Available online freely at www.isisn.org

Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH 2020, 17(SI-1):01-10. **OPEN ACCESS**

Physicochemical Properties and Sensory Characteristics of Mustard Sauce Incorporated with Modified Potato Peel Starch

FMNA, Aida [1*], Nur Nafisha Omar Razi[1] and Norshazila Shahidan[2]

[1]Faculty of Applied Sciences, Universiti Teknologi MARA (UiTM), 40450 Shah Alam, **Selangor, Malaysia**
[2]Faculty of Bioresources and Food Industry, Universiti Sultan Zainal Abidin, Besut Campus, 22200, Besut, **Terengganu, Malaysia**

[*]Corresponding author: aidafirdaus@uitm.edu.my

The potato processing industries produce a huge volume of potato peels as its by-product. High fat content in mustard sauce can be replaced by non-fat biopolymers such as modified starch obtained from potato peel. The objectives of this study were to determine the physicochemical properties of the modified potato peel starch as well as physicochemical and sensory characteristic of the mustard sauce incorporated with modified potato peel starch. The potato peel starch was modified by using the oven heat moisture treatment (HMT) at 120°C for an hour. The percentage of moisture and ash of the HMT potato peel starch were 11.36% and 0.34% respectively. The L*, a* and b* values of HMT potato peel starch were 65.48, 3.17 and 9.09 respectively. The pH value of the HMT potato peel starch was 5.25. There were no significant different in pH value of mustard sauce incorporated with the HMT potato peel starch but it showed gradual decreased in fat content and viscosity, increased in L* value and a* value. No significant difference in b* value noted as the HMT potato peel starch increased. The mustard sauce with formulation 1 and formulation 3 (with 2.5% and 7.5% of HMT potato peel starch as fat replacer respectively) were significantly preferred. As a conclusion, the best formulation according to the physicochemical and sensory of the mustard sauce was the formulation 3 as it contains less fat and less viscous texture and no changes in pH of the product.
Keywords: Heat moisture treatment potato peel starch, fat replacer, mustard sauce

Introduction

In 2007, the United Nations declared 2008 as The Year of potato and in 2014, Chinese potato production reached one-fifth of the total output in the world. This shows that the potato (*Solanum tuberosum* L.) is one of the most important foods for human consumption after wheat, rice, and corn (Saldana & Schieber, 2009; Wu, 2016). A lot of potato products that have been introduced and become favorite food for many peoples around the world such as French fries, hash brown, potato chips, potato stick, mash potato, and potato soup.

The potato processing industries produce a huge volume of potato peels as their by-product. It is also known as zero value by-products because potatoes are usually peeled during processing and being discarded. The potatoes can be peeled with many ways such as by steam, lye or abrasive peeling, depending on the type of product (Sepelev & Galoburda, 2015; Saldana & Schieber, 2009). Abrasion peeling usually for chip production while steaming for dehydrated and frozen potato products. Raw potato peel waste originally contains high content of starch but abrasion peeling was said to produce more starch compared to the steam peeling (Sepelev & Galoburda, 2015).

In term of nutritional value content of potatoes, in different processing methods to obtain its powder, the oven baked samples have moderate amount of ash, crude fiber and crude protein. Besides, it consists lower fat content compared to deep-fried samples (Kalaimangai et al., 2019).

In term of food products contains potatoes as main ingredients, in one study reported by Nurul Zaizuliana et al. (2020), the proximate composition of incorporation of sweet potato flour in ice-cream product was found to give significant effects on the protein, fat and fibre content of the ice creams. The results also revealed that the antioxidant content of ice cream formulated with sweet potato flour was higher compared to ice cream formulated with tapioca flour. Not only for nutrients content, tubers plant such as potatoes also studied for its prebiotic potential as they are rich with fiber, starch and oligosaccharides (Napisah and Rosma, 2020)

The huge volume of potato peels usually disposes and causing environmental concern due to its microbial spoilage (Wu, 2016). It shows that industrial processing produces about 70 to 140 thousand tons of potato peels worldwide annually and the potato peels waste traditionally used for the production of low quality of animal feed but it was not suitable for non-ruminants without further treatment (Wu, 2016; Sepelev & Galoburda, 2015). Besides, modified starch also can be used as the fat replacer in a food product which can give the desirable eating qualities of fat such as viscosity, mouth feels and appearance (Ognean, 2006).

