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Effect of Reheating Process on the Frozen Coating System

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Abstract: This study was conducted to determine the effect of the reheating process on the frozen coating system of chicken nuggets including its water content, fat content and sensory evaluation using local agriculture and agro based flours such as wheat, rice and sago which are commonly used in Small Medium Enterprise (SME) in lowering cost of coating product ingredients. Three frying temperatures were used namely, 150, 165 and 180°C. Three types of batter, wheat, rice and sago batters were prepared at water to batter ratio of 1:1:2. Chicken nuggets were reheated for 420 seconds in a mini fryer. Results showed that increasing of reheating temperature resulted in the reduction of coating moisture content and an increase in substrate moisture content. However no significant difference was detected ($p>0.05$). Moisture content of coating and substrate chicken nuggets before reheating was higher than after reheating using 150, 165 and 180°C of frying temperature. Coating oil content increased while substrate oil content decreased but no significant difference was evident ($p>0.05$). Oil content of coating and substrate chicken nuggets before reheating were lower than after the reheating process. For sensory evaluation, no significant difference ($p>0.05$) was evident between all the attributes for all samples except in the coating colour and crispiness attribute. The highest score for coating colour was achieved at 180°C of frying temperature followed by 165 and 150°C for all types of batter. The same pattern of result was found for crispiness attribute except for rice batter where the highest score was achieved at 165°C of frying temperature. In conclusion, the physicochemical and sensory property evaluated was affected by the frozen coating system of chicken nugget by the different reheating temperatures. Further research, analyze on heat and substance transfer during the phase change in food system by conducting moving boundary analysis (MBA) studies during the thawing process, drying and frying are highly recommended in order to increased quality of food produced.

Key words: Reheating · Frozen Coating System · Chicken Nugget

INTRODUCTION

Frying is one of the methods of heat processing. Foods that are prepared through this method are liked by consumers [1]. According to [2] the majority of consumers chose the product (chicken nuggets) which is cooked using the frying method for most of the attributes studied. The function of frying is to modify the quality of certain foods and to add to the preservation effect. Frying is divided into two namely, pan and deep fat frying. The time taken for certain foods to be readily cooked depends on the types of food, the thickness of the food, oil temperature, frying method and consumer needs.

Chicken nuggets are one of the livestock products. This product is prepared from the chicken breast meat which is marinated and then coated and added with breadcrumbs. The coating of fried food becomes more important today because of the ability of the coating to control the transfer of the moisture and fat between the frying medium and food. The usage of suitable coating could decrease the loss of moisture and the absorbing of oil during frying.

The main ingredient in the preparation of the coating is batter. Some of the batter has its own different physicochemical characteristics. In the frying industry, choice of the suitable batter will produce optimum taste, colour, texture and crispness to the product. Generally, the wheat batter is much applicable in homemade usage compare to other batter. The nutrition value of wheat batter is heavily influenced by the level of extraction

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because wheat structure and composition of every part is different.

Thus, the higher the extraction rate, the higher the nutrient value. As for the rice batter, the pretreatment before the processing and the type of mill used also influences the characteristics of the batter. Nevertheless, the sago batter is said to have potential to be the alternative to the wheat and rice batter as a food coating material.

The reheating of the food after freezing is one of the pretreatments before the food is consumed. The reheating could reduce the microbial content in food. This is because; exposure of food before freezing at the environmental temperature causes the sudden increase of bacteria count. Thus, food should not be exposed for more than two hours before freezing.

Freezing is one of the usual methods to preserve food especially for long term preservation. A perfect storage while freezing is very important to ensure that the food product is safe. Yet, food freezing gives an obvious effect to the texture and it also influences the quality of the food after it is thawed depending on the rate, time and the freezing temperature, storage relative humidity, thawing methods and the composition of the food. The reheating of the food can be done with several methods including microwave heating, broiling and frying.

Hence, this study is carried out to determine the effect of the reheating process on the frozen coating system of chicken nuggets from the physicochemical and sensory aspect which used wheat, rice and sago batter as the food coating materials.

MATERIALS AND METHODS

Materials

Chicken Meat: The frying product used is chicken nuggets. The main ingredient for the production of chicken nuggets is the chicken breast meat that has been deboned. The chicken is supplied by Ayam Dinding Sdn. Bhd., Kajang, Selangor. It is kept in the freezer at -18°C until it is used.

