the influence between linearly related variables.

Study on HEN-D Formulation

The ingredients used in cereal bars preparation were divided into three group that were based ingredients, binder, and supplement and flavor. Base ingredients contain rolled oats, puffed rice, cornflakes, *Moringa oleifera* leaves powder, almond, walnut, black sesame, white sesame, chia seed, and dark chocolate. Brown sugar, golden syrup and butter were under the binder group. The third group, supplement and flavour, contains fish oil and vitamin D (for fortification of omega-3 and vitamin D), and strawberry and lemon essence (to mask the fish oil taste and odour). *Moringa oleifera* leave or 'daun kelor' was chosen to be used as one of the ingredients due to its nutritional benefits such as high protein content of 23.7g/100g, calories per energy of 364.0 Kcal/100g and Total Dietary Fiber of 26.3 g/100g. In addition, *Moringa oleifera* leaves contain high amount of antioxidants and bioactive compounds that can help in lowering the risk of chronic diseases.

To prepare HEN-D bars, rolled oats, puffed rice, cornflakes, almond and walnut were roasted at 180°C for 6 minutes in the oven. These roasted ingredients were removed from the oven after 6 minutes of roasting and let to cool at room temperature. Then, in a bowl, these roasted ingredients were mixed with the other dried ingredients. The binder mixture was heated and stirred to get a thick consistent syrup. Once the right consistency has been achieved, the binder mixture was removed from the stove and was let to cool until it reached 50°C. Fish oil and flavour (strawberry and lemon essences) were added into the binder, and this mixture was mixed again to ensure uniformity. Base ingredients were added into the warm binder mixture (which contained fish oil and essences), and this mixture was immediately mixed to ensure uniformity of final HEN-D bar content. This final HEN-D bar mixture was transferred and pressed into stainless steel mould (30 cm x 21 cm x 2.5 cm) with 21 small sections (3 cm x 7 cm x 2.5 cm).

Study on Scale-up of HEN-D Bar Process

In this study, the effect of baking or heating process on the Vitamin D and DHA content in HEN-D bars was evaluated. Two types of samples (unbaked and baked HEND bars) were prepared to study the changes of Vitamin D and DHA. For unbaked bars, the moulded HEN-D bars did not undergo baking process, instead the bars were chilled for 20 minutes in refrigerator. As for the baked bars, the moulded bars were baked at 180°C for 15 minutes in a preheated oven. After baking, the baked bars were cooled down. All bars (unbaked and baked) were removed from the mould and packed in aluminium sachets, individually. The DHA and Vitamin D content in both unbaked and baked samples were analysed to determine the loss of these important ingredients due to baking

process. This study was important for determining the best processing method for extending the shelf-life of HEN-D bars during scale-up.

In the early stage of scale-up study, HEN-D bars were produced based on the formulation mentioned in formulation study section. Since the scale-up study was conducted in a factory, thus the formulation required some modifications so that the bars can be produced in mass quantity using the industrial equipment. Initially, the small batch HEN-D bars were produced manually in UTM laboratory. The ingredients were mixed and then this mixture was manually pressed into mould and baked. Then the baked HEN-D bars were manually wrapped in aluminium sachet. For large batch production which was performed in the factory, the ingredients were mixed and then the mixture was placed into the moulding machine. Once the bars came out from the moulding machine, they were baked and sent to the packaging machine.

Toxicity Analysis

Determination of toxicity was carried out by evaluation of cell viability. The assessment of cell viability was performed using the V79-4 pulmonary fibroblasts (Virgilio et al, 2004).

Study on Shelf-life of HEN-D Bars using Antimicrobial Packaging and Accelerated Method

Starch based films were prepared according to the method described by Gennadios and Testin (1993), with minor modifications. For antimicrobial (AM) incorporated films, thymol was mixed with the film solution in a separated beaker with different concentration, 1% and 2% (v/v) just before casting (Kavoosi et al., 2013). Ten millilitres of the film mixture were pipetted into petri dishes (100 mm in diameter by 15 mm in depth). The petri dishes were placed for 24 hours in Memmert oven which was set at 50°C. The effectiveness of AM agent incorporated into starch-based film to hinder the growth of microorganisms was tested by monitoring AM activity based on the agar diffusion method and liquid culture test.

