Enhanced Knowledge in Sciences and Technology Vol. 3 No. 2 (2023) 402-411
© Universiti Tun Hussein Onn Malaysia Publisher's Office

EKST

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/ekst
e-ISSN : 2773-6385

Formulation and Characterization of Soy- free Meal Replacement Drink

Siti Nurul Natasya Mazlan[1], Nurhafizah Malik[1*]

[1] Faculty of Applied Sciences and Technology
Universiti Tun Hussein Onn Malaysia, 84600 Pagoh, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/ekst.2023.03.01.046
Received 15 January 2023; Accepted 19 February 2023; Available online 30 November 2023

Abstract: A healthy diet is important for good health and well-being. A good diet practice helps to prevent chronic diseases such as heart disease, diabetes and cancer. However, urbanization caused some people to not have enough time to eat and prepare a wholesome meal. Therefore, meal replacement is one of the initiatives for a healthy diet which contain essential nutrients to cater the needs of a healthy wholesome meal plan. Nevertheless, there are group people who may exhibit sensitivity towards certain ingredients especially soy-based ingredients. Therefore, in this study, three meal replacements differ in the source of protein were formulated which was soy protein as a control sample, pea protein, and soy-pea protein. A market study on the acceptance of soy-free meal replacement beverages served as the basis for this study, followed by the development of the three meal replacement beverage samples. Sensory analysis involved hedonic sensory testing to determine customer acceptance. Physicochemical analysis such as pH analysis, total soluble solids (TSS), solubility, wettability, colour, moisture content and nutrient composition were also performed. Particle morphology of three samples was examined using a scanning electron microscope (SEM). In the wettability and solubility, the soy protein took the shortest time which was 43.57s followed by pea protein, 60.93s and soy- pea protein, 75.67s. In the moisture content, pea protein, 5.83%, followed by soy- pea protein, 4.98% and soy protein, 4.53%. The first choice of the panellists in terms of sensory properties was pea protein. In terms of nutritional value, this meal replacement contains a high energy content which was 360.33 kcal/100g, Carbohydrate was 56.73%w/w, protein was 20.37%w/w, total sugar was 37.43%w/w, total fat was 1.03%w/w, Vitamin D was 1.63 mcg/100g, and Magnesium was 536.53 mg/kg. Future research could explore other legumes that could be added to the beverage to increase the protein content.

Keywords: Meal Replacement, Physicochemical, Nutrition Content, Sensory, Morphology

**Corresponding author: nurhafizah@uthm.edu.my*

1. Introduction

Lately, most people are concerned about their health. Therefore, meal replacement drinks are a way to get enough nutrients without preparing a full meal. Meal replacement drinks typically contain plant-based protein, complex carbohydrates, healthy fats and micronutrients to provide healthy calories in a smaller amount than you would typically consume during a meal (breakfast, lunch, dinner). Meal replacements are characterized by keeping the body full for a long time, allowing for faster weight loss. Recently, people around the world have been struggling with hectic lifestyles and health problems that cause them to skip meals and eat low-quality foods that are high in sodium, high in sugar, and lack nutritional value, such as fast food, which can affect both their mental and physical health. Increasing obesity in Malaysia is causing people to worry about their health, which affects both physical and mental health. Substitute meals should contain all the essential nutrients such as protein, carbohydrates, fat, fiber, vitamins and minerals. In addition, soy protein is a common allergen, while pea protein is hypoallergenic. Most vegetable proteins used in the food industry recently are derived from soy and wheat. However, due to allergen concerns, food manufacturers are looking for alternative protein sources [2]. In addition, changing consumer trends toward greener options and dietary choices based on ethical, health, or religious preferences such as allergies, vegetarianism, and genetic modifications encourage the search for alternative protein sources [3]. The objective of this study was to formulate a soy-free meal replacement beverage using pea protein as an alternative to soy protein, characterize the nutrient content, physicochemical properties, sensory evaluation, and particle morphology of the soy-free meal replacement, and investigate consumer acceptance of the product through a market survey.