Wheat, Rice and Sago Batters: There are three types of batters that are used as the dip materials which are Anchor brand wheat batter (Federal Batter Mills Berhad, Port Klang), Erawan rice batter (Tiga Gajah Cho Heng Sdn. Bhd., Butterworth, Penang) and sago batter.

Frying Oil: This oil functions as a frying media. The palm oil used is Vesawit brand (Yee Lee Edible Oils Sdn. Bhd., Ipoh, Perak).

Others: Other materials used are distilled water, salt 1.25% (w/w) and sodium tripoliphosphate, STPP (Mle Food Grade Selangor) 0.5% (w/w).

Methods

Sample Preparation: Sample preparation is divided into several stages which are the preparation of coating solution, chicken nuggets preparation, coating procedure and chicken nuggets frying.

Preparation of Coating Solution: The three types of batters used are wheat, rice and sago batters. The coating solution is prepared separately for each type of batter based on the ratio of dry batter to water at 1:1:2. Then, every mixture is mixed with electric mixture (Black & Decker model ™ CT Type 1 CT 06484 Black & Decker U.S Inc. Shelton) at number 2 speed for two to three minutes.

Chicken Nuggets Preparation: The chicken breast meat that is kept at a frozen temperature needs to be thawed a day before use at 4°C temperature for 24 hours. Then, the meat is left at room temperature for 20 minutes before the production process is done. After 20 minutes, the chicken meat is ground two times using the grinder (Beem-gigant Type E-5-6 Fleishwolf Starkey, Germany) until a medium fine particle is formed. Later, the meat mixture is added with salt 1.25% (w/w) and sodium tripoliphosphate (STPP) 0.5% (w/w). Then, the mixture is finely mixed for 2 minutes using the grinder (Hobart Machine Modure el N-50 serial no. 99-704-383 North York Ontario Canada) until a meat paste is formed. After that, the meat paste will be kept at a frozen temperature (-18°C) before it is used. When it wants to be used, it is thawed at 4°C temperature and is formed. The nuggets formation process is started by weighing the thawed meat paste to 45 gram per unit. Only then it will be formed into a nugget size which is 5 cm (L) x 5 cm (W) x 1.5 cm (H) by using a mould.

Coating Procedure: Chicken nuggets that were formed will be dipped separately into the mixture of coating solution of wheat, rice or sago and tossed.

Chicken Nuggets Frying: Frying is done by oil immersion in the fryer which is filled with 5.0 litre palm cooking oil

which is first heated for 20 minutes. For frying before frozen, the temperature used is 180°C for 7 minutes while the frying after frozen, the temperature used are 150, 165 and 180°C. The chicken nuggets are fried separately. The types of batters and the frying temperature are chosen randomly.

Early Research: Before much research findings were available, the refrying time needed for the chicken nuggets is determined by measuring the sample internal temperature while frying. Chicken nuggets that have been formed, are dipped into the coating solution of wheat, rice and sago batter separately and tossed. The thermocouple that is connected to the digital thermometer is jabbed horizontally on the centre of the sample (approximately 1.5 cm from the surface). Then, nuggets are fried at 180°C for 7 minutes. The first frying time was known from previous study. After that, the nuggets will be kept at the frozen temperature of -18°C for 3 days. After 3 days, the frozen nuggets are fried separately at a study temperature of 150, 165 and 180°C. The chicken nuggets internal temperature will be noted down every 15 seconds. The time taken for the internal sample to achieve 60 to 80°C and the wanted colour of the chicken nuggets have been used as the refrying time for the actual study. The earlier studies are repeated as three replications to get the accurate frying time.

Actual Study: For the actual study, the chicken nuggets that have been formed, are dipped in the coating solution of wheat, rice and sago batter separately and are tossed. Then, the nuggets are fried at 180°C for 7 minutes. After that, these nuggets will be kept at a frozen temperature of -18°C for 3 days. After 3 days, the frozen nuggets are fried separately at three temperature treatments of 150, 165 and 180°C. The refrying time is as found in the early study which is 7 minutes. The sample that has been fried, is tossed and left to cool at room temperature.

The sample that has been fried is used for the analysis of moisture content, oil content and sensory evaluation. For the moisture and oil content, the nuggets are separated into two parts which are coating and substrate. The coating part is achieved through scraping. Substrate is divided into surface and middle layer while the rest is assumed as the middle part.

