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Research Article

Quality Evaluation of Extruded Rice Snack

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ABSTRACT

Rice is one of the most commonly utilized components in extruded snacks and cereals because of its wide availability and exceptional expansion capabilities. Along with rice exports, there are many opportunities for the worldwide market in the diversification of value-added products (processed rice products). Therefore, the quality evaluation of extruded rice cereal is important to be studied. Extruded rice snack processing was conducted with CAR 11 rice type as raw material with amylose content of 40% by using a twin-screw extruder that had feed moisture of 18% with seven extrusion conditions: Zone 9 (100°C, 110°C, 125°C, 125°C, 125°C, 140°C and 140°C), die zone temperature (110°C, 110°C, 110°C, 125°C, 140°C and 140°C) and screw speed (200 rpm, 300 rpm and 400 rpm). After extrusion, the physicochemical of final extruded rice cereal was performed such as moisture content, water activity, pH, color of L* value, Water Absorption Index (WAI), Water Solubility Index (WSI), hardness and crispiness values of extruded rice cereal were (3.03% to 5.76%), (0.142 to 0.216 ± 0.002), (6.57 to 6.65 ± 0.06), (76.38 ± 0.32 to 86.55 ± 0.32), (6.30N ± 0.16 to 7.20N ± 0.18), (23.11 ± 3.39 to 41.23 ± 0.36), (18.67 ± 0.24 to 38.93 ± 1.51), (18.2 ± 1.22 to 27.9 ± 1.37), respectively. The results obtained showed an increase in temperature, decrease in moisture content and color of L*, increase in WAI, WSI and hardness. On the other hand, increasing screw speed lead to decreasing in WAI, crispiness and the color of the L* value but increasing in the texture of hardness. To conclude, the extrusion processing by a twin-screw extruder has a slight effect on the physicochemical quality of extruded rice snacks. In condition, extrusion condition C3 (zone 10 at 110°C and a die zone at 125°C with a 200 rpm screw speed) provides extruded rice cereal of good quality and characteristic, with moisture content of 4.45%, water activity 0.173 ± 0.007, color of L* 80.75 ± 0.07, WAI 6.58 ± 0.33, WSI 23.11 ± 3.39, higher in crispiness 27.9 ± 1.37, also sensory evaluation was satisfied with overall 6.98 ± 1.28.

Keywords: Extrusion; Quality evaluation; Rice snack; Food quality; Water absorption index; Water solubility index

INTRODUCTION

Rice production is so vital to Asian societies that the word for rice in one Asian language often also refers to the dish itself [1]. In Cambodia, it is approximately cultivated on 85% of the total land [2]. Rice produced up to 10.8 million metric tons in 2018, accounting for over half of the country's agricultural GDP [3]. It is a main food source for the Cambodian population, served for primary meals, snacks and desserts. All of these products are well-known and widely used in Cambodia [4]. They are made from the Indica rice variety [5], such as Raing Chey, CAR4, Phkar Romdoul, Chul'sa, IR66 and CAR11 which is suitable for the production of rice-based products due to its high amylose content which are range from 22.2 to 40 [6]. However, all of these products were produced using the traditional method, which resulted in limited production and product quality. Several studies have been conducted to increase the quality and quantity of rice-based products in order to develop them. Because of a lack of research on the quality and shelf life of one of the rice-based products, rice snack or rice cereal. As can be seen, breakfast in Cambodia consists of food and rice. To accommodate their new lifestyle, which is quick and consumes

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adequate nourishment as well, we would prefer to substitute their typical breakfast with rice cereal. Since it is also a new product in Cambodia, rice snack was chosen for the study. Thus, it is important to brush up on some characteristics, such as the physicochemical properties of rice cereal and also evaluate its quality and taste through sensory evaluation. Therefore, the aims of the current study to evaluate on physical and chemical of extruded rice snack on seven extrusion conditions. There are two specific objectives: (1) To analyze the physical and chemical quality of extruded rice snack on seven parameters: Moisture content, water activity, pH, color, water absorption index, water solubility index and texture analysis (Hardness and crispiness) and (2) To conduct a sensory evaluation on the texture of extruded rice cereal using a hedonic test on 50 untrained panelists.