As an inexpensive by-product, potato peel wastes actually contain a large quantity of starch, protein and low amount of fat (Sepelev & Galoburda, 2015). Many studies have been made on potato peel waste application in order to decrease the industrial waste to the environment.

In this study, starch from potato peel was modified and was used as fat replacer in low-fat mustard sauce production. The starch needs to be modified because native starch cannot function as thickening and stabilizer (Hajibabaei et al. 2014). The mustard sauce contains high content of fat and non-fat biopolymers such as modified starch that can be used to replace the fat functional attribute (Hosseinvand & Sohrabvandi, 2016). Modified potato peel starch is one of the alternative choices to produce the low-fat mustard sauce due to its effective cost (by-products or a waste from industry), tasteless and has the creamy texture and it can function well as fat replacer.

The objectives of this study were to determine the physicochemical properties of modified potato-peel starch from potato peel and to determine the physicochemical and sensory characteristic of mustard sauce incorporated with modified potato peel starch. This study would benefit the mustard food industries as it's provided useful findings on the usage of modified starch from potato peel using heat-moisture treatment to develop a new product of mustard sauce.

Materials and Methods

Materials

Potato peel was sponsored by Hamonfa Enterprise. Another basic ingredient to produce mustard sauce such as oil, egg, vinegar, sugar and mustard were purchased from the local supermarket around Shah Alam, Malaysia. Chemicals were provided by Universiti Teknologi MARA (UiTM), Shah Alam.

Overall Experimental Design

In this study, starch was isolated from the potato-peel and the native starch of the potato peel was modified by using the heat-moisture treatment which is the physical modification method. Physicochemical properties of the modified potato-peel starch (MPPS) were studied. The physical analysis that was studied for this modified potato peel starch was color measurement while for the chemical properties analysis was the determination of ash, moisture, and pH.

The mustard sauce was produced by using modified potato peel starches with different concentration which was 0% (control), 2.5%, 5.0% and 7.5% (Hosseinvand and Sohrabvandi, 2016), where the usage of oil in the formula was reduced proportion to the additional of potato peel used. The physicochemical properties studied were color, viscosity, and proximate analysis. While sensory evaluation was conducted using thirty untrained panelists to evaluate the different formulations of mustard sauces with the bread as the carrier.

Production of Heat-Moisture Treatment (HMT) Potato Peel Starch

The potato peel sample was ground and was transferred into a beaker. 100 mL of water was added and mixed. The mixture was filtered and placed in the refrigerator overnight to allow precipitation of starch. After isolation, the starch was dried at 60 ºC in a convection oven for 2 hours. It was then weighed, ground, and sifted through a 100mesh screen and was stored at room temperature in a sealed container. The moisture of the native starch powder was then adjusted to 20-25% by using water (Lim et al. 2001). The starch mixture was mixed by using a mixer and the moisture of the mixture was measured. The moisture adjusted starch (200 g) was transfer into a beaker and conventionally heat in oven at 120 °C for 1 hour. After heat-moisture treatment, the starch was dried to approximately 10% moisture in a convection oven (40ºC) overnight. The sample was ground and sieved through a 60mesh screen in a plastic bag and stored at room temperature (Nadir, 2015).

Color Measurement of HMT Potato Peel Starch

The color of the modified potato-peel starch was measured by using chromameter (model CR 400, Konica Minolta, Japan). The modified potato peel starch was placed in a clean and clear petri dish for the measurement. The values were recorded using the Commision International de I' Eclairage (CIE) L*a*b color system. The CIE system was used in the three dimensionless calorimetric measurement where L* indicates the lightness, a* indicates red-green and b* indicates blue-yellow axis color (Nielsen, 2017).

Moisture Analysis of HMT Potato Peel Starch

The moisture content is determined as the loss in weight that results from drying a known weight of food to constant weight at 105ºC. This method is satisfactory for most foods, but with a few, such as silage, significant losses of volatile material may take place. Moisture content is an important parameter that needs to be controlled to ensure longer shelf life and give a suitable texture. This is because high moisture content may cause microbial spoilage.

