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OPTIMIZATION OF NOODLE FORMULATION USING COMMERCIALIZED EMPTY FRUIT BUNCH PALM OIL CARBOXYLMETHYL CELLULOSE (CMC) AND FLOURS WITH DIFFERENT PROTEIN CONTENT

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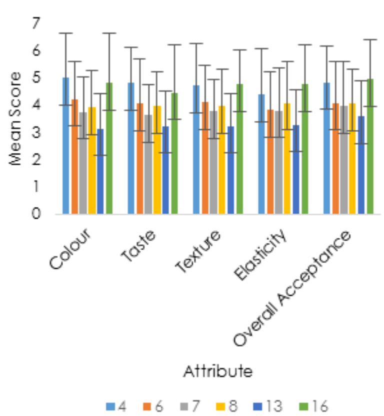
Graphical abstract



Abstract

Carboxylmethyl cellulose (CMC) is extracted from empty fruit bunches of oil palm, which usually comes from industrial waste. The focus of this research is to recycle cellulose from the oil palm tree to produce a food product which is noodles. In this research, the noodles were produced from commercialized CMC (0 – 2%) by using 15 different formulations with different types of flour such as high protein flour, wheat flour and low protein flour which provides an added factor to improve texture. Proximate, physicochemical analysis and sensory test were conducted in order to determine the noodle's nutrient content, colour, texture and acceptance level among the consumer panels. Based on the proximate analysis, high protein flour produced noodles that were similar to the positive control product which was a commercialized yellow noodles (Mi Kuning Rakyat). Fat, crude fiber, moisture and ash content did not show a significant difference among the formulation tested (p>0.05) because the CMC used and different types of flour with different protein content used did not affect them. The compression test that was used to analyze texture in the physicochemical analysis revealed that Formulation 3 (F3), which was made up from high protein flour and 1% (w/w) CMC, had highest hardness with a mean score of 3.13 ± 0.06N and was significantly different (p<0.05) in comparison with other 14 formulations. This indicates that the use of high protein flour helps in the formation of gluten network in the noodles while an optimum amount of CMC (1.0%) gives a good texture to the noodles. For hedonic test, Formulation 4 (F4), which was made up of 1.5% (w/w) CMC and high protein flour which contain 11.5-13.5% of protein, has a highest acceptance level for consumer due to a good taste and a better texture. Therefore, the integration of high fibrous flour from an empty fruit bunch of oil palm in the form of commerciallized CMC with flours with different protein content into noodle formulation can produce an improved noodles' quality that have higher acceptance level among the consumers.

Keywords: Carboxymethyl cellulose, palm empty fruit bunch, formulation, noodles, sensory

Abstrak

Karbosikmetil selulosa (CMC) diekstrak daripada tandan kosong kelapa sawit yang merupakan hasil sisa buangan industri. Hal ini membolehkan selulosa daripada bahan buangan kelapa sawit digunakan semula untuk menghasilkan CMC seterusnya digunakan dalam produk makanan iaitu mi kuning. Mi kuning daripada CMC komersial (0 – 2%) telah dihasilkan menggunakan 15 formulasi yang berbeza dan penggunaan tiga jenis tepung berbeza iaitu tepung tinggi protein, tepung pelbagai guna dan tepung rendah protein sebagai faktor tambahan untuk menambahbaik tekstur mi. Analisis proksimat, fizikokimia dan penilaian sensori telah dijalankan untuk menentukan nutrisi dalam setiap formulasi mi yang dihasilkan dan menilai tahap penerimaan pengguna terhadap produk makanan mi. Melalui analisis proksimat yang dijalankan, kandungan protein menunjukkan perbezaan yang paling signifikan disebabkan oleh penggunaan tepung yang berbeza. Tepung tinggi protein juga menghasilkan mi yang tidak mempunyai perbezaan yang signifikan dengan produk kawalan positif iaitu mi kuning komersial (Mi Kuning Rakyat). Manakala analisis proksimat yang lain seperti kandungan lemak, serat kasar, kelembapan dan abu menunjukkan perbezaan yang tidak begitu ketara antara sampel ($p>0.05$) disebabkan oleh penambahan CMC dan penggunaan tepung yang berbeza tidak memberi perbezaan yang signifikan. Ujian fizikokimia pula menunjukkan bahawa Formulasi 3 (F3) yang diperbuat daripada tepung tinggi protein dan 1% (w/w) CMC mempunyai perbezaan yang signifikan ($p<0.05$) dengan 14 formulasi yang lain dengan min skor 3.13 ± 0.06N untuk analisis tekstur melalui ujian tekanan. Kandungan protein yang tinggi membantu dalam pembentukan gluten serta penggunaan CMC (1.0%) pada tahap yang optimum memberi tekstur yang baik kepada mi kuning. Manakala untuk analisis warna pula menunjukkan tiada perbezaan yang begitu ketara antara sampel. Berdasarkan ujian hedonik pula, Formulasi 4 (F4) yang dihasilkan daripada 1.5% (w/w) CMC dan tepung tinggi protein yang mana mengandungi 11.5-13.5% protein paling digemari oleh pengguna kerana rasa yang sedap dan tekstur yang lebih baik. Oleh yang demikian, penambahan CMC pada kadar yang optimum daripada CMC komersial dalam formulasi pembuatan mi serta penggunaan tepung yang berbeza mampu menghasilkan mi yang disukai oleh pengguna.