Analysis

Moisture Content Determination: The method used is the oven method according to AOAC [3]. The sample used is coating and substrate before and after refrying at 150, 165 and 180°C. Coating is achieved through the scraping with knife while the substrate layer is found from the chicken nuggets surface and middle layers. About 5.0g coating and substrate sample is put out into a clean aluminium tray which is dried in the oven at 105°C temperature overnight. Then, the sample is taken out of the oven and is left to cool. The weight of the tray with the dried sample before and after is weighed. The sample moisture content is determined by using the formula below:

Water content (%):

$$\frac{\text{Weight of wet sample (g)} - \text{Weight of dry sample (g)}}{\text{Weight of wet sample (g)}} \times 100 \quad (1)$$

Oil Content Determination: The method used is the Soxhlet Extraction method according to AOAC [3]. The sample used is the dry sample from the moisture content analysis. Approximately about 1.0g dry coating and substrate sample is crushed, wrapped in filter paper and put into the Soxhlet container separately. About 50ml hexane is put into the aluminium container and installed to the Soxhlet System (Tecator Soxtec System HT, 1043 Extraction Unit, Saga Instrument) that has been heated at 140°C. The tap water is opened for the condenser refrigeration. After boiling (30 minutes) for hexane vaporization, rinsing (40 minutes) and evaporating (10 minutes), the aluminium container with the extraction result is put into the oven (105°C for 20 minutes) to dry up the hexane residue. Then, the aluminium container is cooled off in a drying canister and is weighed. The oil content in the sample is determined using the formula below:

Fat content (%):

$$\frac{\text{Weight [(flask+fat) } - \text{ empty flask] (g)}}{\text{Original sample weight (g)}} \times 100 \quad (2)$$

Sensory Evaluation: The method used is scoring test. This method needs the involvement of a trained panel member. In this study, ten trained panels are used and two replications were done. The sample used is the fried chicken nuggets coated with three types of batters (wheat, rice and sago) at three levels of temperatures (150°C, 165°C and 180°C).

The sensory evaluation is done at the UKM food preparation laboratory. All the chicken nugget samples

have been fried, cut into the same size and arranged on a glass plate while the distilled water served is for mouth rinsing. In this study, the chicken nuggets chosen are used as reference where this sample is given a standard score which is stated in the sensory evaluation form for further evaluation. The standard score is achieved as the result of the discussion among all the panel members who are headed by a chief panel who play an important part in coordinating and choosing the right term for every attribute. This is necessary in order to produce an evaluation form which can be accepted by all panel members and reflects the attributes of the evaluated products.

There are five chicken nugget samples given at each sensory evaluation session including the reference. After the panel has taken a short break, evaluation proceeds for the other four chicken nugget samples. The test sample is coded with a three digits random number with the reference number given an 'R' code. Then, the sample permutation is done in order to avoid bias among the panel. The panel is required to deliver intensity score for each attribute in scale. The score for each of the sample test is given by comparing the score given with the available reference sample in the evaluation form. There are seven attributes evaluated which are the coating colour, coating attachment, hardness, crispness, oily taste, juiciness and overall acceptance.

Statistic Analysis: The data attained is analyzed using Statistical Analysis System (SAS) software version 6.12. The method used is Analysis of Variance (ANOVA) and Duncan Multiple Range analysis procedure to determine the significant difference between means at confidence level 95% (P:0.05).

RESULTS AND DISCUSSION

Physical Analysis

Refrying Time Determination: The profile of the increase of the coated chicken nuggets internal temperature is shown in Fig. 1. Before the refrying process, which is right after the sample was taken out from the freezer (0 second), it is found that the internal temperature of the coated chicken nuggets is -4.5°C. During the early frying which is around 90 seconds, the increase rate of the coated chicken nuggets internal temperature is slow. At 105 seconds, the chicken nuggets internal temperature started to increase and exceeds 0°C. After that, the increase rate of the chicken nuggets internal temperature increased rapidly and

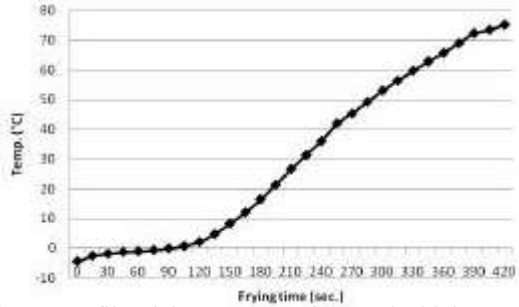

Fig. 1: Profile of the Increase of Coated Chicken Nuggets Internal Temperature

achieved the temperature of 70°C at 390 seconds. Frying is continued until the internal temperature reaches 75°C where at that temperature, it is found that the coated fried chicken nuggets have been cooked perfectly. The frying time for the coated chicken nuggets reaching 75°C is 420 seconds. At the same time, at that temperature it is found that the golden brown appearance of the chicken nuggets colour is also satisfactory. Hence, the frying time for the coated chicken nuggets is set at 7 minutes.