MATERIALS AND METHODS

Raw material preparation

White rice called CAR11 was the raw material use in this study. The rice samples were transformed to rice flour by using fine grinder. Then, the amylose content analysis of rice was conducted. The reagents were Potassium Iodide (KI), Iodine (I_2), Sodium hydroxide (NaOH), ethanol 95% and acetic acid. The equipment used for analyze amylose experiment such as hot plate, volumetric flasks and spectrophotometer. Soon after, the extruded rice cereal processing started, equipment used such as twin-screw extruder. After get the finished product for all condition, the physicochemical parameter were analyze, the equipment used such as pH meter for analyze pH of rice cereal, chroma meter for color parameter, water activity meter for water activity, hot air oven which were used to analyze moisture content, WAI and WSI, texture analyzer to analyze rice cereal texture such as hardness and crispiness parameter. Last but not least, centrifuge used to analyze WAI and WSI.

Rice samples that is consider for rice cereal extrusion called CAR11. To prepare the rice sample as raw material for extrusion process, the CAR11 is grinding by using fine grinder with 1.66 mm sieve.

Processing of extruded rice snack

The extruded rice cereal was produced by TSE 24 MC Twin-Screw extruder. The die of 2.98 mm diameter was used. Tap water was fed into the first barrel section of the extruder to maintain a feed moisture content of 18%. This experiment was conducted with seven conditions which are C1, C2, C3, C4, C5, C6 and C7 by using three different screw speeds which are 200 rpm, 300 rpm and 400 rpm. The temperature profile of the seven conditions from zone 2 to zone 9 was the same which are 40, 40, 40, 50, 60, 70, 80 and 90 degree Celsius but the difference is in the zone 10 and die temperature. The zone 10 temperatures of screw speed 200 rpm were 110 and 125 and die temperatures were 125 and 125 degree Celsius. While zone 10 of screw speed 300 rpm has 3 conditions which are 100, 110 and 140 degree Celsius, die zone temperatures were 110, 110 and 140 degree Celsius. However, the zone 10 temperature of screw speed 400 rpm were 125 and 140 degree Celsius, die zone temperature was 125 and 140 degree celsius. After that, the extruded rice cereal was cut and dried in the air oven at 105 degree celsius for 20 minutes. Soon after, put it in the microwave with 1000 wavelength for 20 second.

Physico-chemical analysis

pH and titratable acidity: Five grams of the samples were weighed and mixed with 45 ml of distilled water in the Erlenmeyer flask 100 ml and were homogenized. Afterward, the pH of the solution was analyzed by a pH-meter (LAQUA F-72-HORIBA), as expressed in AOAC Official Method 981.12. Nevertheless, titratable acidity was analyzed by using the titration method, as described in AOAC Official Method 942.15 [7].

Moisture content: Two grams of small pieces of samples were weighed in a dried aluminum capsule and placed in an oven for drying (model UM300) at 105°C for 3 h, as reported in AOAC Official Method 925.10. The moisture content was calculated as the following equation.

$$\%MC=(W_2-(W_3-W_1)/W_2) \times 100 \quad (1)$$

Where:

%MC=Percentage of moisture content

W_1=Weight of the wet sample (g)

W_2=Weight of sample and aluminum before drying (g)

W_3=Weight of sample and aluminum after drying (g)

Water activity (a_w): Two grams of the samples were chopped into small pieces and weighed. The water activity was determined by using a water activity meter (AQUALAB 4TEV) in the ambient temperature, as described in AOAC Official Method 978.18.

Color measurement: The color of the samples was measured by using a portable colorimeter (Chroma CR400, Tokyo, Japan). The parameters were expressed in L* value (black to lightness), a* (- is greenness and + is redness) and b* (- is blueness and + is yellowness), which were recorded using a D65 illuminant (daylight, 65℃ light angle) on the color scale of fresh rice vermicelli [8].

Water Solubility Index (WSI) and Water Absorption Index (WAI): According to the methods outlined by Anderson et al.[9], the Water Absorption Index (WAI) and Water Solubility Index (WSI) were determined. For each sample, evaluation was carried out in triplicate and included. Extrudates were grounded so they could go through 30 mesh sieves. 2.5 g of the ground extrudate was suspended in 25 ml of water for 30 minutes at room temperature with steady stirring and then it was centrifuged at 3,000 g for 15 minutes. A known-weight aluminum dish was used to decant the supernatant, which was then dried at 105°C in a circulation or renewed forced air oven until it reached a constant weight. The tube containing the leftovers was also weighed.