The real-time test was conducted for determining the shelf-life of ready-made HEN-D bar wrapped in AM film and control film. This includes physical analysis of the bar (texture profile analysis, water activities and moisture content), microbial analysis and chemical analysis (peroxide value and free fatty acid). The tests were conducted under accelerated method at temperature 40°C for 12 weeks.

Development of An Integrated Web-based System

An integrated web-based system was designed with three main processes which are the literature review on inventory control system, problem identification, and data collection. The overall set up was developed using the Agile Kanban Methodology. Kanban in Japanese language means signboard or billboard, and this technique is generally used in industry to improve efficiency. Kanban Methodology consists of four stages which are concept, inception, construction iteration and release. The last step is Requirement Analysis and Design on both user and system necessities. The outcome is integrated into a web-based system for inventory management and information for crowd-funding approaches.

RESULTS AND DISCUSSION

Socio-Economic Impact Study on Children’s Health

There were 90 respondents involved in this study, after being filtered from hundreds of respondents. The distribution of the respondents in terms of their background characteristics were analysed using descriptive statistics involving frequency and percentage. From 90 respondents, 9 (10.0 %) were male (father of the child/children) and 81 (90.0%) were female (mother of the child/children). For respondents’ background characteristic on age, majority of respondents are 31-35 year-old (43.3%) than followed by 36-40 year-old (32.2%), 26–30 year-old (11.1%), 40-45 year-old (10.0%), above 45 year-old (2.2%) and 20-25 year-old (1.1%). Besides, 87.8% respondents were below 40. For respondents’ background characteristic on race, 80 (88.9%) were Malay, 4 (4.4%) were Chinese, 3 (3.3%) were Indian and 3 (3.3%) were others.

From 90 respondents, 79 (87.8%) were university graduates while the rest, 11 (12.2%) did not graduate from university or college. 34 (37.8%) of the respondents were B40, 44 (48.9%) were M40 and 12 (13.3%) were T20. The respondents whom received Bantuan Sara Hidup (BSH), Rancangan Makanan Tambahan (RMT) and Program Susu Segar (PSS) were 21 (23.3%), 2 (2.2%) and 2 (2.2%), respectively. In addition, respondents who have financial problem were 25 (27.8%).

Table 1: Level and score range of respondents’ nutritional knowledge

Variable	Level and score range	n	(%)	Mean	Standard Deviation	Min.	Max.	Median
Possible score						0	25	
Total Score		90	100	16.85	2.154	11	21	17
Percentile Score (PS)	PS1: 19-21	22	24.4					
	PS2: 18	16	17.8					

PS3: 17	17	18.9
PS4: 0-16	35	38.9

Table 2: Coefficient and collinearity diagnostic data of socioeconomic and nutritional knowledge

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-7.854	6.444		-1.219	.226		
	SOCIOECONOMY	1.401	.717	1.716	1.953	.054	.013	76.919
	NUTRIKNOWLEDGE	.821	.385	1.419	2.133	.036	.023	44.101
	SE_NK	-.097	.043	-2.695	-2.274	.025	.007	139.961

a. Dependent Variable: STUNTING

Collinearity Diagnostics^a

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions			
				(Constant)	SOCIOECONOMY	NUTRIKNOWLEDGE	SE_NK
1	1	3.957	1.000	.00	.00	.00	.00
	2	.029	11.762	.00	.00	.00	.00
	3	.015	16.366	.00	.01	.01	.00
	4	9.148E-005	207.969	.99	.99	.99	.99

a. Dependent Variable: STUNTING

Table 1 shows level and score range of respondents' nutritional knowledge. Nutritional knowledge as moderation variable is referred to knowledge on nutrition that should be served to their child/children. The results were divided into four levels of nutritional knowledge based on the score and named as percentile score. For example, Percentile Score 1 (PS1) has the highest score with score range from 19 to 21. 21 (over 25) is the highest score achieved by the respondent, meanwhile 16 is the lowest score by the respondent. After that, the stunting level of the children (0-5 year-old) were determined. From 90 respondents, 136 children under 5 years old were identified. Based on WHO Child Growth Standard, it was found that 58 of the children (43%) have the prevalence of stunting.