The frying time is determined based on the internal temperature of the wheat batter coated chicken nuggets that have the highest viscosity and the lowest frying temperature which is 150°C. The temperature between 71 to 90°C is the best internal temperature to ensure the whole part of the meat is perfectly cooked and the meat tenderness is increased when the internal temperature exceeds 71°C. At the same time, *Salmonella sp.* which is in the meat could be destroyed by cooking at 62.2°C for five minutes. Nevertheless, 70°C has been delineated as the minimum internal temperature to quickly deactivate this microorganism [4]. Hence, the frying time that is used in this study is set by taking the time where the coated chicken nuggets reach 75°C.

Chemical Analysis

Moisture Content

Coating Part: Based on Figure 2 it is found that moisture content for the chicken nuggets coating before refrying is at the highest. This is because the freezing process caused the formation of ice crystal in the chicken nuggets. Thus, when sample is thawed, the ice crystal will melt and contribute to the high value of the moisture content. Frying at 180°C gives the lowest moisture content compared to frying at the temperature of 150 and 165°C with no significant difference ($p>0.05$). The high temperature treatment speeds up the crust formation on the coating part and causes a faster dehydration process. [5].

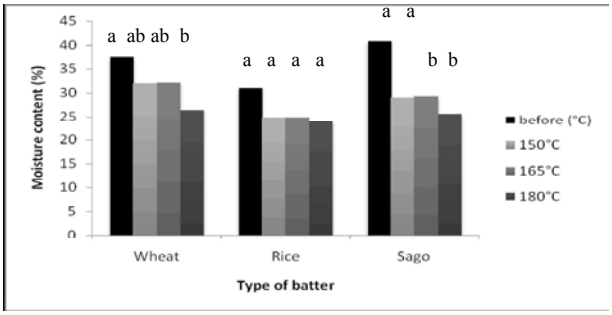

Fig. 2: Percentage of the Moisture Content of the part of the Coating of Coated Chicken Nuggets at Different Refrying Temperature; Note: [a-b]The same alphabet at the same histogram group shows there is no significant difference (p>0.05)

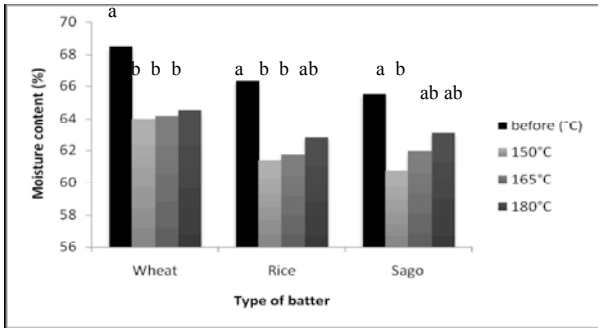

Fig. 3: Percentage of Moisture Content on the Part of Coated Chicken Nuggets Substrate at Different Refrying Temperature; Note: [a-b]The same alphabet at the same histogram group shows there is no significant difference (p>0.05)

For the wheat coating, there is no significant difference (p>0.05) achieved among the four temperature treatments except for the temperature before refrying; 180°C where the moisture content before frying is much higher than 180°C with the significant difference (p<0.05). As for the rice coating, there is no significant difference among the four temperature treatments while the sago coating gives a significant difference (p<0.05) between the temperature before and after frying (150, 165 and 180°C).

Theoretically, the higher the frying temperature, the lower the moisture content for the coating. This is due to the water vaporization that occurs during frying. While frying, the heat is transferred from the hot oil to the food through convection. This will increase the food temperature and cause the water vaporization [6]. Other than that, it is stated that during the food frying, heat will be transferred to food from the oil. This caused water to be steamed from the food [6].