WSI stands for the weight of dry solids in the supernatant stated as a percentage of the sample's original weight and WAI stands for the weight of residue left behind after the supernatant has

been removed per unit weight of the original dry solids minus the mass of supernatant evaporation residue and given as:

WAI=MR/(MS-MER) (2)

Where, WAI=Water Absorption Index

MR=Mass of the centrifuge Residue (g)

MS=Sample Mass (dry basis) (g)

MER=Mass of the supernatant Evaporation Residue (g).

WSI=MER/MS × 100 (3)

Where, WAI=Water Absorption Index

MER=Mass of the supernatant Evaporation Residue (g)

MS=Sample Mass (dry basis) (g)

All the seven-condition performed WAI and WSI in triplicated.

Texture analyzing

A texture analyzer (TA-XT plus C, stable micro systems) and compression plate were used to determine the extrudate's mechanical qualities (hardness). The trigger force for the compression tests was 25 grams, the test speed was 2 mm/sec, the post-test speed was 10 mm/sec and the load cell was 5 kg. Using a Warner-Bratzler blade probe, an extrudate sample was compressed. A force-versus-distance curve was produced by the compression. The greatest peak force needed to break a sample is used as a measure of hardness, the higher the value, the harder the sample or the greater the resistance to breaking at a spot. To measure the crispiness, the peak of the hardness was count from the first the knife touches the sample until it completely cut. All of the experiment was conduct in 10 replicated.

Sensory evaluation

The sensory evaluation was performed by using affective test. In this sensory assessment, the seven different samples were prepared with seven different code which were 258 for first sample, 115 for second sample, 479 for third sample, 658 for the fourth sample, 309 for the fifth sample, 582 for the sixth sample and 818 for the seventh sample. The 50 untrained panelists were participated in this sensory evaluation. All of the panelists were students who studied at Institute of Technology of Cambodia. Evaluation of sensory properties in terms of hardness, crispiness and overall acceptability were carried out by using a 9 point Hedonic scale, where 9=extremely like and 1=extremely dislike. Evaluations of hardness, crispiness and overall; acceptability were performed under a quiet and well lighted room.

Statistical analysis

All data obtained in this research were expressed as mean values ± Standard Deviation (STD). One-way Analysis of Variance (ANOVA) was performed by using SPSS software and Duncan's multiple range test was used to determine significant differences between mean values among the treatments at a significance level of 95% ($p<0.05$). Each sample was repeated in triplicate at different locals. Meanwhile, the colony number was changed into a logarithm colony forming unit per gram (log CFU/g).

RESULTS AND DISCUSSION

pH and titratable acidity

Instant extrudate rice cereal's pH might change based on the brand and the particular ingredients utilized during production. The kind of rice used to make the extruded rice cereal is one of the major variables. The pH of the finished product can vary depending on the type of rice used because different types have varied pH values. According to the Figure 1. The result show that the pH value of the extrudate rice cereal were range from 6.57 to 6.65 which were not significant difference with P value>0.05. As can be seen in the Figure 1 shown that the condition C3, C4, C5, C6 with pH value 6.58 ± 0.014, 6.58 ± 0.014, 6.57 ± and 6.62 ± 0.014 which were not significant different (P>0.05). Similarly, the highest pH value in condition C7 (6.65 ± 0) when compare to condition C2 (6.64 ± 0.01) and C6 (6.62 ± 0.01).

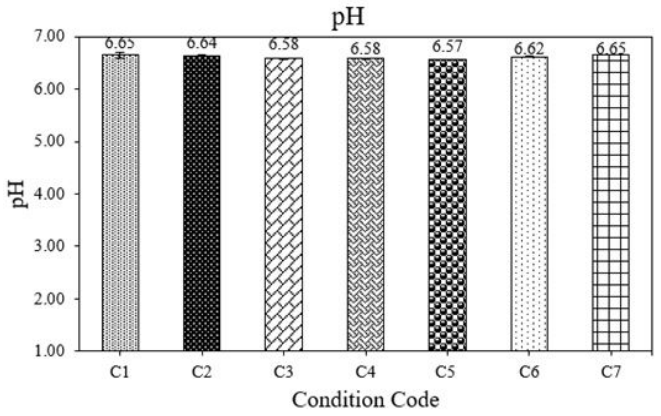

Figure 1: pH of extrudate cereal in different condition.

