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Determining the Effect of Pre-Treatment in Rice Noodle Quality Subjected to Dehydration through Hierarchical Scoring

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Abstract: Fresh rice noodle was usually coated in a large amount of oil to avoid stickiness and extend the shelf life. Pre-treatment has been applied to reduce the quantity of oil in rice noodle. In this research, the pre-treatment and temperature effect on the rice noodle quality subjected to hot air drying, heat pump drying, and freeze drying was investigated. Texture, color, oil content, and starch gelatinization of the dried noodle was further evaluated. Results revealed that there were significant differences ($p < 0.05\%$) in texture, color, oil content, and starch gelatinization in rice noodle subjected to pre-treatment. Furthermore, the texture, color, oil content, and starch gelatinization demonstrated a significant difference ($p < 0.05\%$) in freeze drying rather than hot air drying and heat pump drying. The findings indicate that the qualitative features of the dehydrated noodle are synergistic to pretreatment and drying temperature. Despite superior quality shown by freeze drying, the hierarchical scoring has proven that rice noodle undergoing hot air drying at 30 °C to produce comparable quality attributes. The hierarchical scoring can be a useful tool in quality determination for the food industry.

Keywords: pre-treatment; hot air drying; heat pump drying; freeze drying; quality attributes; hierarchical method

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1. Introduction

Rice noodle is the most consumed type of rice product after plain rice grains in Asia as they are highly nutritious and adhere to food standards. Rice noodle may be eaten either by frying, by combining with meat and green sprouts, or by boiling as a broth of noodle soup. In general, rice flour and water make up its main ingredients. Starch is usually added in rice noodle production to increase the chewy texture before the concentration of the milled rice is adjusted. Normally available fresh either in strips or sheets from the wet market, the noodle is then steeped, spread, steamed, and cut into sheets [1–3].

The fresh rice noodle is usually prepared in Asia in a high volume of oil to avoid stickiness. Oil coating is one of the strategies to extend its shelf life apart from mere illustration purposes due to its shining features [4]. Known as the non-gluten free food, which is always referred to for a healthy food regime, the presence of abundant oil in rice noodle somehow gives contradictory interpretation of such a food product. Thus, pretreatment was initiated to describe the non-oil coated rice noodle by soaking the sample in distilled water for 5 min and rinsed immediately within 2 min [5].

The emergence of the Asia Pacific economy has promoted the demand for good quality noodle products among consumers. Fresh rice noodle of high quality should be uniform and straight strands, with a white and translucent shading, a superior texture with the absence of broken strands, as well as adequate gelatinization [6]. There is a lack of gluten in rice protein; consequently, viscoelastic dough is not used for uninterrupted purposes. Rice flour is thus pre-gelatinized in order to serve as binder for the residual flour. The gelatinization rate is maintained sufficiently during the extrusion to achieve the required binding power [7,8].

Another concern with rice noodle is the high moisture content, which provides convenient medium for the undesirable microbial growth [9,10]. Therefore, rice noodle is subjected to several drying procedures with the aim to inhibit the growth. The influence of drying temperature and pre-treatment is in focus on rice noodle undergoing several drying procedures such as hot air drying, heat pump drying, and freeze drying. However, improper drying could aggravate the quality of noodle, whereby the color and texture could be hugely affected. Thus, hierarchical scoring is implemented in this study to conveniently determine the best noodle quality analysis.

2. Materials and Methods

2.1. Materials

A packet of rice noodle with the common coating of palm oil was purchased from a similar local noodle supplier known as Koperasi JML in Bandar Teknologi Kajang, Selangor, Malaysia (2.9611° N, 101.8187° E). It was purchased fresh on the Wednesday, i.e., the same day the shelves were loaded, to ensure drying can occur instantly before it reaches its expired date. Rice noodle is transparent, creamy in color, greasy, and long-range in size. The measurement of fresh rice noodle is 2 × 1 × 0.15 cm.

2.2. Pre-Treatment

A total of 400 g of fresh rice noodle was taken as original rice noodle, and half was soaked with distilled water in 5 min and rinsed immediately in 2 min.