In this study, pea protein was replaced by soy protein as a protein source. The reason is that pea protein contains high quality protein because it has a balanced amino acid ratio and contains all essential amino acids except methionine [4]. Peas are high in carbohydrate and protein, low in fat, and rich in minerals and vitamins. Although pea protein is high in lysine, it is low in tryptophan and methionine. The next ingredient was rice bran. Rice bran is extensively studied and used in the food industry because of its high nutritional value, especially its fat, protein, mineral, and vitamin content, as well as its high content of phytochemicals. In addition, rice bran has antibacterial, antioxidant, and cholesterol-inhibiting properties, which are very important for human health [5]. Sacha inchi came next. Sacha inchi seeds are rich in oils (35-60 wt%), which contain high levels of linolenic and linoleic acids and proteins (25-30 wt%), making them a good source of lipids and proteins [6]. The next ingredient was acacia gum as a prebiotic powder due to its special properties, such as its high solubility and its widespread use as a stabilizer, emulsifier, flavoring agent, thickening agent, or surface finishing agent. The next ingredient was a vitamin and mineral premix to ensure that the meal replacement contained all the nutrients essential to the body. Skim milk powder was added to the meal replacement drink. Skim milk powder is commonly used as an ingredient in many formulated foods. The final ingredient added to the meal replacement drink was non-dairy creamer. Non-dairy cream powder is a product that is not made from milk and contains other fats besides cream, or cream powder with less than 30% cream as an ingredient [7].

2.0 Materials and Methods

2.1 Materials

The ingredients for this meal replacement were pea powder, soy powder, sacha inchi powder, rice bran powder, vitamin and mineral powder, prebiotic fibre, skim milk powder, and cream powder. Aluminium bag was used as packaging, which can hold 25g in one bag.

2.2 Methods

2.2.1 Market survey, formulation, and sample preparation of meal replacement drink

An online survey was conducted via Google Forms to determine consumer acceptance of meal replacement beverage consumption and acceptance of the idea. Three meal replacement beverage recipes were then developed. Table 1 shows the list of ingredients and the percentage for a serving that was used with the ingredients used for the formulation soy protein, pea protein, and soy protein meal replacement powder for 20 g in a serving. The amounts of each ingredient were calculated based on the commercial meal replacement drink [8].

Table 1: The measurement of each ingredient for meal replacement drink

Ingredients	Measurement of the formulation (g)		
	Soy protein	Pea protein	Soy-Pea protein
Pea powder	0	3.5	3.0
Soy powder	3.5	0	3.0
Rice bran	3.5	3.5	2.5
Sacha inchi	0.5	0.5	0.5
Pineapple flavour	1.5	1.5	1.5
Prebiotic fibre	3.0	3.0	1.5
Vitamin- mineral premix	1.0	1.0	1.0
Skim milk powder	5.25	5.25	5.0
Creamer	1.75	1.75	1.5

All ingredients were weighed according to the calculation shown in Table 1. Several attempts were made to find a taste that could be accepted by all people. Aluminum packaging was used as packaging for this beverage to protect the powder from the sun and make it last longer. The soy-free meal replacement contained pea protein as the primary protein source, extracted pineapple, rice bran as the primary carbohydrate source, sacha inchi powder as the primary fat source, the addition of vitamins and minerals, a prebiotic culture of acacia gum that can restore the significant growth of these beneficial bacteria in the intestine, which in turn contributes to the complete breakdown of food, and pineapple as a natural colorant. In summary, the aim of this study is to investigate the acceptability of the soy-free meal replacement drink through market research and sensory testing, nutrient content, physicochemical properties, and morphological characteristics to ensure that this meal replacement drink provides multiple health benefits and helps people maintain a healthy weight.