Moisture content

One of the most important parameters in the processing of food is the moisture content. For components and goods to remain stable and have a long shelf life, moisture is crucial. For shelf stability and safety, low moisture in expanded products is desired. In Figure 2 demonstrated that the extrudate rice cereal have moisture content range from 3.03% to 5.76%. Following Kince et al. revealed that the extrudate rice cereal have content of moisture range from 2.54% to 10.66% [10].

When the feed moisture was 18%, the screw speed was 300 rpm, the extrusion temperature zone 10 was 100°C and the die was 110°C, the maximum moisture content was obtained at 5.76%. On the other hand, the minimum moisture content at 3.03% was obtained when the feed moisture was 18%, the screw speed was 400 rpm, the extrusion temperature zone 10 was 140°C and the die was 140°C. Figure 2 further shows that the moisture content of the extrudates was low at higher extrusion temperatures. This is a result of moisture evaporating more enhanced at higher temperatures. The moisture content of the

extrudates was decreased as the screw speed was increased. A high screw speed may increase the evaporation of moisture by heating the screw through friction. Boakye et al., obtained similar findings on the influence of screw speed and extrusion temperature on the moisture content of extrudates [11].

The second condition used the same screw speed of 300 rmp and extrusion temperature at the die zone of 110C. However, raising the temperature of zone 10 to 110°C caused the moisture content of the extrudate rice cereal to drop to 4.63% ± 0.01 as a result of the higher zone 10 temperature. However, in the third scenario, the die zone extrusion temperature is raised to 125°C while the screw speed is lowered to 200 rpm. The impact of the die zone temperature led to a modest drop in the moisture content of extrudate rice cereal.

Comparing the variations between the fourth and fifth conditions, the sixth and seventh conditions, which share the same extrusion temperature zone 10 (125, 140°C) and die temperature (125, 140°C), but have various screw speeds (200 and 400 rpm, 400 and 300 rpm), respectively. The results indicate that the moisture in the fifth condition (3.26% ± 0.007) declined more than that in the fourth condition (4.02% ± 0.0003) and that the moisture in the extrudate cereal in the sixth condition (3.03% ± 0.00) reduced noticeably more than that in the seventh condition (3.05% ± 0.001). Due to the screw speed's mixing impact and the higher rate of water evaporation, it is possible. The moisture content of all the seven condition show a significant different (P<0.05).

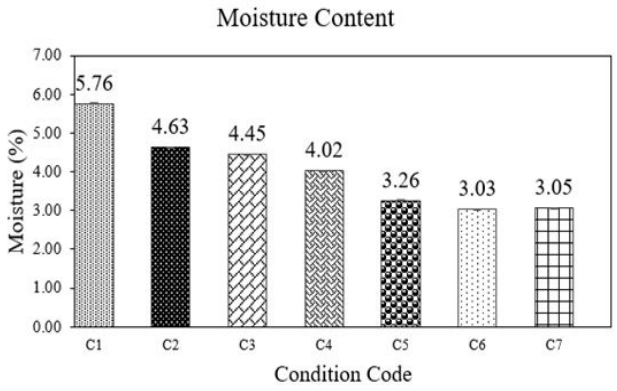

Figure 2: Moisture content of extrudate rice cereal.

Water activity (a_w)

A water activity determination was performed to estimate accessible water in foods. Water activity will anticipate the growth of unwanted bacteria, indicate potential food dangers, govern packaging requirements and influence food packaging standards [12]. It was also water-dependent due to variations in water binding, dissociation, solubility of solutes in water or matrix state. Temperature alters water activity [13]. Figure 3 indicates that the resultant water activity of extrudate rice cereals ranged from 0.142 to 0.216 ± 0.002, which was a statistically significant difference with a P value less than 0.05. According to Kinc et al., the water activity of the ready-to-eat cereals ranged from 0.108 to 0.494.