Kata kunci: Karboskmetil selulosa, tandan kosong kelapa sawit, formulasi, mi kuning, sensori

1.0 INTRODUCTION

Oil palm cultivation in Malaysia has built rapidly and become one of the main planting accounted billions ringgit Malaysia as well as being the country's economy. Starting as a decoration and now various attempts have been made to continue to enhance the oil palm industry. According to the Malaysian Palm Oil Institute (MPOB), in 2014 the area of oil palm cultivation was 5.39 million hectares of land in Malaysia. Since there were increasing in area of palm oil cultivation, earnings of oil palm also increased and caused the increasing of the biomass waste material generated by this industry. Oil palm biomasses include oil palm trunks, pruned and felled fronds, shells, palm press fiber and EFB [1]. In 2012, Malaysia's palm oil industry produces over 83 million dry tons of solid biomass including empty fruit bunches (EFB) as one of the biomass. EFB is the bunch residue after removal of all the fruits and is produced as waste at the end of the palm oil extraction process. Indiscriminate disposal of these wastes will cause serious environmental problems. The traditional methods such as composting and incineration are not suitable to process these organic solid wastes, whereas the nitrogen content of EFB is too low for composting, incineration and the smoke evolved would cause serious environmental pollution by volatiles and dust particles. However, EFB is a suitable and potential renewable biomass material for the conversion into other valuable product because it is locally abundant and rich in lignocellulosic components [2, 3].

Plant waste fibers can be described as lignocellulosics which comprised primarily of cellulose, hemicellulose and lignin. Lignocellulosics include wood, agricultural residue, water plants, grasses and other plant substances [4]. In EFB fibres, lignocellulosic component comprises about 30.5% from their total weight. The rest are oil (2.5%) and water (67%). The compositions of major lignocellulosic components in EFB fibres are cellulose (45% w/w), hemicellulose (32.8% w/w) and lignin (20.5% w/w) [5]. In this study, the lignocellulosic component have been extracted from EFB to produce carboxymethyl cellulose (CMC) and used in the yellow noodles production. A lot of efforts have been made by researchers all over the world to convert plant fibers to value-added products. Various pretreatments involving chemical, physical and

biological treatments were conducted in extracting cellulose, hemicelluloses and lignin [6]. Chemical treatments that have been commonly used are treatments with aqueous sodium hydroxide [7], silane [8], hydrogen peroxide [9], acid [10], hot water [11, 12] and ethanol [13]. Physical treatments normally involved steam [14], ball-milling [15] and microwave [16]. Meanwhile, biological approach normally involved microorganisms such as enzyme like *celluclast* [17], enzyme cocktails [18] and some other microbes.
Basically, CMC is carboxymethyl ether from cellulose that was produced by plant. CMC is a group of cellulose ether ionic soluble in water. Gum cellulose, sodium CMC and salt sodium from carboxymethyl ether cellulose were other derivative's name for CMC [3]. In this study, CMC used was a commercialized CMC derived from EFB. There were many attempts to diversify the use of lignocellulosic derived from EFB. Conventionally, CMC derived from EFB was used in wide application of food, pharmaceuticals, toothpaste, detergents, oil drilling mud, paper coating and others [19]. On top of that, pharmaceutical industry has been using CMC as a tablet film coating agentand gelatin substitute for capsule [20].

Noodle is one of the Malaysian's favourite foods due to its acceptable taste to almost all age groups, available at affordable prices and can be produced either by small, medium or large-scale industries. The main ingredient of noodle is wheat flour [21]. Basic formulation in yellow noodles production involved wheat flour, water, salt and alkali salt water [22]. Noodles are made from wheat flour with high amylose content (>25g/100g) [23] which plays a critical role in creating a gel network and sets the noodle sructure [24]. However, some studies reported that the use of wheat flour could partly substituted with other flours, such as sweet potato flour [25], cassava flour [26], arrowroot and soybean composite flour [27], and maize flour [28]. Besides, other ingredients can also be added to improve the nutritional value of yellow noodles. However, efforts to increase the function of the flour based product such as noodles and pasta have been conducted in various attempts especially in improving fibre and protein content. On the other hand, a previous study revealed that the addition of CMC increased the required fibre content in food product [29]. In this research, CMC was added to different types of wheat flour with different protein content to see a better integration of CMC into yellow noodles in order to produce better quality yellow noodles with added CMC.

High protein flour is milled from either hard red spring or hard red winter wheat. It is high in protein typically 11.5% to 13.5% protein that forms good quality gluten which is essential to contribute good flavour and texture in the noodles [30]. All purpose flour is milled from endosperm generally from white kernel. The endosperm makes up the bulk of the kernel. It is the whitest part, partly because it contains mostly starch and 9.5% to 11.5% of protein. The starch is embedded in chunks of protein [30]. Low protein flour is milled from soft wheat, generally from soft red winter wheat. It is short or fancy patent flour, meaning that it comes from the absolute heart of the endosperm. This gives low protein flour a finer granulation, whiter colour, lower protein content usually about 7.0 to 9.5% protein and slightly higher starch content than other flours. Low protein flour is typically bleached with both chlorine and benzoyl peroxide, yielding a stark white colour and distinctly changed flavor [31].

Therefore, the objectives of this research were to investigate the effect of using CMC in the yellow noodles and also to develop yellow noodles with the addition of CMC and the use of three types of different flour with different protein content. The proximate composition of the yellow noodles were determined through the analysis of crude protein, fat, crude fibre, moisture content, ash content and carbohydrate. Besides, the physicochemical characteristics analysis also conducted to determine the colour and texture of the yellow noodles. Lastly, to determine the acceptance of the users toward the yellow noodles, descriptive test and hedonic test through sensory evaluation were conducted.

2.0 METHODOLOGY

2.1 Chemicals and Materials

The main ingredients in the yellow noodles production were CMC and wheat flour including high protein flour, all purpose flour and low protein flour. CMC was purchased from Waris Nove Sdn. Bhd. whereas the wheat flour was purchased from Yummies Bakery Ingredient. CMC and flour were kept in sealed container at room temperature. Other basic ingredients were salt, sodium carbonate and water also kept in sealed container at room temperature. A commercialized yellow noodles (Mi Kuning Rakyat) was used as a positive control sample.

The chemicals used in this study were chemical with analytical grade. Chemicals used were hexane, catalyst (10 copper: 1 potassium sulphate), 98% sulphuric acid, 4% boric acid, 0.1N hydrochloric acid and sodium hydroxide. All of these chemicals were used for proximate analysis and it was not used in the food preparation.