The analysis started with drying of crucible overnight at 105ºC inside the convection oven and let cooled in the desiccator afterwards. The weight of the crucible was measured and note down after it reach room temperature. Next, 5 grams of each sample were weighed using crucible and were transferred into the convection oven and let dried overnight at 105ºC. After reaching the room temperature, the sample was removed and let cooled in the desiccator and reweighed (AOAC, 2000).

% Moisture = $\frac{W2-W3}{W2-W1}\ X\ 100$

% Total Solid = 100 - % Moisture

Where;

W1 = Weight of crucible (g)

W2 = Weight of crucible (g) + weight of sample (g)

W3 = Weight of crucible (g) - weight of dried sample (g)

Ash Analysis of HMT Potato Peel Starch

The ash content was determined by ignition of a known weight of the food at 550ºC until all carbon has been removed. The residue was the ash and was taken to represent the inorganic constituents of the food. The crucible with cover was dried for four hours in an oven 105ºC. Then, it was cooled in the desiccator and weighed soon after it has attained room temperature. Then 5 grams of sample was weighed into the crucible and if the sample contains high moisture, it was dried in an oven at 105ºC for about one day. The sample then was placed in muffle furnace and brings temperature to 550ºC overnight. Finally, the samples were removed and cooled in a desiccator and the weight was weighed after attaining room temperature (AOAC, 2000). The percentage of total ash was calculated as follows;

$$\% \text{ Ash} = \frac{W3-W1}{W2} X\ 100$$

Where;
W1 = Weight of crucible (g)
W2 = Weight of sample (g)
W3 = Weight of crucible and ash (g)

pH Determination of HMT Potato Peel Starch

pH meter was used in this study to identify the pH of the modified potato peel starch. The pH meter involves the use of an electrolytic cell composed of two electrodes dipped into a test solution. A voltage develops, which is related to the ionic concentration of the solution (Nielsen, 2017).

pH of the samples was measured using Thermo Scientific pH electrode as it gives more precise results than pH papers. pH meter is an electronic instrument that consists of a special bulb which is sensitive to hydrogen ions that are present in the test solution (Javanmard & Endan, 2010). Before taking the pH measurement of sample, the pH meter was calibrated for accuracy. In this method, 2 g of sample was mixed with 4 ml of distilled water for analysis.

Production of the Mustard Sauce Incorporated with HMT Potato-Peel Starch

Production of mustard sauce for control and low-fat mustard sauce samples were formulated as shown in Table 2.1. First, gum (dissolved in hot water for 15 minutes), sugar, mustard powder, and whole egg were mixed (Model 584, Tefal, France) and blended for 3 minutes. Then, oil was gradually added and blended for 6 minutes into the mixture until the emulsion system was established. In the later step, after the addition of vinegar, the mixtures of all ingredients were blended for a further 5 minutes. The all of the prepared samples were kept in the refrigerator until the physicochemical and sensory analysis (Hosseinvand and Sohrabvandi, 2016). Table 2.1 showed the formulation used in the mustard sauce production.

Table 2.1: Formulation of mustard sauce replaced oil with HMT potato peel starch

Ingredient (%)	Control	F1	F2	F3
Oil	60.0	57.5	55.0	52.5
MPPS	0.0	2.5	5.0	7.5
Vinegar	5.0	5.0	5.0	5.0
Sugar	4.0	4.0	4.0	4.0
Xanthan gum	0.5	0.5	0.5	0.5
Mustard	4.5	4.5	4.5	4.5
Egg	22.0	22.0	22.0	22.0
Water	6.0	6.0	6.0	6.0

Note: Mustard sauce formulation based on 1 Kg for each treatment (w/w%) MPPS: Heat moisture treatment potato peels starch. C (0.0% MPPS, 60.0% oil), F1 (2.5% MPPS, 57.5% oil), F2 (5.0% MPPS, 55.0% oil), F3(7.5% MPPS, 52.5% oil).

Viscosity of Mustard Sauce

The viscosity of mustard sauce was measured by using the viscometer (BROOKFIELD-RVT) with the spindle number 4 at 12 rpm (Brookfield Engineering Laboratories Inc., 2017). Approximately 500 mL of sample was poured into the 1000 mL beaker. Each sample was measured in triplicate at room temperature and the viscosity readings were recorded after 15 seconds rotation in centipoise.