As can be seen in Figure 3, among the 7 condition samples, the maximum amount of water activity was in condition C1 (0.216 ± 0.002). The reason that it has high water activity among the sample is probably due to its low temperature in the die zone of 110 degrees Celsius and low screw speed of 300 rpm. And the minimum amount of water activity was in condition C6 (0.142) due to the high temperature in its die zone and also the high screw speed of 400 rmp since water activity is temperature dependent. On the other hand, among all 7 conditions, there was no significant difference (P>0.05), which was condition C6 (0.142 ± 0.005) compared to condition C7 (0.142).

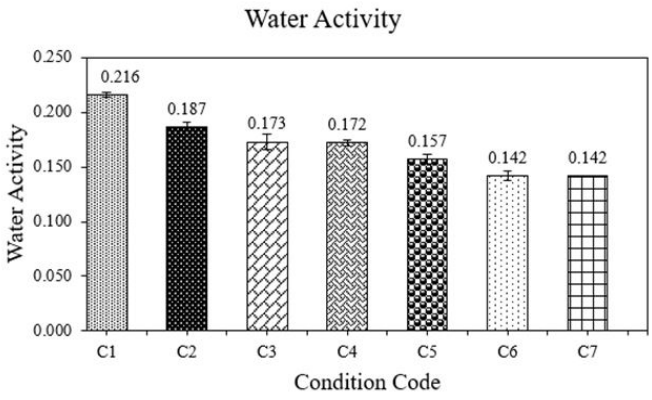

Figure 3: Water activity of extruded rice cereal.

Color of L* values

Color is an important factor of product quality that is directly tied to consumer acceptance of food products and is an important characteristic to note for extruded products. The color of the extrudate is influenced by a variety of processes that take place during extrusion. Browning without enzymes is the most frequent reaction. The formation of the colored compound, which affects the appearance of the extruded product, is the non-enzymatic browning reaction's most important property [14]. The product's lightness was significantly impacted by the high-temperature extrusion. The L* value is affected by moisture content in addition to temperature. As the temperature enhances the rate of the browning reaction, the severity of thermal treatment has a noticeable impact on the product's color. As can be seen in Figure 4, the result indicated that the color of L* (lightness) values of extruded rice cereal ranged from (76.38 ± 0.32 to 86.55 ± 0.32), which is a significant difference (P<0.05). The highest value of L* of the samples was found in condition C1 when compared to the lowest recorded in condition C7 (P<0.05). However, among the seven conditions, there are two that have no significant difference (P>0.05). C3 (8.75 ± 0.07) and C4 (79.84 ± 0.25). Following Choton et al., the lightness (L*) value of extrudates ranged from 51.37 to 72, which was lower than our conditional sample study.

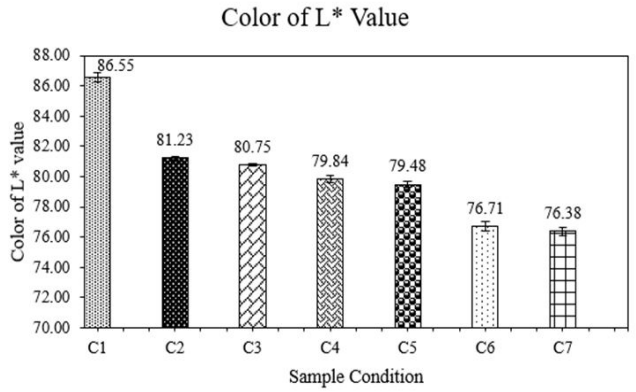

Figure 4: The color of L* value of extruded rice cereal.

Water absorption index and water solubility index

Water absorption index: Water absorption and water solubility are the key functional characteristics of extruded starches when they are dispersed in an excess of water. Extruded starch absorbs water quickly to produce a paste or gel at room temperature, but native starch does not absorb water at room temperature and has almost little viscosity. Because only damaged starch granules absorb water at room temperature and swell, WAI corresponds strongly with cold-paste viscosity. An important factor in the production of breakfast cereals and snacks is a high WAI, an *in vitro* indicates of better starch digestibility.