2.2 Preparation of Yellow Noodles

The basic noodle formula consisted of 100 g of wheat flour, 50 ml of distilled water, 1 g of salt and 1 g of sodium carbonate. Fifteen additional noodle samples were prepared by substituting wheat flour with high protein flour and low protein flour and also addition of 0-2% of CMC. The different formulations were processed into noodles using a kitchen aid mixer. The prepared dough was placed to rest in a plastic bag for 30 minutes. The dough was passed through a small noodle machine for several times with the rollers gap reduce gradually, to get dough sheets. The dimensions of the resultant noodle strands were 2 mm in width and

1 mm in thickness. The preparation of yellow noodles was using methods that have been used by Supatchalee, Juthamat and Anuntachai (2015) [32].

Figure 1 15 types of yellow noodle's formulation that has been prepared using different percentage of CMC and different protein content of wheat flour

Table 1 List of yellow noodles formulations based on Factorial Design

	Type of Wheat Flour (100g)	CMC [% (w/w)]	Salt (g)	Sodium Carbonate (g)	Water (ml)
F1	High Protein Flour	0	1.0	1.0	50
F2		0.5	1.0	1.0	50
F3		1.0	1.0	1.0	50
F4		1.5	1.0	1.0	50
F5		2.0	1.0	1.0	50
F6	All Purpose Flour	0	1.0	1.0	50
F7		0.5	1.0	1.0	50
F8		1.0	1.0	1.0	50
F9		1.5	1.0	1.0	50
F10		2.0	1.0	1.0	50
F11	Low Protein Flour	0	1.0	1.0	50
F12		0.5	1.0	1.0	50
F13		1.0	1.0	1.0	50
F14		1.5	1.0	1.0	50
F15		2.0	1.0	1.0	50

2.3 Determination of Proximate Compositions

The proximate compositions yellow noodles that made up of CMC and different types of flour with different protein content were analyzed according to AOAC method (AOAC, 2010).

2.3.1 Carbohydrate

The carbohydrate content was obtained by subtracting 100% with the entire contents of moisture, ash, protein, fat and crude fiber. The calculation method for carbohydrate content shown below:

$$\text{Carbohydrate} = 100 - \%\ (\text{fat} + \text{crude fiber} + \text{ash content} + \text{crude protein} + \text{moisture content}) \quad (1)$$

2.3.2 Fat

Soxhlet method (AOAC 2010) was used to determine the fat content in noodles. The fat content calculation is shown as below:

$$\%\text{Fat} = [W3-W2]/W1 \times 100 \quad (2)$$

where,
W1: Sample weight
W2: Extraction cup weight
W3: Extraction cup weight + fat weight

2.3.3 Crude Protein

Macro-Kjedahl methods (AOAC 2010) using Distilling Unit System (Model 2100, USA) was used for determination of protein content. The principle of this method is based on the digestible protein content in the medium of sulfuric acid which releases nitrogen gas. Nitrogen released from protein was captured in the form of ammonia salts. Sodium hydroxide (NaOH) was added to liberate ammonia gas where the gas is collected in a solution of boric acid and titrated. This method assumes that carbohydrates and fats do not contain nitrogen and nitrogen sources all contributed by the amino acids from protein. The protein (%) is calculated by determining the percentage of nitrogen produced as shown below.

$$\%N = \frac{0.1 \times (\text{mL acid needed for sample} - \text{blank}) \times 14 \times 100}{\text{Weight sample} \times 1000} \quad (3)$$

To convert % N to an ultimate value of crude protein (Equation 4), a conversion factor of 5.33 was used which is based on the protein contain (18.76%) in the wheat flour based food products (100/18.76 = 5.33).

$$\%\text{Protein} = \%N \times 5.3 \quad (4)$$

2.3.4 Moisture Content

For the determination of moisture, the drying oven method has been used. Crucibles and the lid were dried in a furnace at 105 °C. 5 g of yellow noodles were inserted into the crucible and weighed with the lid (B1). The samples were dried overnight in force air convection oven at 105 °C. The sample were cooled and weighed. The samples were dried until achieving constant weight (B2). The moisture content calculation is shown as below.

Moisture content (%) = [B1-B2]/B1 x 100 (5)

Where,
B1 = weight of the sample before drying
B2 = weight of the sample after drying

2.3.5 Crude Fiber

Gravimetric method (AOAC 2010) was used to determine crude fiber in the sample. Fibertec System (Model 1023 Filtration Module, USA) was used in the determination of this analysis. In determining the content of fiber, fat extraction is not required if the fat content of less than 1%. If the fat content was in the range of 1-10%, fat extraction was done in advance and if the fat was more than 10%, the extraction should be carried out by using petroleum ether, acetone or hexane. It was important to make the procedure more efficient fiber analysis. Percent crude fiber was calculated using the equation described below:

$$\%\text{Crude fiber} = \frac{\text{weight of crude fiber}}{\text{weight of sample}} \times 100 \quad (6)$$

2.3.6 Ash Content

Dry ashing method (dry ashing) was used to determine the ash content using the furnace. A total of 5 g sample was weighed in the crucible and closed. The crucible was heated in a furnace overnight at a temperature of 450-550 °C. The crucible was closed. Then the crucible was weighed. Ash percentage was calculated using the following equation:

Ash content (%) =

$$\frac{\text{weight after ashing} - \text{weight before ashing}}{\text{weight of the sample}} \times 100 \quad (6)$$

2.4 Determination of Physicochemical Properties

2.4.1 Colour

The colour of the cooked yellow noodle samples were measured with Minota Colourimeter, Model chromameter (CR 400, Jepun) using the CIE L* a* b* system. L* value was a measurement of brightness (0-100); a* value represents the red – green coordinates (- is green while + is red); b* value indicates the blue – yellow coordinates (- is blue while + is yellow). The device must be calibrated using white tile before measuring a colour sample. All measurements were performed in triplicates (*n* = 3).