Color Measurement of Mustard Sauce

The color of the mustard sauce was measured by using chroma meter (model CR 400, Konica Minolta, Japan). Each of the mustard of the different concentration of potato peel starch was poured into a clean and clear petri dish for the measurement. The values were recorded by using the Commision International de l' Eclairage (CIE) L*a*b color system. The CIE system was used in the three dimensionless calorimetric measurement where L* indicates the lightness, a* indicates red-green and b* indicates blue-yellow axis colour.

Fat Analysis of Mustard Sauce

The fat in the mustard sauce determination was conducted by using soxhlet method (AOAC, 2000) which was a semi-continuous extraction method. For semi-continuous solvent extraction chamber for 5-10 mins and it must completely surround the sample and the fat content was measured by weight loss of sample or weight fat removed. This method provided a soaking effect of the sample and not causes channeling but this method required more time than the continuous method. The mustard sauce was weighed into the thimbles, placed in the Soxhlet apparatus and appropriate solvent was used as a solvent for extraction which was petroleum ether. The extraction took about 8 hours. The extraction was evaporated and fat was determined by the gravimetric method and the fat content was calculated as equation below:

% Fat on dry weight basis = (g of fat in sample / g of dried sample) x 100

pH Determination of Mustard Sauce

pH meter was used in this study to investigate the pH of the mustard sauce from the different formulation to study the effect of the concentration of the potato peel starch to the pH of the mustard sauce. The pH meter involved the use of an electrolytic cell composed of two electrodes dipped into a test solution. A voltage develops, which was related to the ionic concentration of the solution (Nielsen, 2017)

Sensory Evaluation of Mustard Sauce

The sensory evaluation was conducted by thirty untrained panelists (Curtis, 2013). The analysis was carried out using the nine-point hedonic scale from one (extremely dislike) to nine (extremely like). The attributes of the sensory were based on the taste, color, consistency, appearance and overall acceptability. There were 4 formulations where one of them was the control of this mustard sauce. This mustard sauce was prepared with bread as its carrier in the sensory evaluation (Morten et al., 2006).

Statistical Analysis for Sensory Evaluation of Mustard Sauce

The data obtained were calculated by using Analysis of Variance (ANOVA) to determine whether there were significant differences between each formulation of mustard sauces at 5% interval. The data analysis was performed by using SPSS (statistical package for the social sciences).

Results and Discussion

Physicochemical properties of HMT potato peel starch

Chemical properties of HMT potato peel starch

There were three chemical analyses have been done on the HMT potato peel starch such as moisture, ash and pH. Table 3.1 shows the moisture content and ash content of the HMT potato peel starch which were 11.36% and 0.34% respectively. According to Nadir (2015), the moisture content of the HMT potato starch was about 12.19% and the ash content of the HMT potato starch in his finding was about 0.34%. The ash and moisture content between HMT potato peel starches were in line with his finding.

The other chemical analysis that was determined on the HMT potato peel starch was pH analysis. It was determined by independent triplicate. The Table 3.1 shows that the pH of the HMT potato peel starch was slightly acidic which 5.25. According to Tiamiyu et al., (2017), the pH of the HMT water yam starch was 6.93 which was also slightly acidic. The small difference between the pH of the HMT potato peel starch and HMT water yam starch was due to the different sources of starch.

Table 3.1: Chemical properties of HMT potato peel starch

Chemical properties	HMT potato peel starch
Moisture content (%)	11.36±0.16
Ash content (%)	0.34±0.04
pH determination	5.25±0.11

Note: Values are expressed as mean±standard deviation

Physical Properties of HMT Potato Peel Starch

The physical analysis for the HMT potato peel starch was color measurement. Table 3.2 shows the color measurement of the HMT potato peel starch. The L*, a*, and b* of the HMT potato peel starch were 65.48, 3.17 and 9.09

respectively. According to Nadir (2015), the L*, a*, and b* of the HMT potato starch were 63.71, 4.19 and 10.28 respectively. The positive denomination of L* value indicates the white pigment, a* value indicate red pigment and b* value indicate yellow pigment. There was also a small difference in color measurement of the HMT potato peel starch and the HMT potato starch. This may also due to the different part of potato that been used to produce the starch.