2.2.1 Physicochemical analysis

PH analysis was performed using a digital pH meter (MX-50, Japan). 1 g of pea protein was diluted with 1 g of water. The pH electrode was added to the mixture and the measurement began [9]. The measurement was performed in triplicate. The value was recorded as mean and standard deviation. The method was the same for the soy protein and the combined soy and pea protein meal replacement powder. Total soluble solids analysis (TSS) was performed using a digital refractometer. TTS was expressed in degrees Brix (° Brix). The sample of meal replacement drink powder was diluted in water and dripped into it with a pipette until it covered the prism of the refractometer [10]. To determine the solubility, 4 g of the sample was weighed with a balance. 40 ml of distilled water was measured using a 100 ml graduated cylinder. 4 g of the sample was placed in a 50 ml beaker with the 40 ml of distilled water and heated to 30 °C. The magnetic stirrer was added to the beaker and mixed with the hot plate stirrer at speed level 2 to ensure systematic stirring. The time taken for the sample to dissolve completely was measured using a stopwatch [11]. For the wetting test, four grams of the flour substitute beverage powder was added to a cylindrical container containing 40 ml of water at 80 °C. The time (s) required for all particles to disappear was recorded as the wetting time of the samples under visual observation [12]. MiniScan EZ Hunter Lab 4500 was used for color analysis. The flour substitute powder was mixed with water and placed in individual sample cups with opaque colors. The MiniScan EX Hunter Lab 4500 was calibrated. The color of the meal replacement drink was evaluated with a colorimeter. The color was expressed as L*, a* and b* [13]. To determine the moisture content, the dry powder of the meal replacement was placed on an aluminum tray in the rapid analyzer and weighed. The result of moisture content was expressed in percent (%) [14]. The values of all analyzes were recorded as mean± standard deviation. The methods were the same for the other two samples.

2.2.2 Particle morphology

Particle morphology was evaluated by scanning electron microscopy (SEM) with a COXEM EM30, operated at 20kV and with magnifications ranging from 250x to 2000x. Gold coating was required. SEM images were analyzed for three different sample from same magnification which were 250x, 500x, 1000x and 2000x [15].

2.2.3 Nutritional content analysis

For protein analysis, the sample was analyzed by the Kjeldahl method (AOAC 988.05) [13]. Fat analysis was performed by the Soxhlet method. The solvent used was pentane (AOAC 963.15) [14]. In carbohydrate analysis, the carbohydrate content of the flour was determined by calculating the percentage remaining after measuring all other components [16]. Ash analysis was performed by the dry ashing method [17]. Vitamin D was analyzed by UV-vis spectrophotometer [18]. For caloric analysis, an oxygen bomb calorimeter (model 1341) was used with a digital thermometer for bomb calorimetry [19]. All analyzes were performed in triplicate and results were reported as mean ± standard deviation.

2.2.4 Sensory analysis

The sensory evaluation of meal replacement drink was determined using a hedonic 9- scaletest of color, taste, aroma, and overall acceptance. The scoring test was conducted with 70 untrained panelists in University Tun Hussein Onn Malaysia. The sample was coded as 561 represent pea protein, 348 represent soy protein, and 871 represent soy- pea protein. (SAPA SINI)

2.2.5 Statistical analysis

Data were statistically analyzed using Statistical Program for the Social Sciences (SPSS) software. Analysis of variance (ANOVA)with one-way ANOVA at 95% confidence interval for significance differences $p<0.05$. The mean and standard deviation were calculated from the data of all analyzes, and one-way analysis ANOVA was performed for both meal replacement types. Tukey's test was also calculated to obtain the comparison between samples. The result was expressed as mean ±standard deviation.

3 Results and Discussion

3.1 Physicochemical analysis

In the pH analysis, the highest mean value for soy protein was 7.24, for pea protein 7.18, and finally for soy pea protein 7.26. The pH was expected to be alkaline and between 7 and 8, because when it is acidic, it creates an acidic environment where the disease can thrive freely. Shelf life would depend on the pH of the beverage [13]. Protein content affects the pH in beverage powders. The soy pea protein contains soy protein and pea protein, which provide a variety of proteins in a meal replacement beverage formulation. Pea protein meal replacement drink, on the other hand, consisted only of peas as the main protein source. It was found that there was no significant difference between the samples ($p > 0.05$). In addition to pH, the combination of ingredients and the different types of protein content may also affect the pH of the sample.