2.4.2 Texture

This study used compression method to evaluate the hardness of the yellow noodles that have been generated from 15 different formulations (noodles approximation dimension of 3 mm in diameter) and a positive control product (Mi Kuning Rakyat). This analysis was conducted using a Shimadzu Texture Analyzer Twin-500N Column (Japan). However, the probe used in this study is a cylindrical probe (Probe dimension: 5 mm in diameter). The probe was moved from top to bottom at a controlled speed (0.1 mm/s) at room temperature (25 °C). Fixed plate that also contains a pressure sensor to measure the force applied to the noodles. Thus, by this method, namely, the pressure can be determined hardness value of yellow noodles [33].

2.5 Sensory Evaluation

The objective of this evaluation was to determine the level of user acceptance noodles produced from commercialized CMC extracted from the oil palm EFB. For sensory evaluation, yellow noodles were made one day before the sensory evaluation was carried out to ensure the freshness and quality of the yellow noodles. Once ready, the yellow noodles were kept in the refrigerator. On the day of the sensory evaluation, each panel was given with yellow noodles that were blanched in water at a temperature of 100 °C for 1 minute. Yellow noodles for each formulation were prepared in a small clear plastic to enable panels to evaluate the attributes of yellow noodles. Plain water was provided to the panels for the purpose of rinsing the mouth before and after the test sample.

2.5.1 Descriptive Test

Since this study involved 15 different formulations, descriptive test was conducted to select the five best formulations for hedonic test in order to determine the level of user acceptance. Basicaly, this test was used to evaluate similarity or dissimilarity of the product and to identify and quantify sensory characteristics [34]. A total of 10 semi-trained panel have been selected for this sensory evaluation. Each judging panel evaluated all the 15 samples and a commercialized yellow noodles (Mi Kuning Rakyat) which was used as a reference sample (R). The scores were given on a numerical scale of 1 to 7.

The attributes evaluated in this test were the colour (Score: 1 – Weak yellow, score 7 – Strong yellow), flavor (score 1 - Most dislikes, score 7 - Most liked), texture (score 1 – Not chewy, score 7 - Most chewy), elasticity (score: 1 - least elastic, score 7 - Most elastic) and overall (score 1 - Most dislikes, score 7 - Most liked). Five noodle samples with highest scores for overall acceptability attribute were selected to proceed with hedonic test.

This descriptive test was initiated by collecting 10 semi-trained panel to create a consensus on the score that should be given for each attribute of the reference sample. As a result of this consensus, the panellists gave a score of 5 for the attributes colour, flavor attribute scores 3 and 4 scores to attribute the texture, elasticity and overall acceptability.

2.5.2 Hedonic Test

Seven-point hedonic scale tests was used in sensory evaluation in which score of 1 is the most disliked and most liked was the score 7 [34]. This test was used to assess the level of user acceptance of yellow noodles. Thirty panels consisting of Universiti Kebangsaan Malaysia (UKM) students were involved to determine the best formulation of yellow noodles. The sensory evaluation was carried out at Sensory Evaluation Laboratory, Pilot Plant, UKM. This evaluation was conducted at room temperature (24 ± 1 °C). The attribute evaluated in this test is colour (Score: 1 - Most dislikes, score 7 - Most like), taste (Score: 1 - Most dislikes, score 7 - Most like), texture (score 1 - Most dislikes, score 7 - Most like), elasticity (score: 1 - Most dislikes, score 7 - Most like) and overall (score 1 - Most dislikes, score 7 - Most like). The sample that scored highest for all attributes is most preferred by this user panel.

2.6 Statistical Analysis

Data were analyzed in the form of percentage, mean ± standard deviation by two repetitions. The standard deviation was determined using one-way analysis of variance (ANOVA) followed by Fisher's Least Significant Difference to determine whether there were significant differences between the samples. The significant difference was based on the 95% confidence level ($p<0.05$). All statistical analyzes were assessed using the software Minitab 16.0. Microsoft Excel 2013 version used to generate figure data, radar charts and bar charts.

3.0 RESULTS AND DISCUSSION

3.1 Determination of Proximate Compositions

3.1.1 Carbohydrate

Based on Table 2, it shows that Formulation 4 (F4) had the lowest carbohydrate content which is 70.94 ± 0.99% whilst Formulation 7 (F7) had the highest carbohydrate content of 75.11 ± 1.96%. F4 consisted of high protein flour with 1.5% (w/w) CMC, which resulted in lower content of carbohydrate. The findings are consistent as all grain-based foods such as noodles, cereals, pasta and bread usually contains high carbohydrate content between 50.6% for bread, noodles and pasta 74.7% and 80.4% for cereal products [35]. The results also showed that there were significant differences between sample F7, Formulation 14 (F14) and Formulation 15 (F15) with another sample.

3.1.2 Fat

Based on the formulation of noodles that have been formulated using CMC from EFB of oil palm and the use of three types of flour, the study showed that F1 which consisted of 0% (w/w) CMC and high protein flour had the highest fat content of 2.19 ± 0.75% and there was no significant difference ($p<0.05$) with the positive control.

However, the overall fat content for all formulations of noodle showed no significant difference between each other because the value of p = 0.254 even though the fat content of the positive control relatively high with the value of 2.75 ± 0.21%. Based on the main ingredient in the product packaging Mi Kuning Rakyat, it showed that palm oil is used in the making of yellow noodles whereas in the noodle formulations produced using the CMC and the use of different flour, palm oil is not used. The difference formulation and manufacturing methods caused little significant difference between the positive control and others sample. On the other hand, yellow noodles containing CMC can reduce the absorption of fat and produce a brighter colour of the noodles.