Table 3.2: Color measurement of the HMT potato peel starch

Color	HMT potato peel starch
L*	65.48±0.13
a *	3.17±0.18
b *	9.09 ±0.18

Note: Values are expressed as mean±standard deviation

Viscosity Analysis of Mustard Sauce

Table 3.3 shows the viscosity of the different formulation of mustard sauce. From this analysis, the viscosity of the mustard sauce was decreased when more HMT potato peel starch was added to replace the oil. The viscosity of the control was significantly the highest than the other formulation. This is because, control contain the highest oil content. There was no significant difference ($P<0.05$) between F1 and F2.

The viscosity of formulation 3 (F3) was significantly the smallest than the other formulation due to low oil content which the oil was reduced and substitute by 7.5% HMT potato peel starch. This is supported by Hosseinvand and Sohrabvandi (2016) where the decrease in oil content and addition of carbohydrate-based fat replacer can decrease the effect on viscosity. It was also stated that the large content surface areas between the oil droplets lead to important friction force. This may oppose to free-flowing emulsion in shear rate and increase the viscosity. The decrease of the oil did not cause the high decrease in viscosity due to the increase in HMT potato peel starch as the fat replacer which it stabilizes the emulsion and increases the viscosity of the light mustard sauce (Amin et al., 2014). According to Reddy and Bhotmange (2014), 2% of HMT starch gave about 8.35 cP while 4% just gave about 20.5 cP.

Table 3.3: Viscosity of the different formulation of mustard sauce

Formulation	Viscosity (kcP)
C	36.59 ±0.31^{a}
F1	33.06±0.58^{b}
F2	32.63 ±0.04^{b}
F3	30.23±0.36^{c}

Note: a-c shows the significant difference. Values are expressed as mean±standard deviation. Mean with different letters were significantly different at the level of $P <0.05$. The coefficient of variance was less than 1%. C (0.0% MPPS;60.0% oil), F1(2.5% MPPS;57.5% oil), F2(5.0% MPPS;55.0% oil), F3(7.5% MPPS;52.5% oil)

Colour Measurement of Mustard Sauce

Table 3.4 shows the color measurement of the different formulation of mustard sauce. The colors of the different formulation of mustard sauce were determined by using the chromameter. The lightness has a major impact on the perceived appearance of the product (Mun et al, 2009). Hosseinvand and Sohrabvandi (2016) stated that the carbohydrate-based fat replacer affects the lightness, yellowness, and redness of the low-fat mustard sauce. The sample with small fat droplet size which may due to the presence of the carbohydrate fat replacer and high content of fat result the higher in the lightness of the sample. This is supported by Mun et al. (2009) that stated that research has shown that emulsion color changes from grey to increasingly bright white when the droplet size decrease due to the increase in light scattering.

According to Table 3.4, it shows that there was a significant difference ($P>0.05$) of colour measurement between the full-fat mustard sauce and the low-fat mustard sauce. The L value of F1 was significantly higher than control due to smaller droplet size. The lightness of F1 was significantly the higher than F2 and F3. This may due to the Heat Moisture treatment potato peel starch that improves the lightness of the mustard sauce. Low L* values obtained may be due to the Maillard browning and caramelization processes which happened due to the distribution of water and the reaction between reducing sugars and amino acids (Zarinah et al, 2018; Kent & Evers, 1994).

The a* values showed significantly different (P>0.05) between the full fat mustard sauce with the low-fat mustard sauce. It showed the increase in a* value when more HMT potato peel starch was added and more oil was reduced. The a * values of the low-fat mustard sauce were with the negative denomination which in the range of -5.32 to -5.67, which this show the presence of green pigment. Both of fully fat content mustard sauce and lower fat content mustard sauce show the presence of green pigment.

This is supported by Hosseinvand and Sohrabvandi (2016) and Amin et al., (2014) which stated that the mustard sauce and the family of the mustard sauce which was mayonnaise showed the presence of the green pigment.The b* value of the fully-fat and the low-fat mustard sauce were with a positive denomination which this show the presence of the yellow pigment. This was supported by Hosseinv and Sohrabvandi (2016) which showed that the mustard sauce contains the yellow pigment. There was no significant difference (P< 0.05) between the fully fat mustard sauce and all of the low-fat mustard sauce formulation.