Table 2 is the coefficient table and collinearity diagnostic table of both variables which are independent variables were individually predictor of dependent variables. The coefficient of regression is 1.401 and 0.821 respectively for socio-economic and nutrition knowledge. Socio-economic consists of employment information, household, household income class, BSH, RMT, PSS and financial issues. Meanwhile nutrition knowledge, broadly defined, refers to knowledge of concepts and processes related to nutrition and health including knowledge of diet and health, diet and disease, foods representing major sources of nutrients, and dietary guidelines and recommendations (McKinnon et al, 2014).

The interaction between socio-economic and nutritional knowledge toward stunting was found to be statistically significant [F (3,86) = 4.552, p = 0.005 with R² = 13.7%]. It can be concluded that socio-economic and parent's nutritional knowledge give significant effect toward possibility of stunting in their children. Saaka (2014) in Ghana also reported that increase in maternal childcare knowledge may contribute significantly to child's nutritional status.

Formulation of HEN-D

The data for proximate analysis of formulated HEN-D bar is shown in Table 3. The RNI for Malaysian children for calories, total carbohydrate, total dietary fiber, protein, total fat, sodium and iron are also shown in this table, as benchmark.

Table 3: Proximate Analysis of HEN-D bar

Test	Unit	Results per 100g	Results per serving (27g)	Recommended Nutrient Intake (RNI)
Calories/Energy	Kcal	442	119.34	Boys 1300 – 1670 kcal/day, Girls 1210 – 1560 kcal/day
Total Carbohydrate	g	69.1	18.66	50 – 60 % of total energy intake
Total Dietary Fiber	g	1.7	0.46	20 – 30g/day
Protein	g	8.7	2.35	16g/day
Total Fat	g	7.3	1.97	Boys 36-51g/day, Girls 34 – 47g/day
Sodium	mg	236.84	63.95	1500 mg/day
Iron	mg	3.50	0.95	0.58 mg/day

As can be seen, the values for calories, total carbohydrate, total dietary fiber, protein, total fat and sodium were below the RNI this is because HEN-D bar is just a supplementary functional food. Even though the plan is to provide HEN-D bar to the targeted children daily, they will still need to consume regular meals.

Table 4: Vitamin D, DHA and total sugar in HEN-D

Test	Results	Amount per serving (27g)	Targeted recommendation intake
Vitamin D	50.4 mcg/100g	108mg	>100 mg
DHA	0.4 %	13.66 mcg	15mcg
Total Sugar	32.7%	8.83 g	<15 g

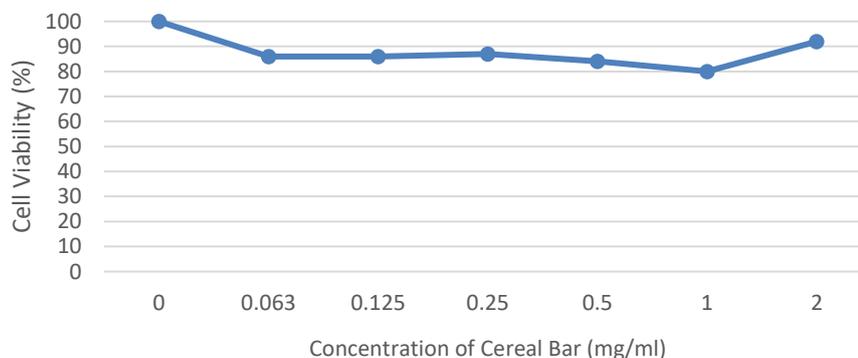
The DHA and vitamin D were added as major supplementary nutrients for children. The retention of the DHA, Vitamin D and total sugar content were tested to ensure it meets the targeted requirement per serving (Table 4). The DHA and Total sugar indicate that the formulation used meet target requirement. Vitamin D was slightly lower than the targeted value but this problem can be solved by increasing the amount of Vitamin D during dough preparation.