3.1.3 Crude Protein

The study showed significant difference between all the three types of flour with different protein content. F2 which consisted of high protein flour and 0.5% (w/w) CMC had the highest protein content of 7.24 ± 0.21% meanwhile F14 (low protein flour and 1.5% (w/w) CMC) had the lowest protein content of 3.90 ± 0.22%. The addition of CMC to each formulation however did not affect the protein content. The positive control product (Mi Kuning Rakyat) had a relatively high protein content of 7.19 ± 0.22% and there was no significant difference ($p>0.05$) with noodles that were made up from the high protein flour.

The results also showed that F10 that made up from medium protein flour and 2.0% (w/w) CMC had higher protein content of 5.43 ± 0.04% when compared to F7 (medium protein flour, 0% (w/w) CMC) at 4.40 ± 0.63%. Although both formulations were made from same medium protein content flour with a slight different in amount of CMC, the results however showed a significant difference ($p<0.05$) between both.

As for formulations made up from low protein flours, it showed that F13 (low protein flour, 1.0% (w/w) CMC) had higher protein content when compared with F14 (low protein flour, 1.5% (w/w) CMC) and F15 (low protein flour, 2.0% (w/w) CMC). It seemed that the addition and percentage of CMC had significant effects on the protein content of the yellow noodles.

Protein component contained in wheat flour are albumin, globulin, gluten and gliadin. Each of these protein components has different chemical and physical characteristics. In the making of noodles, albumin and globulin has the relatively small function while the gluten and gliadin are a water-soluble protein that forms the gluten in improving the quality and texture of the noodles [36]. Besides, the protein content and quality of protein in flour need to be considered before making a food product because it will affect the chewiness of the yellow noodles [37]. Meanwhile, the noodles made up from high protein flour are often slightly darker and stronger but less dense (firmness) compare to the noodles that made up from all purpose flour and low protein flour as reviewed by Oh *et al.* [38]. The protein content in flour greatly affects the texture of noodles thus further increasing the protein content in yellow noodles that the protein intake in the diet is necessary.

3.1.4 Moisture Content

Overall, there were no significant differences between all formulations including a positive control where it shows the addition of CMC from EFB and the use of different types of flour with different protein content did not affect the moisture content of the yellow noodle. This was because the water used for each formulation was the same, 50 ml of water for every 100 g of formulation.

3.1.5 Crude Fiber

Overall, there was no significant differences occurred for all formulations including a positive control where it showed the addition of CMC from EFB and the use of different types of flour did not affect the moisture content of the yellow noodles. This was because the water used for each formulation was the same, 50 ml of water for every 100 g of formulation.

3.1.6 Ash Content

Ash content also showed no significant differences between all samples of yellow noodles. High protein flour was expected to have high ash content as minerals that will transform into ash come from the germ and the endosperm; however, it was reported otherwise in this study [22].

3.2 Formulated Noodles Physical properties

Physicochemical properties were carried out to determine the effect of the addition of CMC and the use of different flour with different protein content to yellow noodles in the physicochemical properties. Measurement of colour and texture analysis was conducted.

3.2.1 Colour

The colour of each sample was measured using a Minolta Chromameter and the Hunter colour system L* a* b* is used to obtain the results. Uses of the tools in determining the colour value of the colour is more objective. Three indicators were used to determine the colour of the L*, a* and b*, where L * value the higher the sample, the sample is sunny or bright.
While the value of +a is a reddish colour and -a is a greenish colour whereas the value +b is a yellowish colour when -b is a bluish colour. However, in this study, only the L* and b* were taken into account as both of these values gave a clear picture of the evidence and the yellowness of noodle.

Yoon *et al.* [39] reported that protein content gives the most impact and significant colour of noodle products. The higher the protein contents of the noodles, the darker the colour of the noodle. However, results from this study showed otherwise where L* and b* for Samples 1 and 5 which were made of high protein flour had the highest value that showed bright yellow colour.

However, the mineral content and starch in the flour also affect the brightness of the colour noodles and environmental factors of planted area and harvested wheat are also the contributing factors, thus resulting colour diversity [40,41]. But in overall, the type of flour, the process of making dough in the production of noodles [42] and the diversity of wheat caused by genetic factors, growth environment and the process of grinding grain greatly affect the colour brightness and yellow noodles as a final product [40].

Table 2 Results of proximate compositions for carbohydrate, fat, crude protein, moisture content, crude fiber and ash content