Table 3.4: Colour measurement of the different formulation of mustard sauce

Formu-lation	L*	a *	b *
C	71.25 ±0.71^{c}	-4.72 ±0.12^{c}	35.43 ±0.79^{a}
F1	81.77 ±0.27^{a}	-5.27 ±0.05^{b}	36.67± 0.06^{a}
F2	78.58 ±0.10^{b}	-5.29 ±0.05^{b}	35.78 ±0.00^{a}
F3	78.63 ±0.02^{b}	-5.60 ±0.07^{a}	35.31 ±0.60^{a}

Note: a-c shows the significant difference. Values are expressed as mean±standard deviation. Mean with different letters were significantly different at the level of P <0.05. The coefficient of variance was less than 1%. C (0.0% MPPS;60.0%oil), F1(2.5% MPPS;57.5% oil), F2(5.0% MPPS;55.0% oil), F3(7.5% MPPS;52.5% oil)

Fat Determination of Mustard Sauce

According to Table 3.5, there were significantly difference (P>0.05) of fat content between all formulation of the mustard sauce. The fat content was significantly decreased when there was HMT potato peel starch added to replace the oil. The control which contains 0% of HMT potato peel starch with 60% of oil was significantly higher than other formulation which contains more potato peel starch which added according to the amount of oil reduced. This is supported by Hosseinv and andSohrabvandi (2016) which stated that the more carbohydrate-based fat replacer, the decreased fat content in the mustard sauce. According to Nadir (2015), HMT potato peel starch only contributes about 0.17±0.08% of fat. The increasing amount of heat-moisture treatment potato peel starch does not contribute the high-fat content to the mustard sauce.

pH Determination of Mustard Sauce

The pH value of the fully fat mustard sauce (control) and the low-fat mustard sauce (F1, F2, and F3) were shown in Table 3.6. The pH value of all formulation of the mustard sauce was acidic. These might due to the acetic acid in the formulation which was the vinegar. The pH of the mustard sauce was in the range of 4.07 to 4.18. It was recommended to use the vinegar as acidulant which it could give the pH of 4.1 or less and it can be a major inhibitory substance against microorganisms especially from Salmonella (Amin et al., 2014). From this study, there was no significant difference (P<0.05) in pH value of all low-fat formulation mustard sauce prepared by using the heat-moisture treatment potato peel starch which functions as a fat replacer.

Table 3.5: Fat content of the different formulation of mustard sauce

Formulation	Fat Determination (%)
C	58.5 ±0.71[a]
F1	56.25±0.35[b]
F2	53.5±0.71[c]
F3	51.75±0.35[d]

Note: a-c shows the significant difference. Values are expressed as mean±standard deviation. Mean with different letters were significantly different at the level of P <0.05. The coefficient of variance was less than 1%. C (0.0% MPPS;60.0% oil), F1(2.5% MPPS;57.5% oil), F2(5.0% MPPS;55.0% oil), F3(7.5% MPPS;52.5% oil)

Table 3.6: pH value of the different formulation of mustard sauce

Formulation	pH Value
C	4.12 ±0.01[a]
F1	4.11±0.04[a]
F2	4.11±0.07[a]
F3	4.09±0.02[a]

Note: a-c shows the significant difference. Values are expressed as mean ± standard deviation. Mean with different letters were significantly different at the level of P <0.05. Coefficient of variance was less than 1%. C (0.0% MPPS; 60.0% oil), F1 (2.5% MPPS; 57.5% oil), F2(5.0% MPPS; 55.0% oil), F3(7.5% MPPS;52.5% oil).