Table 2: The descriptive test for the physicochemical analysis for all samples

Physicochemical analysis	Mean ±standard deviation		
	Soy protein	Pea protein	Soy-pea protein
pH	7.24±0.012[a]	7.18±0.006[a]	7.26±0.015[a]
Total Soluble Solid (°Bx%)	9.33±0.056[a]	8.08±0.146[a]	10.03±0.045[a]
Solubility (s)	43.57±1.83[a]	60.93±2.11[b]	75.67±8.50[c]
Wettability (s)	18.87±2.66[a]	36.48±3.18[b]	44.61±3.54[c]
Moisture content (%)	4.53±0.18[c]	5.83±0.20[a]	4.98±0.57[b]

[a, b] Data was presented as mean ± standard deviation (n=3) for each value. A different letter indicates a significant difference ($p<0.05$) based on ANOVA Tukey's HSD test (Minitab Version 20, Statistical Software

In terms of total soluble solids, the highest °Bx content was found in soybean-pea protein at 10.03%, the second highest °Bx content was found in soy protein at 9.33%, and the lowest °Bx content was found in pea protein at 8.08%. Since there is not enough encapsulating material when the TSS content is too low, the spray drying process does not lead to the formation of powder, while too high TSS content leads to a sticky powder [14]. It was found that there was no significant difference between the samples (p> 0.05). It was due to the total sugar content in the product was in the same weight except for the types of protein. In addition, the sample was a powder, so the value for TSS was less than 10%, which is suitable for powdered beverages

In solubility analysis, the shortest time for soy protein to dissolve was 43.57 s, followed by pea protein at 60.93 s, and the longest time for soy and pea protein to dissolve was 75.67 s. Although all samples were powders, the ingredients were different for all samples. In this study, it was found that there was a significant difference between the samples (p > 0.05). The difference in solubility was due to the protein content of each sample along with the other ingredients.

In the wettability analysis, the soy protein sank into the cup the fastest (18.87 s), followed by the pea protein (36.48 s), and the soy pea protein took the longest to sink into the cup (44.61 s). The difference between these three sample types was due to the protein content of the meal replacement beverage. In this study, there was a significant difference (p> 0.05) between the protein types in the meal replacement beverage

In the moisture content analysis, pea protein had the highest moisture content at 5.83%, followed by soy protein at 4.53% and soy pea protein at 4.93% had the lowest moisture content. It was expected that the moisture content would be less than 6% because the powder type has low water activity. Water activity (aw) is a crucial indicator for spray-dried powder as it has a significant impact on the shelf life of the powder produced. The shorter shelf life was caused by higher free water availability for metabolic activities, as evidenced by high water activity. Foods with low water activity were microbiologically stable, and any deterioration was caused by chemical reactions rather than microorganisms [16]. In this study, a significant difference (p > 0.05) was found between protein types in the meal replacement beverage. The difference in moisture content was due to the components contained in the ingredients.

Table 3: Descriptive test for of L*,a*, and b*

Type of protein	**mean± standard deviation**		
	L*	**a***	**b***
Soy protein	62.48±0.887^{a}	-2.45±0.078^{c}	7.28±0.243^{b}
Pea protein	60.23±1.583^{a}	-3.19±0.042^{a}	7.60±0.410^{a}
Soy- pea protein	59.90±10.372^{a}	-2.56±0.351^{b}	2.37±0.418^{c}