Substrate Part: Percentage of the moisture content on the part of coated fried chicken nuggets at different temperatures is shown in Figure 3 It is found that the moisture content for the substrate before refrying is the highest with the significant difference (p<0.05) on the three temperature treatments. This is due to the melting of ice crystals which was formed on the sample during freezing process. Apart from that, while freezing is done, all the samples are kept in different plastic containers to avoid the release of the water steam into the storage section which is caused by the moisture vaporization from the sample. This is one of the factors that contributes to the high value of the moisture content for the substrate before refrying.

The result of study found that there is no significant difference (p>0.05) between the different temperatures. The lowest moisture content is shown by the substrate with the frying temperature of 150°C. The water movement from the middle part of the substrate to the surface is influenced by the coating type and the thickness [7]. The salt and phosphate content in the processed meat composition has the ability to bind water to help reduce the loss of moisture. Processed meat composition influenced the increase of chemical characteristics which happens quickly on the meat structure because of the high frying temperature (180- 200°C) and this chemical characteristics increase and influenced the processed meat internal moisture content [8].

Overall, it is found that the coating moisture content is lower compared to substrate moisture content. This is because the water vaporization happens on the surface of the fried food first followed by the internal part of the food. This study also shows that the coating moisture content and substrate are higher for sample before refrying compared to the sample after refrying but does not give an obvious value difference.

Oil Content

Coating Part: Percentage of the oil content of the coated fried chicken nuggets coating part at different temperatures is shown in Figure 3.4. The highest oil content value is for the fried coating which is fried at 180°C with no significant difference (p>0.05). This is because when the process of water vaporization occurs, the higher oil temperature enables the faster formation of crust and facilitates the absorption of oil into the food coating [1]. At the same time, the absorption of oil is influenced by the moisture content in the food because the released steam will form a pore on the food which will allow the entrance of oil inside it. The part of the food that lost a high level of moisture will absorb even more oil.

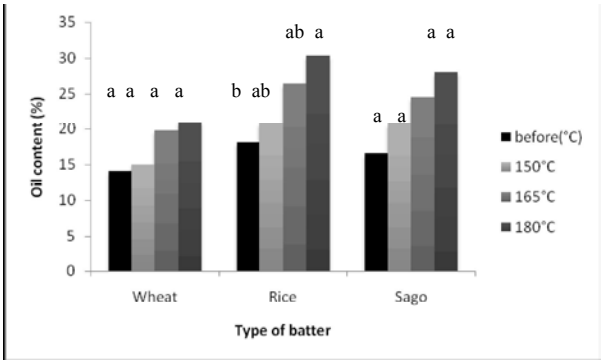

Fig. 4: Percentage of Oil Content on the Part of Coated Chicken Nuggets Coating at Different Refrying Temperature; Note: [a-b]The same alphabet at the same histogram group shows there is no significant difference (p>0.05)

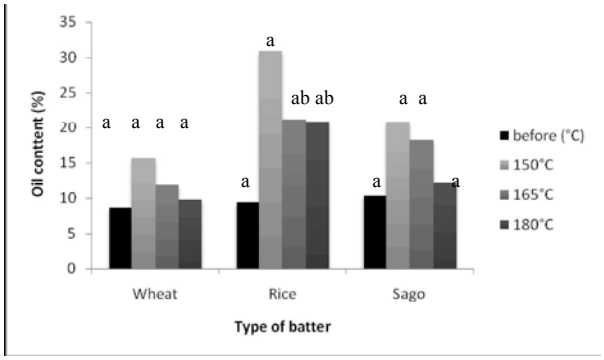

Fig. 5: Percentage of the Oil Content on the Part of Coated Chicken Nuggets Substrate at Different Refrying Temperature; Note: [a-b]The same alphabet at the same histogram group shows there is no significant difference (p>0.05)

The result of the study shows that there is an oil content increase on the coating part with the increase of the frying temperature. The oil content for the wheat and sago coating of the chicken nuggets before the refrying gives the lowest value with no significant difference (p>0.05) except for the rice coating with a significant difference (p<0.05). This is due to the before refrying sample not being given any treatment after it was frozen and the oil absorbed during the first frying is a little bit more than the oil absorbed by the sample that is refried.