Sensory Properties of Mustard Sauce Incorporated with HMT Potato-Peel Starch

Sensory evaluation of the different formulation of the mustard sauce was presented in Table 3.7. The result shows that the taste and appearance attribute of the F1 which contains about 2.5% of heat-moisture treatment potato peel starch was significantly the highest than the other formulation, while there was no significant different of the taste and appearance attribute between control, F2 and F3. This shows that the panelist could not differentiate the control sample with the F2 and F3 but most significantly preferred the taste and appearance of the F1

There was also no significant difference (P<0.05) for the consistency and color of the mustard sauce between all of the formulation. This shows that panelists could not differentiate the consistency and color between the mustard sauce even the fat was reduced and replaced with the heat-moisture treatment potato peel starch up to 7.5%. There was no significant difference (P<0.05) of the acceptability of the control, F1 and F2 and there was no significant difference (P<0.05) between F1 and F3. The acceptability of the control and F2 were significantly difference (P>0.05) than the F1. From this result, the significantly preferred mustard sauce for the sensory characteristic was F1 and F3 with 2.5% and 7.5% of heat-moisture treatment potato peel starch as the fat replacer respectively.

Table 3.7: Sensory evaluation of the different formulation of mustard sauce

Formulation	C	F1	F2	F3
Taste	6.93± 1.39[b]	7.57± 0.95[a]	6.87± 1.20[b]	6.93± 1.05[b]
Consistency	6.93± 1.41[a]	7.40± 1.13[a]	7.20± 1.12[a]	7.40± 1.16[a]
Color	7.00± 1.41[a]	7.60± 0.93[a]	7.23± 1.19[a]	7.13± 1.20[a]
Appearance	7.13± 1.04[b]	7.77± 0.86[a]	7.20± 1.06[b]	7.20± 1.13[b]
Acceptability	6.90± 1.35[b]	7.73± 0.78[a]	6.80± 1.16[b]	7.20± 1.10[ab]

Note: a-b shows the significant different. Values are expressed as mean±standard deviation. Mean with different letters were significantly different at the level of P<0.05. Coefficient of variance was less than 1%. C (0.0%MPPS; 60.0% oil), F1(2.5%MPPS; 57.5% oil), F2(5.0%MPPS; 55.0%oil), F3 (7.5%MPPS; 52.5% oil).

Conclusion

In conclusion, the addition heat-moisture treatment potato peel starch can provide reduction up to 7.5% in preparation of low-fat mustard sauce. The production of the starch required a large amount of potato peel. The heat moisture potato peel starch moisture content, ash content, and pH were 11.36%, 0.34%, and 5.25 respectively. The L*, a*, and b* of the HMT potato peel starch was 65.48, 3.17 and 9.09

respectively. The more HMT potato peel starch added into the formulation of the mustard sauce, the more oil been reduced and it caused the decrease in pH value, viscosity and fat content of the mustard sauce. The significant preferred mustard sauce for the sensory characteristic was formulation 1 and formulation 3 which contain about 2.5% and 7.5% of HMT potato peel starch as fat replacer respectively. The taste and appearance attribute of the formulation 1 was significantly the highest compared the other formulation. For the other attributes such as consistency and color, there was no significant difference between all of the mustard sauce formulation.

CONFLICT OF INTEREST

Authors declare there is no conflict of interest in this review.

ACKNOWLEGEMENT

The authors wish to thank Universiti Teknologi MARA for the financial and facility support to complete this project.

AUTHOR CONTRIBUTIONS

All authors wrote and approved the manuscript.

REFERENCES

Amin., M.,H., Elbeltagy., A.,E., Mustafa.,M., Khalil.,A.,H.,(2014)., Development of low fat mayonnaise containing different type and levels of hydrocolloid gum., Journal of Agroalimentary processes and Technologies 20 (1)., pp 54-63.

AOAC.(2000). Official Methods of analysis, Association of Official Analytical Chemist Washington, D.C., U.S.A.

Brookfield Engineering Laboratories Inc. (2017). *Brookfield Dial Reading Viscometerwith Electronic Drive - Operating Instructions Manual* (Vol. 1).

Curtis, P.C. (2013) Untrained sensory panels. The science of meat quality. John Wiley & Sons. Inc 1, pp. 218.

Hajibabaei, A., Abdolmaleki, F., & Ardakani, S., AY., (2014) Influence of potato and corn modified starches as fat replacers sensory and physicochemical properties of milk. International Journal of Farming and Allied Sciences. 3 (7) pp. 830-834.