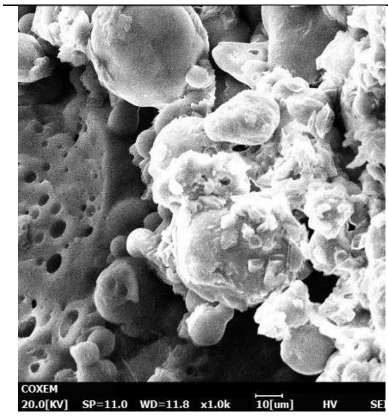
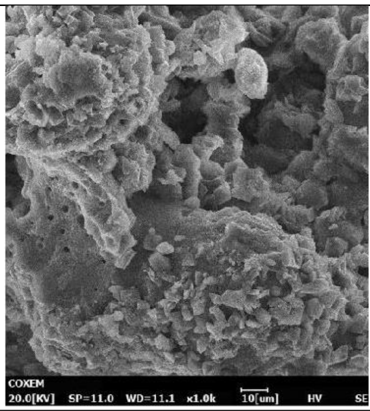
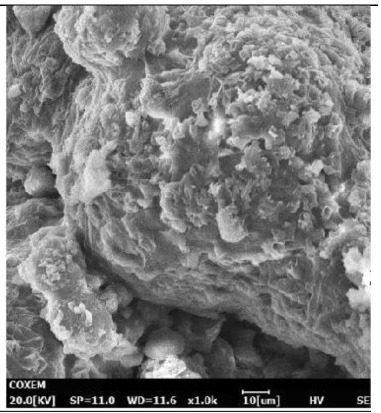
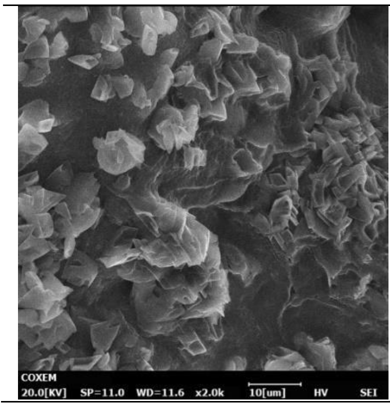
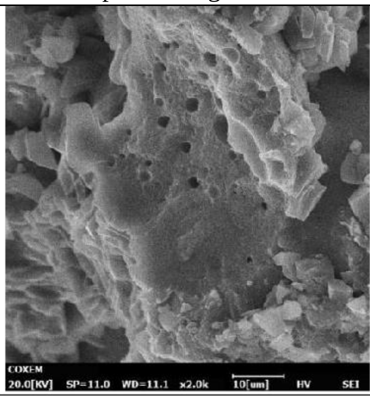
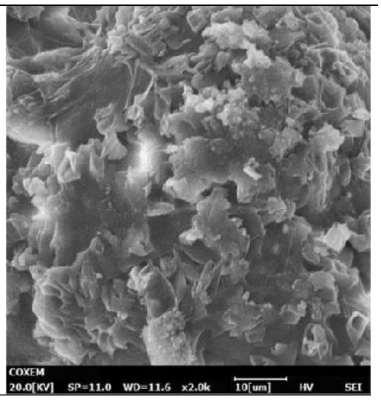
$^{a,\ b}$ Data was presented as mean ± standard deviation (n=3) for each value. A different letter indicates a significant difference (p<0.05) based on ANOVA Tukey's HSD test (Minitab Version 20, Statistical Software)

Table 3 shows that soy protein had the highest brightness (L*) at 62.48, followed by pea protein at 60.23, and soy pea protein had the lowest brightness at 59.90. For red coloration (a*), pea protein had the highest value of -3.19, followed by soybean pea protein with -2.56 and soy protein with -2.45 had the lowest value. For yellow coloration (b*), pea protein had the highest value of 7.60, followed by soy protein with 7.28 and soybean pea protein with 2.37 the lowest. This meal replacement consists of pineapple flavoring to maintain the pineapple flavor and natural yellow coloration. The yellow coloration of the samples was due to enzymatic browning reactions that occurred during spray drying and addition of all ingredients. The high color value for b* in the pea protein was due to carotene and xanthophyll, which give pineapple its yellow color [17]. There was no significant difference in this color analysis (p > 0.05).

3.2 Particle morphology

The image of particle morphology was obtained by scanning electron microscope (SEM). Particle morphology analysis was performed using COXEM EM30 operated at 20 kV with magnifications ranging from 250x to 2000x and coated with gold. Prior to SEM operation, all samples were dried in a drying oven to ensure that the samples did not contain moisture. At the 1000x magnification, the pores in the soy protein were very large and the particles were smooth spherical. In a recent study, it was found that the type of processing had a significant effect on how freely structured the soy proteins were in their gels [18]. In the pea proteins, the pores were not too large and the small irregular particles were closely attached to the large particles. In the soybean-pea protein, however, the small particles were.

Table 4: The comparison between samples under different power magnification

Soy protein	Pea protein	Soy- pea protein
	1000× power magnification	
		
	2000×power magnification	
		

For the power magnification 2000×, all samples for different types of protein exhibited irregular shapes that resembled flakes with sharp and broken glasslike surfaces. A similar result was observed in the study where curcumin was encapsulated by spray and freeze-drying with different formulations of maltodextrin, gum Arabic and modified starch and SEM images of freeze-dried samples demonstrated the glassy structure [19].