Formulation	Carbohydrate	Fat	Crude Protein	Moisture content	Crude Fiber	Ash Content
F1 (Negative control)	71.61 ± 0.16[d]	1.19 ± 0.75[a]	7.23 ± 0.32[a]	16.60 ± 0.57[a]	1.71 ± 0.39[a]	0.58 ± 0.10[a]
F2	71.07 ± 0.04[d]	1.61 ± 0.54[a]	7.24 ± 0.21[a]	17.60 ± 0.29[a]	1.85 ± 0.24[a]	0.59 ± 0.04[a]
F3	71.12 ± 0.84[d]	1.01 ± 0.09[a]	6.94 ± 0.56[ab]	17.63 ± 0.90[a]	2.16 ± 0.68[a]	0.90 ± 0.01[a]
F4	70.94 ± 0.99[d]	1.59 ± 1.13[a]	6.88 ± 0.35[ab]	18.01 ± 0.59[a]	1.82 ± 0.24[a]	0.62 ± 0.15[a]
F5	72.24 ± 0.47 [cd]	1.18 ± 0.36[a]	7.01 ± 0.11[ab]	16.74 ± 0.41[a]	1.94 ± 0.65[a]	0.71 ± 0.16[a]
F6 (Negative control)	72.19 ± 1.07[cd]	1.46 ± 0.77[a]	6.13 ± 1.01[bc]	17.74 ± 0.83[a]	1.95 ± 0.23[a]	0.67 ± 0.16[a]
F7	75.11 ± 1.96[a]	1.21 ± 0.57[a]	4.40 ± 0.63[ef]	16.70 ± 0.92[a]	1.78 ± 0.41[a]	0.60 ± 0.20[a]
F8	72.09 ± 0.95[cd]	1.14 ± 0.24[a]	5.54 ± 0.30[cd]	18.36 ± 1.38[a]	1.94 ± 0.21[a]	0.66 ± 0.06[a]
F9	73.12 ± 0.75[abcd]	1.49 ± 0.78[a]	5.18 ± 0.43[de]	18.77 ± 1.92[a]	1.83 ± 0.39[a]	0.39 ± 0.06[a]
F10	72.87 ± 0.68[abcd]	1.34 ± 0.43[a]	5.43 ± 0.04[cd]	18.47 ± 1.94[a]	1.88 ± 0.21[a]	0.60 ± 0.04[a]
F11 (Negative control)	72.26 ± 1.21[cd]	1.45 ± 0.48[a]	4.11 ± 0.11[f]	19.95 ± 0.69[a]	2.29 ± 0.52[a]	0.43 ± 0.21[a]
F12	72.68 ± 0.80[bcd]	1.24 ± 0.31[a]	4.07 ± 0.45[f]	19.31 ± 1.03[a]	1.78 ± 0.42[a]	0.40 ± 0.20[a]
F13	72.88 ± 0.35[abcd]	1.82 ±1.11[a]	3.99 ± 0.02[f]	19.34 ± 0.23[a]	1.59 ± 0.61[a]	0.61 ± 0.27[a]
F14	74.21 ± 3.77[abc]	1.46 ± 0.74[a]	3.90 ± 0.22[f]	18.42 ± 3.34[a]	1.53 ± 0.35[a]	0.68 ± 0.14[a]
F15	74.63 ± 2.55[ab]	1.43 ± 0.81[a]	4.12 ± 0.41[f]	17.31 ± 1.71[a]	1.99 ± 0.88[a]	0.69 ± 0.26[a]
Positive control	71.08 ± 0.43[d]	2.75 ± 0.21[a]	7.19 ± 0.22[ab]	17.02 ± 0.53[a]	1.60± 0.21[a]	0.59 ± 0.37[a]

Table 3 Colour measurement (L* and b*) for 15 different formulations and the positive control

Formulation	L*	b*
F1 (Negative Control)	68.55 ± 2.6 [a]	51.13 ± 2.76[a]
F2	66.00 ± 0.02[abc]	49.98 ± 0.25[ab]
F3	67.15 ± 1.91[d]	47.23 ± 1.31[cde]
F4	67.14 ± 2.86[ab]	48.20 ± 0.80[bcd]
F5	69.75 ± 1.20[a]	48.17 ± 1.40[bcd]
F6 (Negative Control)	62.22 ± 0.97[cd]	44.50 ± 1.84[f]
F7	64.16 ± 1.91[bcd]	48.56 ± 0.91[bc]
F8	63.30 ± 2.57[bcd]	46.54 ±2.01[cdef]
F9	65.98 ± 1.03[abc]	47.65 ± 0.34[h]
F10	65.60 ± 1.77[abc]	47.90 ± 0.20[bcde]
F11 (Negative Control)	63.05 ± 0.78[bcd]	47.50 ± 0.91[cde]
F12	63.49 ±1.25[bcd]	48.23 ± 1.72[bcd]
F13	61.18 ± 1.06[d]	45.98 ± 0.07[def]
F14	63.46 ± 3.38[bcd]	46.68 ± 0.45[cdef]
F15	62.28 ±7.41[cd]	45.66 ± 3.09[ef]
Positive Control	69.33 ± 0.69[cd]	34.56 ± 0.77[g]

[a-g]Mean with different alphabet showed significant different (p<0.05)

3.2.2 Texture

In this study, compression test was conducted and the results were shown in Graph 1. Results from the compression test were defined as hardness of the food, which can be valued in the Newton (N). Based on Figure 2, F3 had the highest hardness of 3.13 ± 0.06N. This was due to the protein content in the flour used for F3. F3 was made up from high protein flour and 1.0% (w/w) CMC. Protein content in the flour will harden the dough, thus, resulting in chewy texture on noodles and increased the hardness [38]. In order to produce noodles with good quality, usage of flour with at least 9.5% of protein was suggested.

For the negative control formulation, F1 (high protein flour), F6 (white flour) and F11 (low-protein flour) where all of these formulations contained 0% (w/w) CMC and different type of flours showed effects on the texture of yellow noodles. The lower the protein content of the flour, the lower the hardness of the yellow noodles significantly. The value of hardness for F1, F6 and F11 were 1.98 ± 0.17N, 1.74 ± 0.06N and 1.49 ± 0.06N.

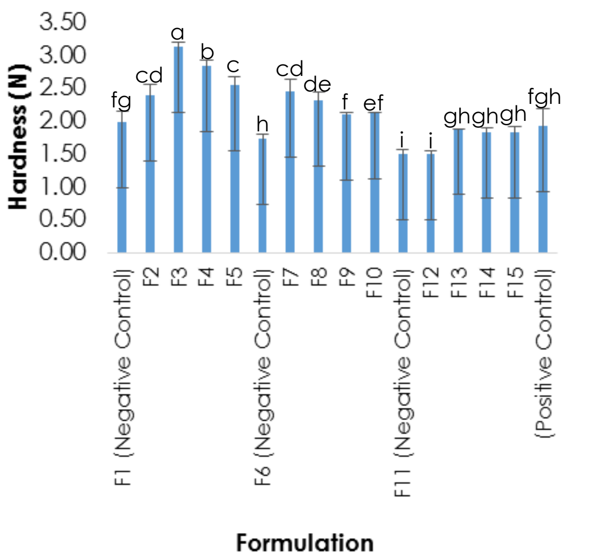


Figure 2 Texture analysis of compression test that measures the hardness of the yellow noodles for 15 different formulations and a positive control

It was expected that the addition of CMC will increase the hardness of yellow noodles. Nevertheless, the findings from this study showed contradict results. For both high protein flour and all purpose flour, all the formulations showed that the addition of CMC increased the hardness of yellow noodles. However, formulations made from low protein flour did not show similar pattern. This may due to the protein content in the low protein flour which affecting the hardness of yellow noodles. Although F11 – F15 had similar percentage of CMC as F1 – F10, however, the protein content in each formulation was different. As stated earlier, flours with high protein content will produce harder dough and chewy noodles.