Based on intake recommendation, the target for HEN-D bar formulation is to contain at least 100 mg DHA per serving. Algae DHA powder contain 100mg DHA/1g powder. By taking into consideration of approximately 14% DHA loss after baking, initial concentration was increased to per serving 116 mg DHA content, equal to 1.16 g algae DHA powder. Thus, in the whole formulation of total weight 545 g (20 bars), the amount of DHA Algae powder needed to be added is 2320 mg. From the DHA test results, HEN-D bar contain 0.4 % (0.4 g/100 g or 400 mg/100 g). So, for 1 bar (27 g) the DHA content is 108 mg/serving which meet the targeted intake recommendation >100 mg.

The target for vitamin D content in the HEN-D bar is 15 mcg/serving. The initial concentration of vitamin D that need to added is 25 mcg calculate after taking in consideration the 39 % loss after baking at 180 °C for 15 min. Thus, in whole formulation of total weight 545 g (20 bars) the amount added is 500 mcg. From the results, 50.6 mcg Vitamin D per 100 g. So, for 1 bar (27 g) the vitamin D is 13.66 mcg/serving which is slightly lower than target of 15mcg. Loss of Vitamin D here is 45 %, initial addition of Vitamin D needs to be increase to 570 mcg in a in a 1 batch (545 g), which make 20 bars (approx. 27 g serving size).

Toxicity Analysis

Figure 2: Viability of V79-4 cells at various concentrations of the HEN-D sample



After the best formulation was obtained, toxicity test was conducted on the HEN-D bar. Figure 2 shows the optical density values and V79-4 cell viability obtained after 24 hour exposure. It was concluded that the formulated HEN-D did not inhibit the viability of V79-4 cells at all the tested concentrations following 24 hour exposure hence it is safe for consumption.

Process Optimization and Up-scaling Production Process

In industry, there are two ways to produce cereal bar, either by baked version or unbaked version. Hence, the baking test was conducted to decide which processing version could enhance the shelf-life and retain the required Vitamin D and DHA in HEN-D bar during storage. Results from the experiment in Table 5 shows that immediately after the baking process (180 °C for 15 min), 60.8 % of Vitamin D, and 85.6% of DHA were successfully retained. Loss for Vitamin D is 39.2 % and DHA is 14.4 %. Even though, there was losses in Vitamin D and DHA during baking, baking process was selected in production of HEN-D bar because during storage study, the baked product shown to have better stability compared to unbaked bar.

Table 5: Amount of Vitamin D and DHA after baking process

Sample	Vitamin D (mcg/100g)	DHA (mg/100g)
Before	84.8	2117
After	51.6	1813
Loss	39.2%	14.4%

After selecting the processing method which is with baking, the formulation undergoes a series of modification for mass production. Modifications were carried out with consideration of potential allergy issues from nuts ingredient, healthy amount of sugar content and practical source of DHA suitable in large-scale processing. DHA is the main component in HEN-D formulation for brain booster function, therefore it must be made available in the final product. Besides nutritional content, the final sensory properties of HEN-D particularly the texture, hardness, chewiness and taste were optimized accordingly. Sugar and vitamin D contents were also tested, and all these three ingredients were in the acceptable range as in Malaysia Dietary Guideline for Children and Adolescents 2013.

In up-scaling study, three final samples were prepared that were HEN-D bar chocolate flavour with chocolate topping (chocolate topping unbaked) (Sample 1), HEN-D bar chocolate strawberry/orange flavour and fruit toppings (Sample 2) and HEN-D bar original recipe (Sample 3). From sensory analysis, Sample 2 was selected based on its taste and nutritional contents. The final designs for wrapper (primary packaging) and box (secondary packaging) are shown in Figure 3.

Figure 3: Design for HEND bar wrapper and box



Development of Active Packaging and Shelf-life Study

Active packaging technology is known as a packaging technique that incorporating antioxidants, antimicrobial or other quality enhancer agents into packaging materials via immersing or coating method. Among different types of active packaging applications, the active packaging incorporating with antimicrobial substances has been increased greatly (Imran *et al.*, 2014; Mauriello *et al.*, 2016) due to its promising effect. Previous research by Lukic *et al* (2020) revealing great potential of thymol for application as an active food packaging material with aim to decrease requirements for amount of the active ingredients.