3.3 Sensory analysis

From the Table 5, for the color parameter, the highest score was sample 561 which was 6.47±1.55 followed by sample 348 which was 6.15±1.41 and the lowest score for the color parameter was code 871 which was 6.07±1.80. For the aroma, the highest score was sample 561 which was 6.58±1.34 followed by sample 871 which was 6.03±1.74 and the lowest score was sample 348 which was 5.62±1.59. For the taste parameter, the highest score was sample 561 which was 6.80±1.25 followed by sample 871 which was 6.02±1.63 and the lowest score was sample 348 which was 5.98±1.41. For the overall acceptance, the highest score was sample 561 which was 6.78±1.30 followed by sample coded 871 which was 6.28±1.46 and the lowest score was sample coded 348 which was 6.05±1.32. In this study, all the parameter were significant different ($p<0.05$) except for the color parameter, there was no significant different($p>0.05$) between coded sample, As expected, the highest score in terms of overall acceptance and taste was sample coded 561 which was pea protein meal replacement drink whereas the control sample which coded 348 has the lowest score which was under expected

Table 5: Descriptive test for three types of protein

Sample	Parameter	mean± standard deviation
561	Color	6.47±1.55[a]
	Aroma	6.58±1.34[a]
	Taste	6.80±1.25[a]
	Overall acceptance	6.78±1.30[a]
348	Color	6.15±1.41[a]
	Aroma	5.62±1.59[c]
	Taste	5.98±1.41[c]
	Overall acceptance	6.05±1.32[c]
871	Color	6.07±1.80[a]
	Aroma	6.03±1.74[b]
	Taste	6.02±1.63[b]
	Overall acceptance	6.28±1.46[b]

[a, b] Data was presented as mean ± standard deviation (n=3) for each value. A different letter indicates a significant difference ($p<0.05$) based on ANOVA Tukey's HSD test (Minitab Version 20, Statistical Software

3.4 Market survey

The questionnaire had been distributed among the students and staff at the University Tun Hussein Onn Malaysia Pagoh branch. There were 80 respondents who answered the questionnaire through an online survey, which was Google Form application to determine consumer acceptance of the consumption of meal replacement drinks and the acceptability of the idea. The respondents gave positive feedback on the important factors when purchasing soy- free meal replacement drink. Four important reasons that the respondents considered when purchasing a product were price about 55%; nutritional content about 75%; taste about 67.5% and packaging about 47.5%. Another factor like uniqueness and texture, the respondents did not really consider when purchasing the product. Nutritional analysis

Table 6: The nutritional fact for the pea protein meal replacement drink

Parameter	mean± standard deviation
Energy (kcal/100g)	360.333±1.528
Available Carbohydrate (%w/w)	56.733±0.321
Protein (%w/w)	20.367±0.351
Total Sugar (%w/w)	37.433±0.153
Total Fat (%w/w)	1.033±0.578
Vitamin D (mcg/100g)	1.633±0.058
Magnesium (mg/kg)	536.533±0.231

This meal replacement content high content of energy. Meal replacement generally contains a tight range of total calories, macro-, and micronutrients, and is a nutrient- dense tool, especially useful for calorie- restricted diets through portion control [20,21]. Pea protein meal replacement cannot be claimed as healthy beverages due to the Guidelines on healthier choices. The nutrient value for total sugar based on cereal drinks is less than 5g/100 ml meanwhile, in pea protein meal replacement drink the total sugar was 37.4%. On the other hand, for the protein content, pea protein meal replacement can be claimed as high protein content because according to the food act 1983, the recommended value for claiming high protein content for botanical beverage powder higher than 16.7g/100g, meanwhile, for the pea protein meal replacement, the protein content was 20.37g/ 100g [22]. However, for the carbohydrates content, it can be claimed as high content of carbohydrates because according to FDA regulatory requirement for nutrient content, the high nutrient should be in 20% or more of the Dietary Value (DV) per Reference Amounts Customarily Consumed (RACC) [23,24,25].

Conclusion

In conclusion, the formulation of a soy-free meal replacement drink proved successful. Pea powder, soy powder, rice bran, Sacha inchi, pineapple flavour, prebiotic fibre, vitamin and mineral premix, and skim milk powder and creamer were among the ingredients employed in the designed meal replacement. To achieve this wonderful taste, the development underwent numerous tests. The panellists preferred sample code 561, which was a pea protein meal replacement drink, for all aspects, including colour, scent, taste, and overall acceptability, based on the descriptive test of sensory evaluation from the hedonic 9-scale. The meal replacement drink's physicochemical and nutritional evaluations were of the highest quality. There weren't many distinctions in the particle morphology of the three samples, which all had irregularly shaped particles of various sizes. The analyses revealed that this MRD has the potential to be developed on a larger scale for commercialization.