As can be seen in the Figure 4 illustrated that the WAI of the extruded rice cereal was ranged from 6.30 ± 0.16 to 7.20 ± 0.18, which were significant difference($P<0.05$). According to [15], reported that the WAI of extruded snack varied ranging from 3.65 to 4.78, which were lower than WAI found in our study. According to Choton et al., the WAI decreased as the screw speed was increased. As can be seen in Figure 5, the highest WAI of extruded rice cereal was recorded in condition C4 which is use screw speed in 200 rpm while the lowest WAI of extruded rice cereal was marked in condition C6 which was use the high speed of screw (400 rpm). Singh and Muthukumarappan [16] and Singha et al. [17], were previously studied a decrease in WAI with an increase in screw speed.

According to Yousf et al., [18], reported that the increasing of barrel temperature, it also causes the increase of WAI. At this point if condition C1 compared to condition C7 which had the same speed of screw (300 rmp) but difference die temperature (110 degree celsius, 140-degree celsius) respectively, it shown that the condition C7 (7.18 ± 0.00) with high die temperature have higher WAI than condition C1 (6.65 ± 0.23) which had low die temperature.

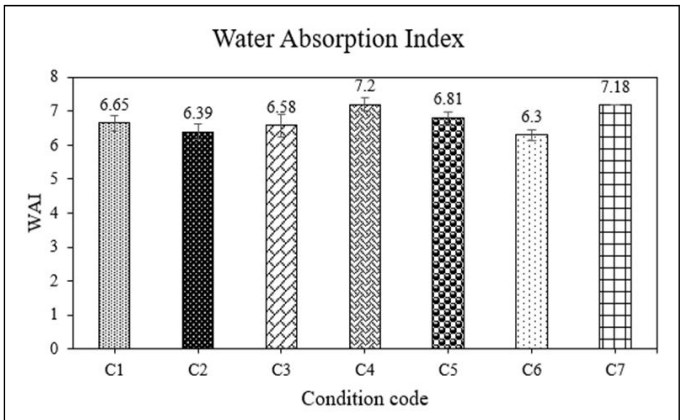

Figure 5: Water absorption index of extrudate rice cereal.

Water solubility index: WSI is frequently used as a measure of the degree of breakdown in macromolecules during extrusion, including fiber and starch granules. It is usually used as an indicator of how many soluble substances have been released from the material's starch component after extrusion. Since breakfast cereals are typically served with liquid milk or water, having a high WSI or being overly soluble in the liquid medium is undesirable.

As can be seen in the Figure 6, the resulted shown that the WSI was ranged from 23.11 ± 3.39 to 41.23 ± 0.36, which were significance difference ($P<0.05$). According to said that the WSI of extruded snack were ranged from 15.91 to 38.98, which were lower than our study. The high speed of the screw increased water solubility, according to Boakye et al. If taking a glance to the bar chart show that the maximum of WSI was record in condition C6 (41.23 ± 0.36) with high screw speed (400 rpm) and minimum were marked in condition C3 (23.11 ± 3.39) with low screw speed (200 rpm). In addition, higher temperatures cause starch to break down into smaller molecular weight fractions with higher solubility, which raises the WSI. At this point, if compare between condition C1 (26.60 ± 0.16) and C7 (35.99 ± 0.55) which had the same screw speed but difference die temperature, it shown that the condition with high temperature had high WSI.

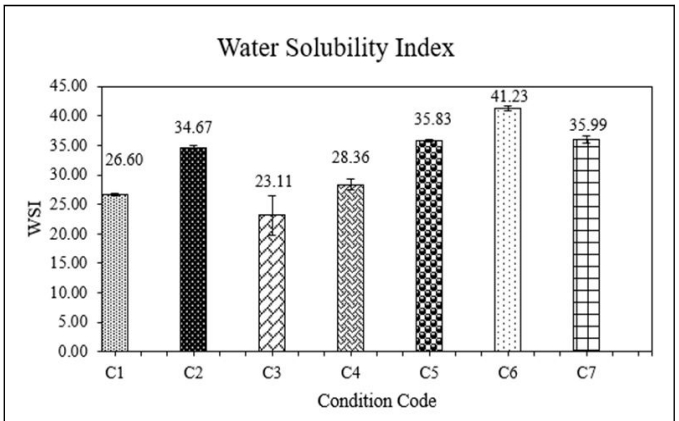

Figure 6: Water solubility index of extrudate rice cereal.