Substrate Part: Percentage of the oil content on coated chicken nuggets substrate at different temperature is shown in Figure 5. The highest oil content is the substrate which is fried at 150°C with no significant difference (p>0.05) while the lowest oil content is for the substrate before refrying with no significant difference (p>0.05)

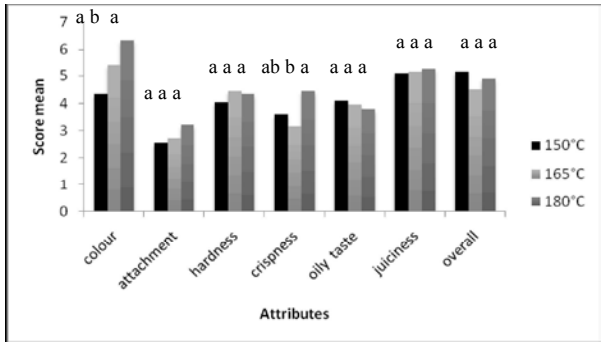

Fig. 6: Mean Value (n=7) Intensity Score for the Result of the Sensory Evaluation of Coated Fried Chicken Nuggets with Wheat Coating; Note: [a-b]The same alphabet at the same histogram group shows there is no significant difference (p>0.05)

except for the rice coating where there is a significant difference (p>0.05) between the oil content for both temperatures. For substrate, the higher the moisture content in the substrate, the lower the quantity of the oil absorption. This is because the quantity of the frying oil absorbed in the food is related to the moisture content. According to [9] pores formed in the food because of the water vaporization from the food while frying cause the oil to be absorbed into the food. The decrease of the oil content at a high temperature is influenced by the changes of the food structure. High heat grant on the food that contained protein component caused a stronger traction of its hydrophobic bond. Even though the process caused a faster contraction at the surface level and further accelerated the oil absorption, but the chicken nuggets chemical ingredient characteristics slowed the water release to the surface. Thus, the percentage of oil absorption in the internal part of the chicken nuggets is decreased.

Overall, it could be concluded that the higher the temperature, the lower the oil content for the substrate with all the three types of coating which are wheat, rice and sago. The oil content of this study is directly proportional with the production of moisture for the coated chicken nuggets.

Sensory Evaluation: In this study, sensory evaluation was conducted using the scoring test. Scoring is an important method in producing new products, quality control and stability test during storage. It can be used to evaluate one or more samples [4].

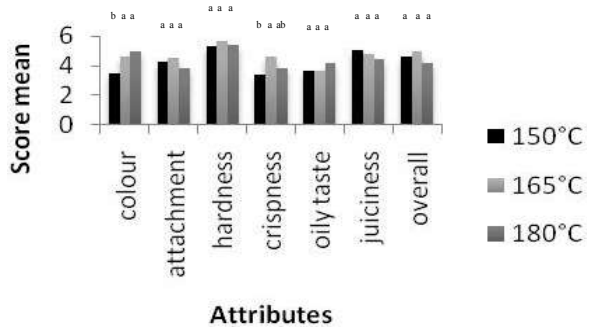

Fig. 7: Mean Value (n=7) Intensity Score for the Result of the Sensory Evaluation of Coated Fried Chicken Nuggets with Rice Coating
Note: [a-b]The same alphabet at the same histogram group shows there is no significant difference ($p>0.05$)

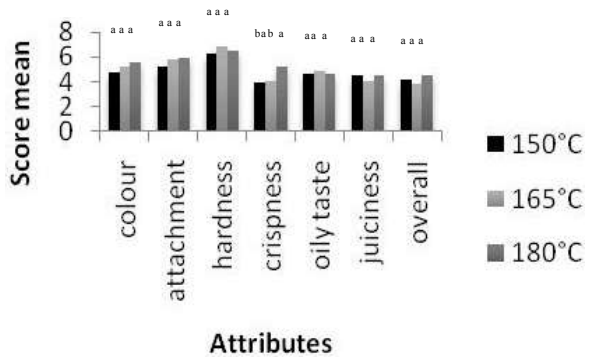

Fig. 8: Mean Value (n=7) Intensity Score for the Result of the Sensory Evaluation of Coated Fried Chicken Nuggets with Sago Coating
Note: [a-b]The same alphabet at the same histogram group shows there is no significant difference ($p>0.05$)

There are seven attributes evaluated in this scoring test which are the coating colour, coating attachment, hardness, crispness, oily, juiciness and overall acceptance. Mean value (n=7) intensity score for the sensory evaluation result of the wheat, rice and sago coated fried chicken nuggets each is shown in Figure 6-8.

The level of acceptance of coated product depended on the coating characteristics such as the general appearance, colour, batter texture and crispness [10]. There is no significant difference ($p>0.05$) achieved for all the attributes evaluated except for the coating colour attribute and crispness for the refrying temperature for the same batter coating.