From this research, the optimum formulation of AM starch-based film incorporated with thymol obtained was 5g starch, 4g of Hydroxyethyl cellulose (HEC), 80 mL of distilled water, 5 mL glycerine, 5g of glyoxal and 2% (v/v) thymol. Based on the antimicrobial testing (agar plate test and liquid culture test), 2% thymol film was found to be the highest antimicrobial effect among 0%, 1% and 2% thymol film. In an accelerated temperature of 40°C, the real test was carried out by studying the physical properties changes of the cereal bar wrapped with the control film and AM film. It was found that 2% thymol film retained the best conditions of the cereal bar after 1 month with good control of moisture which able to inhibit the growth of bacteria.

Table 6 shows microbial analysis on sample stored under accelerated condition. It can be noted that the bacterial count in sample B which is AM packaging increased slower compared to sample B in commercial packaging from week 3 to week 9. The results were due to the ability of antimicrobial packaging to reduce microbial growth, hence increasing the shelf-life as well as the safety of food products (Irkin & Esmer, 2015). These results were in agreement with Mousavian *et al.* (2021) which reported season salads packed with OPP and LDPE films immersed in thymol essential oil for three days had lower mould and yeast count.

On the other hand, there was no growth of coliform from week 0 to week 12 in both sample A and sample B, hence proving that both types of packaging were as effective in preventing the growth of coliform. In conclusion, both samples were accepted under the Microbiological Standard in Food Act 1983 which states that the total plate count for aerobic bacteria should be less than 1×10^5 CFU/ g while for Coliform it should be below 5×10^4 CFU/ g.

Table 6 : Microbial profile of samples A (commercial packaging) and sample B (with AM film) during 9 weeks storage at accelerated condition

Parameter	Unit	Sample	Week		
			3	6	9
Aerobic Plate Count	CFU/gm	A	50	60	60
		B	10	45	45
Coliform	CFU/gm	A	NG	NG	NG
		B	NG	NG	NG

Based on Table 7, peroxide value and free fatty acid reading increased for both sample A and B. However, sample B exhibit slower increment which may due to antioxidant properties of thymol that has been reported to possess various pharmacological properties including antioxidant, free radical scavenging, anti-inflammatory, analgesic, antispasmodic, antibacterial, antifungal, antiseptic and antitumor activities (Naagor Meeran et al., 2017).

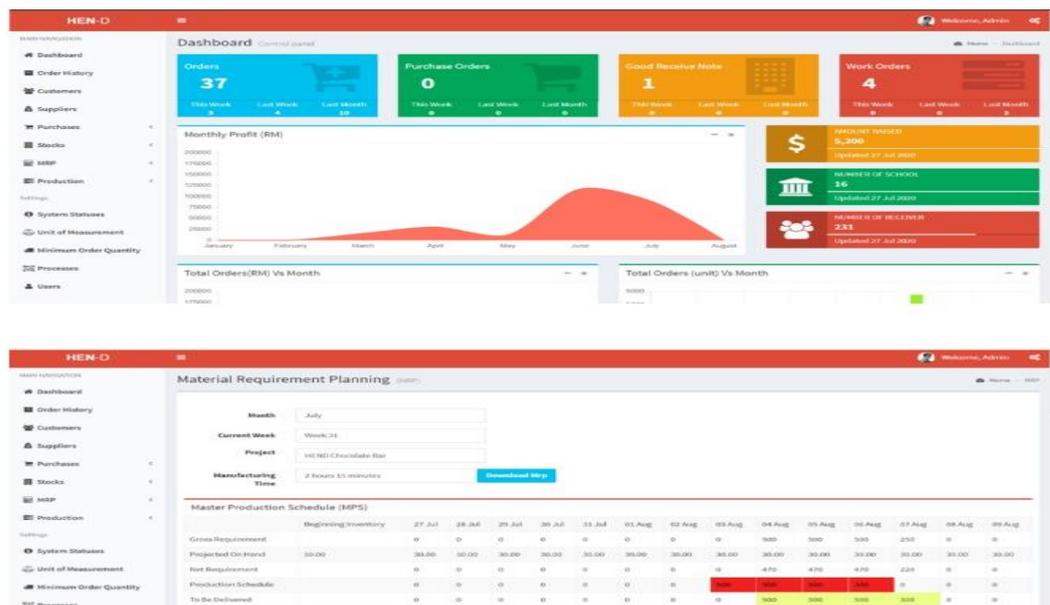
Table 7: Free fatty acid and peroxide value of samples A (commercial packaging) and sample B (with AM film) during 9 weeks storage at accelerated condition.