3.3 Sensory Evaluation

Sensory evaluation of the product noodles is one of the methods for determining the quality of noodles directly and quickly [43]. The sensory evaluation was carried out to select the best formulation of yellow noodles. In this study, two types of tests have been conducted which included both descriptive and hedonic test. Descriptive test was conducted to determine the five best formulations, which involved semi-trained panel while hedonic test was carried out by the user panel to determine the most preferred, and the best formulation. From the descriptive test, five formulations were chosen which consisted of F4, F6, F7, F8 and F13. Meanwhile, the most preferred yellow noodles by the users in hedonic test was F13 which was made up of low protein flour and contains 1.0% (w/w) CMC.

3.3.1 *Descriptive Test*

There were 15 yellow noodles formulations involved in this study, but only five best formulations were chosen for hedonic test. 15 formulations were too much for sensory evaluation and the panel will tend to be bored and bias in the evaluation [34]. The descriptive test was carried out on 10 semi-trained panels. In this sensory evaluation, Formulation 16 (F16) or Mi Kuning Rakyat bought from market was treated as reference or positive control. Reference or positive control is necessary in this sensory evaluation because it was used to compare between the yellow noodles with added CMC and commercialized yellow noodles in the market. It there is no significant difference between the noodles, which means the yellow noodles with added CMC are at the same quality level with those commercialized noodles in the market.

For the attributes of colour, flavor and texture, all samples showed no significant difference. This was due to the almost similar colour, flavor and texture among all the samples, which resulted in the panel having difficulty to distinguish between all the samples. However, Sample 1 had brighter colour and was significantly different when compared to other samples. It was revealed that the addition of CMC did not affect the colour of the samples. Meanwhile, for the elasticity, Sample 1 had the highest mean score of 4.90 ± 1.73. Sample 1 was the most elastic noodles while Sample 10 had the lowest mean score of 3.10 ± 0.89. Nevertheless, hardness had a positive relationship with elasticity and texture. Sample 1 had a relatively low hardness and the elasticity was also low.

For the overall acceptance, Sample 4 had the highest mean score of 4.90 ± 1.60 which indicates that it was the most preferred yellow noodles amongst all. Through this attribute, five samples with highest mean scores were chosen for the hedonic test which involved user or consumer as the panel. The five formulations that been chosen were F4, F6, F7, F8 and F13.

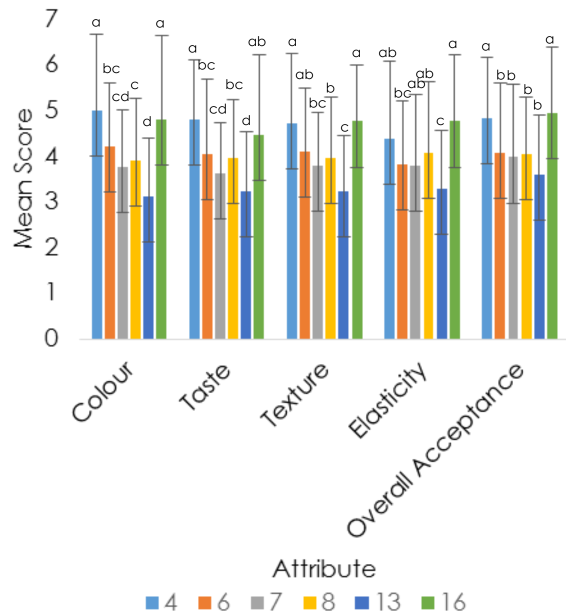
3.3.2 *Hedonic Test*

Hedonic test was carried out by using samples chosen after undergoing descriptive test. Those samples were F4 (high protein flour, 1.5% (w/w) CMC), F6 (white flour, 0% (w/w) CMC), F7 (white flour, 0.5% (w/w) CMC), F8 (white flour, 1.5% (w/w) CMC) and F13 (low protein flour, 1.0% (w/w) CMC) and all these samples were compared with existing product in the market which was Mi Kuning Rakyat (F16). Five attributes were considered including colour, flavor, texture, elasticity and overall acceptance.

Based on the analysis of the hedonic test, it seemed that the users had chosen F4 that was made from high protein flour and 1.0% (w/w) CMC as the most liked amongst all the yellow noodles. Besides, F4 also showed no significant difference ($p>0.05$) with the positive control product (F16). This indicates that F4 had similar qualities as the positive control (F16). For other attributes as well, F4 had the highest mean scores and there were significant differences (p<0.05) with other samples.

For the colour attribute, the user panel chosen F4 as the most liked colour with a mean score of 5.00 ± 1.28 and it showed that F4 had no significant difference (p>0.05) with positive control product (F16). F4 also showed significant difference (p<0.05) with other formulations. This indicates that the user preferred yellow noodles with brighter yellow colour. Meanwhile, there were no significant differences occurred (p<0.05) for F6, F7 and F8 where all the three samples were made from wheat flour. Protein content in wheat can affect yellow noodle's colour.

For the taste attribute, F4 (4.80 ± 1.29) had the highest mean score and it had significant difference (p<0.05) with F6, F7, F8 and F13 but there was no significant difference (p>0.05) with positive control sample (F16). This showed that yellow noodles produced by using F4 were almost similar to the positive control product (F16), which was already on the market. By using 1.5% of CMC and high protein flour, the yellow noodles produced had the same taste with the existing product. For the texture attributes, F4 also showed no significant difference (p>0.05) with positive control sample (F16) and F6. The addition of 1.5% (w/w) in high protein flour was preferred and favored by consumers. Similarly to the attributes of elasticity, F4 showed no significant difference (p>0.05) with F7, F8 and positive control product (F16).