For the wheat coating colour, there is a significant difference ($p<0.05$) among the three frying temperatures which are 150,165 and 180°C. The highest mean value is given to 180°C temperature followed by 165 and 150°C. The result of the same mean value is also observed for rice and sago coating colour. This may be due to the same refrying time which is seven minutes, the 180°C temperature provide an even more attractive and satisfying coating colour for the panel members making the evaluation. According to [11] the increase in the frying temperature directly influenced the colour of the coated fried food to a darker colour. This concurs with the result of the study conducted where the coating of the coated fried chicken nuggets which are given the highest temperature treatment (180°C) has the darker colour and golden brown.

At the same time, a darker colour would also give the perception that the sample has been cooked completely compared to the less dark sample. The formation of the food colour is influenced by the heating time and frying temperature as a result of oil absorption while frying, the thickness of the coating and the browning reaction by the components that occur in the food ingredients like sugar and protein source [12]. The colour of the cooked food is influenced by the ingredients composition, cooking method, coating medium and the oil used [13].

For the crispness attribute, chicken nuggets with the wheat coating for 180°C has the higher mean score than 165°C with a significant difference ($p<0.05$) while the chicken nuggets with rice coating has a significant difference ($p<0.05$) for 150 and 165°C where the mean score for crispness is higher for 165°C compared to 150°C. The chicken nuggets with the sago coating gives a significant difference ($p<0.05$) at 150 and 180°C where the mean score for the 180°C is higher than the 150°C.

Overall, it is observed that the highest mean score value is achieved for 165 and 180°C while the lowest is 150°C. In other words, the crispness of coated chicken nuggets that are fried at a high temperature is higher compared to the ones that are fried at a lower temperature based on the evaluation of the majority of the panel members. This is because, water evaporation occur during the frying process and is increased with the temperature increase. This resulted in the accelerated formation of the crust [5].

For the coating attachment, different refrying temperature does not give any significant impact ($p>0.05$) for all types of coating. The highest mean score is given for 180 and 165°C compared to 150°C. Generally, coating attachment is influenced by the viscosity and increased when the dilution is low. Apart from that, there is no significant difference ($p>0.05$) found for the hardness, oily taste and juiciness attributes.

The reduction of moisture loss could increase the juiciness of the product [14]. The result of the analysis found that the higher the refrying temperature used, the higher the moisture content in the chicken nuggets substrate and this will further increase the juiciness.

Overall, based on the achieved mean score, the majority of the panel members chose the chicken nuggets sample with the frying temperature of 150°C for the wheat coating, 165°C for the rice coating and 180°C for the sago coating for the attributes of overall acceptance with no significant difference ($p>0.05$).

CONCLUSION

The moisture content for the chicken nuggets coating is the highest before the refrying and the lowest at refrying temperature of 180°C. For the wheat coating, there is a significant difference ($p<0.05$) for coating moisture content before refrying and coating refrying temperature of 180°C. For the rice coating, there is no significant difference ($p>0.05$) for the four temperature treatments while for the sago coating, there is a significant difference ($p<0.05$) for the moisture content before refrying and coating for the three refrying temperatures. The moisture content for chicken nuggets substrate is the highest for the substrate before refrying. For the refrying temperature, the increase of temperature produced the increase in moisture content in the substrate with no significant difference ($p>0.05$). There is a significant difference ($p<0.05$) for the substrate moisture content before refrying and the three temperatures for the wheat batter, at 150 and 165°C for the rice batter and 150°C for the sago batter.

The oil content for wheat and sago coating increased when the refrying temperature increased with no significant difference ($p>0.05$) while there is a significant difference ($p<0.05$) for the rice coating. The oil content for the substrate decreased when the frying temperature increased with no significant difference ($p>0.05$) for the wheat and sago coating while there is a significant difference ($p<0.05$) for the rice coating. The oil content for the coating and substrate before refrying is much lower compared to the oil content at the three refrying temperatures (150, 165, 180°C).

For the sensory evaluation, there is no significant difference ($p>0.05$) found for all the attributes evaluated for all samples except the attributes of the coating colour and crispness. The frying temperature did not give any significant difference ($p>0.05$) on the overall acceptance during refrying.

For further research it is highly recommended that researchers should study and analyze on heat and substance transfer during the phase change in food system by conducting moving boundary analysis (MBA) studies during the thawing process, drying and frying so that the quality of the food product produced could be increased.

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