Hosseinvand, A. & Sohrabvandi, S. (2016). Physicochemical, textural and sensory evaluation of reduced-fat mustard sauce formulation prepared with Inulin, Pectin and β-glucan. Croat. Journal Food Science. Technology. 8 (2),pp. 46-52.

Javanmard, M. and Endan, J. 2010. A Survey on Rheological Properties of Fruit Jams. International Journal of Chemical Engineering and Applications 1(1): 31-37.

Kalaimangai a/p Sugumaran, Nu rul Zaizuliana Rois Anwar, & Asmaliza Abd. Ghani @ Yaacob. (2019). Effect of Different Processing Methods on the Physicochemical Properties and Sensory Evaluations of Sweet Potatoes Chips. *Journal Of Agrobiotechnology*, *10*(2), 51-63. Retrieved from https://journal.unisza.edu.my/agrobiotechnology/index.php/agrobiotechnology/article/view/208.

Lim, S.T., Chang, E.H., & Chung, H.J. (2001) Thermal transition characteristics of heat-moisture treated corn and potato starches. Carbohydrate Polymers, 46: 107-115.

Morten,C., Meilgaard, B., Carr, T. & Civile, G.V. (2006). Sensory Evaluation Technique. CRC Press.

Mun, S., Kim, Y. L., Kang, C. G., Park, K. H., Shim, J. Y., & Kim, Y. R. (2009). Development of reduced-fat mayonnaise using 4αGTase-modified rice starch and xanthan gum. Biological Macromolecules, 44(5): 400-407.

Nadir, A.S., Helmy, I.M.F., Nahed, M. Abdelmaguid,Wafaa, M. M. Abozeid & Ramadan, M.T.(2015) Modification of Potato Starch by Some Different Physical Methods and Utilization in Cookies Production.,International Journal Current Microbiology Application Science 4(10): 556-569

Napisah, H. and Rosma, A. (2020). Fermentation of Dioscorea hispida oligosaccharides as prebiotic potential by lactic acid bacteria and bifidobacterium. IOP Conf. Ser.: Mater. Sci. Eng. 716 012005

Nielsen.,S.,S. (2017).,FoodAnalysis., Springer New York Drdrecht Heidelberg London.,pp: 85-587

Nurul Zaizuliana Rois Anwar, Mohamad Faris Samsudin, Noor Atikah Abdul Latiff, Norshazila Shahidan, Zarinah Zakaria and Che Abdullah Abu Bakar. Effect of Incorporating Sweet Potato (Ipomoea batatas) Flour on the Proximate Composition, Antioxidant Activities and Sensory Evaluation of Ice Cream. The International Conference on Food and Applied Bioscience 2020: Insights for Research and Industry 4.0. Faculty of Agro-Industry, Chiang Mai University, Thailand. pg 148-158. Proceeding book.

Ognean., C.F. (2006) Journal of Agroalimentary Processes and Technologies, Review– Natural Food Extracts and Additives Section. 12(2): 433-442.

Reddy, D.K. & Bhotmange, M.G. (2014). Viscosity of starch: a comparative study of Indian Rice (Oryza Sativa L.) varieties. International Review of Applied Engineering Research. ISSN 2248-9967 Volume 4, Number 5 (2014), pp. 397-402.

Saldana, MD. A., & Schieber, A,.(2009) Potato peels: a source of nutritionally and pharmacologically interesting compounds- a review. Food 3, (2), pp. 23-29

Sepelev, I., & Galoburda, R. (2015) Industrial potato peel waste application in food production: a review. Food science, 1, pp. 130-136.

Tiamiyu, H.K., Babajide, J.M. & Adeyeye, S.A.O. (2017). RETRACTED ARTICLE: Some quality attributes of heat-moisture treated water yam (*Dioscore alata*) starch, Cogent Food & Agriculture, 3:1, 1278192.

Wu D. (2016) Recycle technology for potato peel waste processing: A review., Procedia Environmental Sciences .31 pp. 103 – 107.

Zarinah Z., Nurul Farahin, M., Siti Nuriah, M.N., Napisah, H.,and Norshazila, S. (2018). Development and Physicochemical properties of Breadfruit (*Artocarpus altilis*). Resistant Starch Bread. J. Agrobiotech. Vol. 9 (1S), 2018, p. 182–193.