Acknowledgement

This research was made possible by funding from research grant number ABC-MO83 provided by the Ministry of Higher Education, Malaysia. The authors would also like to thank the Faculty of Applied Sciences and Technology, Universiti Tun Hussein Onn Malaysia for its support

References

[1] Gorissen, S. H. M., Crombag, J. J. R., Senden, J. M. G., Waterval, W. A. H., Bierau, J., Verdijk, L. B., & van Loon, L. J. C. (2018). Protein content and amino acid composition of commercially available plant-based protein isolates. *Amino Acids*, 50(12), 1685–1695. https://doi.org/10.1007/s00726-018-2640-5

[2] Karaca, A. C., Low, N., & Nickerson, M. (2011). Emulsifying properties of chickpea, faba bean, lentil and pea proteins produced by isoelectric precipitation and salt extraction. *Food Research International*, 44(9), 2742–2750. https://doi.org/10.1016/j.foodres.2011.06.012

[3] Shevkani, K., Singh, N., Kaur, A., & Rana, J. C. (2015). Structural and functional characterization of kidney bean and field pea protein isolates: A comparative study. *Food Hydrocolloids*, 43, 679–689. https://doi.org/10.1016/j.foodhyd.2014.07.024

[4] Watchararuji, K., Goto, M., Sasaki, M. and Shotipruk, A. (2008). Value-added subcritical water hydrolysate from rice bran and soybean meal. *Bioresource Technology*, 99: 6207-6213

[5] Rosida, D. F., Mulyani, T., & Septalia, L. R. (2016b). A Comparative Study of Non-Dairy Cream Based on the Type of Leguminosae Protein Source in Terms of Physico Chemical Properties and Organoleptic. *Agriculture and Agricultural Science Procedia*, *9*, 431–439. https://doi.org/10.1016/j.aaspro.2016.02.160

[6] Kamble, J.R ., Sherikar, A.S ., & Disouza, J. I . (2021). Accelerated Stability Study of Arsenazo III Used for Detection of Calcium from biological system through UV-Spectrophotometer, Biochemistry analyzer, pH meter, HPLC and HPTLC. *InternationalJournal of Pharmaceutical Sciences and Research*, *12*(3), 1615–1623.https://doi.org/10.13040/ijpsr.0975-8232.12(3).1615-23

[7] Li, J. L., Sun, D. W., & Cheng, J. H. (2016). Recent Advances in Nondestructive Analytical Techniques for Determining the Total Soluble Solids in Fruits: A Review. *Comprehensive Reviews in Food Science and Food Safety*, *15*(5), 897–911. https://doi.org/10.1111/1541-4337.12217

[8] Choosing the Right Meal Replacement Shake | NutriliteTM Malaysia. (2021b). Amway.

Retrieved June 2, 2022, from https://www.nutrilite.com.my/en/blog/choosing-the-right-meal-replacement-shake

[9] Elfalleh, W., Nasri, N., Marzougui, N., Thabti, I., M'rabet, A., Yahya, Y., Lachiheb, B., Guasmi, F., & Ferchichi, A. (2009). Physico-chemical properties and DPPH-ABTS scavenging activity of some local pomegranate (*Punica granatum*) ecotypes. *International Journal of Food Sciences and Nutrition*, *60*(sup2), 197–210. https://doi.org/10.1080/09637480903067037

[10] Hogekamp, S., & Pohl, M. (2003). Porosity measurement of fragile agglomerates. *Powder Technology*, *130*(1–3), 385–392. https://doi.org/10.1016/s0032-5910(02)00240-1

[11] Mauer, L. J., & Bradley, R. L. (2017). Moisture and Total Solids Analysis. *Food Science Text Series*, 257–286. https://doi.org/10.1007/978-3-319-45776-5_15

[12] Nielsen, S. S. (2010). Food Analysis (Food Science Text Series) (4th ed.). Springer. https://doi.org/10.1007/978-1-4419-1478-1

[13] Yam, K. L., & Papadakis, S. E. (2004). A simple digital imaging method for measuring and analyzing color of food surfaces. Journal of Food Engineering, 61(1), 137–142. https://doi.org/10.1016/s0260-8774(03)00195-x