Parameter	Unit	Sample	Week		
			3	6	9
Peroxide value	%	A	6.7	7.5	8.2
		B	6.0	7.5	7.5
Free fatty Acid	Meq/kg of oil	A	1.25	1.28	1.31
		B	1.22	1.30	1.30

An Integrated Web-based System

The whole process in development of web-based inventory system was called Kanban board. This board is responsible in displaying the task workflow between each different team to optimize the team effectiveness. This method prints every work item visually to help each team member to track the progress of work given at every development stage. This also allow team members to view the work of others and identify the problem existed in the process to be solved. The workflow was improved throughout the whole project as each team collaborates with each other. The Kanban principle solely focuses on the visualization of each workflow that is easy to understand by all members, the act of leadership at all levels, welcome changes at any stage and flexibility, promote collaboration among team members and make each process explicit and easy. This approach is very beneficial to the company as it helps them analysing and improvising their product throughout the development process so that they can stay competitive in the market. The final step is requirement analysis and design Software Design Document (SDD) was used to document all the diagrams associated with the implementation design of this project. The focus of requirement analysis and design is more on both user and system necessities for Integrated Inventory Control system (Figure 4).

Figure 4: Integrated Inventory Control system



CONCLUSION

From this integrated research program, it shows that socio-economic factor has influence on the nutritional knowledge and it plays a big role towards stunting. The percentage of prevalence of stunting, 40% which is quite similar to the percentage of B40, 37.8%. Poverty, obesity and lifestyle behaviours are the most associated factors of vitamin D deficiency among children in Malaysia. Hence, nutritious food aid programs should be empowered, or a high-energy nutrient-dense meal (HEN-D) as supplementary functional food should be developed and supplied to stunted and undernourished children in Malaysia.

Through this integrated research program, a supplementary functional food known as HEN-D bar was successfully developed. This food was specially formulated for children to help children achieve the daily recommended nutrient intake (RNI). It can help in preventing stunting and undernourished condition in children. In scaling-up the production of HEN-D bars, the original formulation has been modified to ensure the suitability of mass production via industrial equipment. The baking process has been optimised, and this baking step shows to assist in retaining essential nutrients and preventing microbial growth during storage. From sensory analysis study, chocolate strawberry/orange flavour HEN-D bar with fruit toppings had been selected as the final product. The used of AM packaging as layer inside the primary packaging not only prevented microbial growth, but also reduced oxidation reaction hence prolonged the shelf life.

A systematic HEN-D distribution and monitoring system, blended with Integrated Inventory Control, has been established from this program. The desired characteristics for the intended system are effective, transparent, and accurate. This system was developed to ensure that HEN-D bars will arrive at the end-user (children) at the right time and at the right place. Using this system, the schools will never run out of HEN-D bars as the developed inventory management system will keep track of stock level, hold stock after an order if the order is cancelled and it also will also notify the users of the system for the case of low and out-of-stock items. A strong continuous support and massive participation of public and private donor is expected for children healthy food intake campaign via crowd-funding platform. The product enhancement can be progressively done based on the continuous measurement and monitoring, also from feedback given by the end-user through the developed system.

Stunting is a health problem that not only resulted from lack of nutrition, but also as an outcome of socio-economic factors and nutritional knowledge. This project means to prepare a platform for nutritious food aid programs that aims to prevent stunting among Malaysian children. It is a complex problem involving many aspects. Thus, the encouragement and participation of all parties such as government bodies, educational institutions and the public need to be synergized. This is to ensure that such programs can continue to run and reach the right target group.

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