Texture analyzing

Hardness: In a texture analyzer, hardness is the force that is required to compress food between the tongue and palate to a given deformation or to penetration [19].

According to Cuj-Laines et al., [20], the extruded snack texture of hard ranged from 16.63 N to 58.29 N. As can be seen in Figure 7 indicated that the hardness texture of extruded rice cereal was in the range that had mentioned above (18.67 N ± 0.24 to 38.93 N ± 1.51) which were significantly different P values of less than 0.05. The maximum hardness (38.93 N ± 1.51) was obtained at 400 rpm screw speed, 140°C zone 10, 140°C die temperature and 18% feed moisture content. The minimum hardness (18.67 N ± 0.24) was obtained at 300 rpm screw speed, 100°C zone 10, 110°C die temperature and 18% feed moisture content. Lower hardness is a favorable property for extruded products.

According to Alam et al., when the screw speed and die temperature increased, the hardness increased. In Figure 7, Compared the condition C1, C2 and C7 which had the same screw speed but difference zone 10 temperature (100°C, 110°C, 140°C) and die temperature (110°C, 110°C, 140°C), the result indicated that the condition which had the higher temperature had high amount of hardness. If comparing condition C1, C3 and C5 which had difference screw speed and die temperature, the bar chart also indicated that the condition that had higher screw speed and temperature increased the mount of hardness.

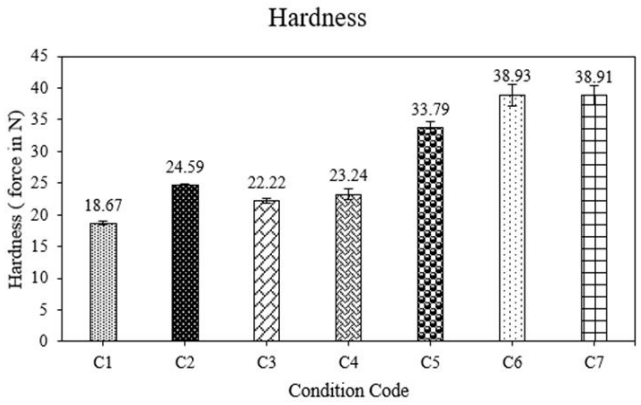

Figure 7: Extruded rice cereal hardness by texture analyzer.

Crispiness: The number of positive peaks during product breaking is known as crispness or crunchiness. The same program that was utilized for the texture analysis was used to count the positive peaks or assess sharpness. A macro section was marked to count the positive peaks during rupture along the force-time deformation curve in order to quantify the crispness [21].

According to the extruded snack texture of crispiness ranged from 10 to 25. As can be seen in Figure 8 indicated that the crispiness texture of extruded rice cereal was in the range that had mentioned above (18.2 ± 1.22 to 27.9 ± 1.37) which were significantly different (P<0.05). The maximum crispiness (27.9 ± 1.37) was obtained at 200 rpm screw speed, 110°C zone 10, 125°C die temperature and 18% feed moisture content. The minimum crispiness (18.2 ± 1.22) was obtained at 400 rpm screw speed, 140°C zone 10, 140°C die temperature and 18%feed moisture content. High crispiness is a favorable property for extruded products.

Mention the screw speed is the main factor effect on crispiness of the extruded snack. As can be seen in the bar chart, if compared condition (C1, C2, C7) which had the same screw speed of 300 rpm to condition (C3, C4) with speed of screw 200 rpm and the condition (C5, C6) with the screw speed 400 rpm, the result shown that the increased of screw speed decreased the crisp of extruded snack.

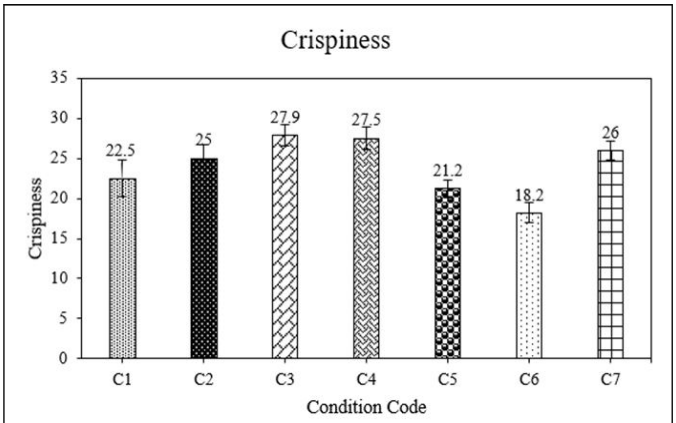

Figure 8: Extruded rice cereal crispiness by texture analyzer.