$^{a-d}$Mean with different alphabet showed significant different (p<0.05)

Figure 3 The mean score and standard deviation for each attribute for the 15 different formulations and a positive control for hedonic test

Table 4 Mean scores for each attribute for the 15 different formulations and a positive control for descriptive test

Formulation	Colour	Taste	*Chewiness*	Elasticity	Overall Acceptance
F1 (Negative Control)	3.70 ± 1.34^{a}	3.30 ± 1.16^{a}	3.60 ± 1.71^{a}	4.90 ± 1.73^{a}	3.20 ± 1.23^{d}
F2	3.90 ± 1.37^{a}	3.40 ± 0.84^{a}	4.45 ± 1.77^{a}	4.85 ± 1.11^{a}	3.70 ± 1.25^{cd}
F3	3.90 ± 1.52^{a}	3.40 ± 1.26^{a}	4.50 ± 1.35^{a}	4.10 ± 1.52^{abcd}	3.60 ± 1.51^{cd}
F4	4.20 ± 1.55^{a}	4.40 ± 1.26^{a}	4.40 ± 1.26^{a}	4.70 ± 1.42^{ab}	4.90 ± 1.60^{a}
F5	4.20 ± 1.69^{a}	3.5 ± 1.27^{a}	4.40 ± 1.51^{a}	4.20 ± 1.23^{abcd}	4.25 ± 1.23^{abc}
F6 (Negative Control)	4.40 ± 0.97^{a}	4.10 ± 1.29^{a}	3.90 ± 1.10^{a}	4.00 ± 1.05^{abcd}	4.70 ± 0.95^{a}
F7	4.60 ± 0.97^{a}	4.50 ± 1.27^{a}	3.85 ± 1.20^{a}	4.35 ± 0.58^{abc}	4.60 ± 1.17^{ab}
F8	4.90 ± 0.99^{a}	4.40 ± 1.08^{a}	3.90 ± 1.52^{a}	4.40 ± 1.18^{abc}	4.70 ± 0.67^{a}
F9	4.70 ± 1.06^{a}	3.80 ± 0.92^{a}	3.50 ± 1.27^{a}	4.50 ± 1.43^{abc}	4.40 ± 0.97^{abc}
F10	4.55 ± 1.21^{a}	4.10 ± 1.29^{a}	3.45 ± 0.83^{a}	3.10 ± 0.88^{d}	4.20 ± 1.03^{abc}
F11 (Negative Control)	4.40 ± 0.88^{a}	4.70 ± 1.06^{a}	3.20 ± 1.75^{a}	3.20 ± 1.81^{d}	4.40 ± 0.97^{abc}
F12	4.40 ± 0.84^{a}	4.40 ± 1.08^{a}	3.10 ± 1.52^{a}	3.55 ± 1.54^{cd}	4.10 ± 0.99^{abcd}
F13	4.60 ± 1.26^{a}	4.10 ± 1.10^{a}	4.15 ± 1.29^{a}	3.70 ± 1.34^{bcd}	4.50 ± 0.85^{abc}
F14	4.40 ± 1.35^{a}	4.00 ± 0.94^{a}	3.40 ± 1.35^{a}	3.90 ± 0.57^{abcd}	4.00 ± 0.67^{abcd}
F15	4.50 ± 1.51^{a}	4.30 ± 1.16^{a}	4.00 ± 0.94^{a}	4.10 ± 0.99^{abcd}	4.20 ± 0.92^{abc}
(Positive Control)	5.00	3.00	4.00	4.00	4.00

Mean with different alphabet showed significant different (p<0.05)

For the colour attribute, the user panel chosen F4 as the most liked colour with a mean score of 5.00 ± 1.28 and it showed that F4 had no significant difference (p>0.05) with positive control sample (F16). F4 also showed significant difference (p<0.05) with other formulations. This indicates that the user preferred yellow noodles with brighter yellow colour. Meanwhile, there were no significant differences occurred (p<0.05) for F6, F7 and F8 where all the three samples were made from wheat flour. Protein content in wheat can affect yellow noodle's colour.

For the taste attribute, F4 (4.80 ± 1.29) had the highest mean score and it had significant difference (p<0.05) with F6, F7, F8 and F13 but there was no significant difference (p>0.05) with positive control sample (F16). This showed that yellow noodles produced by using F4 were almost similar to the positive control sample (F16) which was already on the market. By using 1.5% of CMC and high protein flour, the yellow noodles produced had the same taste with the existing product. For the texture attributes, F4 also showed no significant difference (p>0.05) with positive control sample (F16) and F6. The addition of 1.5% (w/w) in high protein flour was preferred and favored by consumers. Similarly to the attributes of elasticity, F4 showed no significant difference (p>0.05) with F7, F8 and positive control sample (F16).

4.0 CONCLUSION

In this study, 15 formulations of yellow noodles were made up of different percentage of CMC from EFB of oil palm and three different types of wheat flour which were high protein flour, all purpose flour and low protein flour. Through this study, determination of the proximate composition for all the formulations had been conducted and the results showed that carbohydrate and protein content showed significant differences (p<0.05) between all the yellow noodles were produced. The use of different wheat flours which contain different percentage of protein content caused significant differences between all the yellow noodles. Meanwhile, yellow noodles formulation from high protein flour had insignificant difference with the positive control (F16). Besides, addition of CMC from EFB and the use of three different types of wheat flour showed significant differences (p<0.05) between yellow noodles for texture analysis. This was due to the protein content in flours where high protein flour produced better texture in yellow noodles because of the increasing in gluten formation. Furthermore, the addition of CMC from EFB and the use of three different types of flour affect colour of yellow noodles and showed significant differences (p<0.05) between the samples. The high protein content of the flour produced a brighter yellow colour of the noodles.

Hence, the present study showed that yellow noodles that was made up from low protein flour with the addition of 1.0% (w/w) CMC had the same quality as the yellow noodles in the market and was the most preferred among the user panels through the sensory evaluation.

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