[14] Pérez-Palacios, T., Ruiz, J., Martín, D., Muriel, E., & Antequera, T. (2008). Comparison of different methods for total lipid quantification in meat and meat products. *Food Chemistry*, *110*(4), 1025–1029. https://doi.org/10.1016/j.foodchem.2008.03.026

[15] Peters, H. P. F., Bouwens, E. C. M., Schuring, E. A. H., Haddeman, E., Velikov, K. P., & Melnikov, S. M. (2013). The effect of submicron fat droplets in a drink on satiety, food intake, and cholecystokinin in healthy volunteers. *European Journal of Nutrition*, 53(3), 723– 729. https://doi.org/10.1007/s00394-013-0576-9

[16] Singh, V., Verma, M., Singh, N., Singh, J., Kaur, P. K., Singh, N., & Mishra, V. (2021). Advancement on Biomass Classification, Analytical Methods for Characterization, and Its Economic Importance. Clean Energy Production Technologies, 249–272. https://doi.org/10.1007/978-981-16-1862-8_10

[17] Laudisi, F., Di Fusco, D., Dinallo, V., Stolfi, C., Di Grazia, A., Marafini, I., Colantoni, A., Ortenzi, A., Alteri, C., Guerrieri, F., Mavilio, M., Ceccherini-Silberstein, F., Federici, M., MacDonald, T. T., Monteleone, I., & Monteleone, G. (2019b). The Food Additive Maltodextrin Promotes Endoplasmic Reticulum Stress–Driven Mucus Depletion and Exacerbates Intestinal Inflammation. *Cellular and Molecular Gastroenterology and Hepatology*, *7*(2), 457–473. https://doi.org/10.1016/j.jcmgh.2018.09.002

[18] Crowley, S. V., Kelly, A. L., & O'Mahony, J. A. (2014). Fortification of reconstituted skim milk powder with different calcium salts: Impact of physicochemical changes on stability to processing. *International Journal of Dairy Technology*, *67*(4), 474–482. https://doi.org/10.1111/1471-0307.12150

[19] Quek, S. Y., Chok, N. K., & Swedlund, P. (2007). The physicochemical properties of spray-dried watermelon powders. *Chemical Engineering and Processing: Process Intensification*, *46*(5), 386–392. https://doi.org/10.1016/j.cep.2006.06.020

[20] Sarkar, T., Salauddin, M., Hazra, S. K., & Chakraborty, R. (2020). Comparative study of predictability of response surface methodology (RSM) and artificial neural network-particle swarm optimization (ANN-PSO) for total colour difference of pineapple fortified rasgulla processing. *International Journal of Intelligent Networks*, *1*, 17–31. https://doi.org/10.1016/j.ijin.2020.06.000

[21] Polumbryk, M., Shestel, O., Yatsenko, O., Yuschenko, N., & Kuzmyk, U. (2019b). Surface morphology of soybean, pea, whey protein isolates, and their dried gels. *Ukrainian Food Journal*, *8*(1), 70–79. https://doi.org/10.24263/2304-974x-2019-8-1-8

[22] Cano-Higuita, D., Malacrida, C., & Telis, V. (2015). Stability of CurcuminMicroencapsulated by Spray and Freeze Drying in Binary and Ternary Matrices of Maltodextrin, Gum Arabic and Modified Starch. *Journal of Food Processing and Preservation*, *39*(6), 2049–2060. https://doi.org/10.1111/jfpp.12448

[23] Shao, A. (2017). Role of Meal Replacements on Weight Management, Health and Nutrition. *Superfood and Functional Food - an Overview of Their Processing and Utilization*. https://doi.org/10.5772/66331

[24] Wartella, E. A., Lichtenstein, A. H., & Boon, C. S. (Eds.). (2010). Institute of Medicine (US) Committee on Examination of Front-of-Package Nutrition Rating Systems and Symbols, *Front-of-Package Nutrition Rating Systems and Symbols: Phase I Report*. National Academies Press (US).

[25] Malaysia, & International Law Book Services. (2015). *Food act 1983 (Act 281) & regulations: (as at 20th february 2015)*. Petaling Jaya: International law book services