Sensory evaluation

In Figure 9 illustrates the sensory evaluation of extruded rice cereal under 7 different conditions, such as the first condition with zone 10 at 100°C and the die zone at 110°C with a screw speed of 300 rpm. Second condition with zone 10 at 110°C and a die zone at 110°C with a screw speed of 300 rpm. Third condition with zone 10 at 110°C and a die zone at 125°C with a 200 rpm speed of the screw. The fourth condition is zone 10 at 125°C, die zone at 125°C and screw speed 200 rpm. The fifth condition is zone 10 at 125°C, die zone at 125°C and screw speed 400 rpm. The sixth condition is zone 10 at 140°C, die zone at 140°C and screw speed at 400 rpm. And the seventh condition is zone 10 at 140°C, the die zone at 140°C and a screw speed of 300 rpm by using affective method with untrained panelists. Each descriptor was given a score value based on the score of each condition: Liked extremely=9, like very much=8, like moderately=7, like slightly=6, neither like nor dislike=5, disliked slightly=4, disliked moderately=3, disliked very much=2 and disliked extremely=1. This sensory result was significantly different with (P<0.05) according to one-way ANOVA. The result disclosed that C3 had the highest score of overall acceptability (6.98 ± 1.28) than other conditions, which was 7.27 ± 1.23 for crispiness and 6.27 ± 1.50 for hardness. Chaiyakul et al., [22], said that extrusion under high barrel temperatures decreased hardness and crispiness. As can be seen in the figure indicated that the low hardness and crispiness was in condition C6 which was under high barrel temperature (140°C).

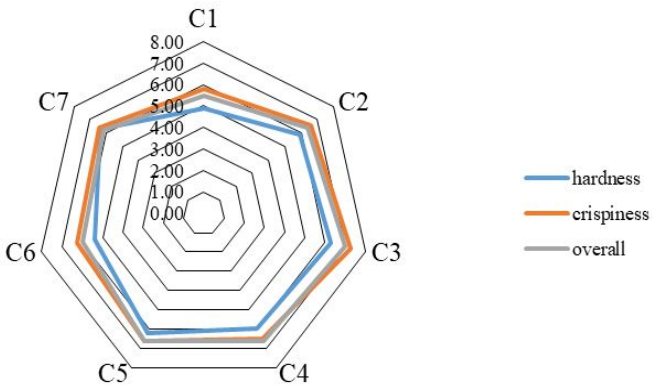

Figure 9: The spider graph of sensory evaluation of extruded rice cereal.

CONCLUSION

To conclude, this study aims to study the effect of the extrusion process on the physicochemical quality of extruded rice cereal. Car 11 was the type of rice that was chosen as a raw material because of it has a high amylose content (40%). The extruded rice cereal was processed with 18% feed moisture. The experiment was conducted with seven conditions. Based on the results obtained, the condition that had a higher barrel temperature decreased the moisture content and water activity. According to the result, the higher barrel temperature and screw speed decrease the color of the L* value. The higher screw speed and barrel temperature decreased the water absorption index and the higher temperature barrel increased the water solubility index. As can be seen from the texture analyzer, higher barrel temperatures and screw speeds increased the texture of hardness, while higher screw speeds decreased the texture of crispiness. In condition C3 (zone 10 at 110°C and a die zone at 125°C with a 200 rpm speed of the screw) provide extruded rice cereal a good quality and characteristic, with moisture 4.45, water activity 0.173 ± 0.007, color of L* 80.75 ± 0.07, WAI 6.58 ± 0.33, WSI 23.11 ± 3.39, higher in crispiness 27.9 ± 1.37, also higher in sensory evaluation with overall 6.98 ± 1.28. As recommendation for further study, extruded rice cereal should be chosen rice sample with amylose content range from 22% to 26% to improve it texture (increase crispiness, decrease hardness). For sensory evaluation, color and aroma parameter should be added.

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