2.3. Hot Air Drying

Rice noodle was subjected to laboratory-scale hot air oven (20–250 °C, Memmert) with the equipment precision of ±3 °C. The oven was pre-heated at the designated drying conditions for about 30 min to reach steady state. The rice noodle is subjected to the initial drying temperature of 30 °C. The drying diffusion was fixed at a relative humidity at 20.3 to 28.6 ± 1.0% and a velocity of 1.401 ± 0.5 ms^{-1}. The moisture content of the equilibrium (EMC) was measured by increasing the drying phase up to the same level as the drying period, as defined by the constant mass of drying sample observed. This was then replicated at 60 °C and 90 °C at a similar air velocity [11,12]. The temperatures were chosen in reference to the relative humidity as a parallel comparison to heat pump drying.

2.4. Heat Pump Drying

The rice noodle was arranged horizontally on the 0.27 m × 0.23 m wire mesh tray within the drying container, vertical towards the air flow. The dryer consisted of two parallel drying chambers with the size of 0.95 m × 0.33 m × 0.33 m, but only one in the middle section was used for this experiment. The operating temperature was subjected to the ambient conditions and the heater set-up. The drying process fluctuated at 50 °C ± 1.0 as the heater was on, and drying operated at 38 °C as the heater was removed. The relative humidity ranged from 18.2% to 25.2% ± 1.0, and default air flow velocity of heat pump drying was recorded at 4.6 ms^{-1} ± 0.5 [13].

2.5. Freeze Drying

The rice noodle was kept inside a deep chest freezer (Mistral, Khind (M) Sdn Bhd, FZ-220) for several hours around −18 °C. The vacuum pump was turned on for around 30 min. The frozen samples were then subjected to freeze drying. The freeze drying was performed for 24 h under different pressures which were 0.256 kPa (−10 °C) and 0.0120 kPa (−40 °C) for main freeze drying. The final drying was not necessary for rice noodle [14].

2.6. Texture Analysis

The texture of dried rice noodle was individually determined by employing the hardness test which evaluated the highest point that the dried rice noodle would crack, subject to the amount of force [15]. The noodle texture was determined by placing the dried noodle on the plate and was sheared. The texture of dried noodle was measured by texture analyzer (TA-XT, Stable Micro Systems Ltd., Surrey, UK). The analyzer probe used in the study was the Warner Bratzler Blade Set with a rectangular slot blade.

A 3 mm thick blade with a flat cut lower end for friction control was used for the test cell. The blade was sliced in the sample at a constant speed while the blade traveled through the slit (pre-test speed: 2.0 mm s^{-1}; test speed: 2.0 mm s^{-1}; post-test speed: 10.0 mm s^{-1}). The down-stroke interval was 15.0 mm (varies from 25 mm to 35 mm), so that the blade could cut the sample thoroughly). The sample resistance to cutting was observed at each 0.01 s and projected in a graphical plot. The greatest shearing force reflected the top curve point as the maximum shear strength of such sample [16].

2.7. Colour Analysis

The color of fresh rice noodle was analyzed to the dried samples by a colorimeter (Lovibond, LC100/SV100, Tintometer, Dortmund, Germany). The dried rice noodle was analyzed in relation to the spectrum of light–dark, L* (range from 0 to 100), blue–yellow, b* (range from −60 to +60), and green–red, a* (range from −60 to +60) [17]. The color analysis of dried rice noodle was measured with fresh noodle as the initial color measurement. ΔL represented L_o-L*, L_o is for fresh sample, and L* for dried sample, which follows for the respective Δa, and Δb [18]. A total color change, denoted as ΔE, was measured by utilizing this equation:

$$\Delta E = \sqrt{\Delta L^2} + \Delta a^2 + \Delta b^2 \quad (1)$$

2.8. Fat Content Analysis

Next, 10 g of well-grinded dried noodle was placed in a porous thimble and was inserted into the Soxhlet extractor by following standard extraction procedures. By using petroleum ether as the extracting solvent, the process was repeated periodically for about 8 h, after it was assumed that all the fat had been extracted from the sample and present in solution in the flask. The measured weight of the round bottom vessel was used as the fat content found in the initial noodles, relative to the empty flask. The last step was replicated up to the equilibrium [19].

Using W as the sample weight (g) and M as the oil weight (g), the fat content in the sample is calculated in 3 replicates in order to reach accuracy by calculating:

$$= M/W \times 100 \quad (2)$$

2.9. Starch Gelatinization

The starch gelatinization behavior was analyzed via the DSC 4000 System, by Perkin Elmer (100-40 V/50-60 Hz). The system consisted of a single furnace, heat flux DSC, and a CryoFill Liquid Nitrogen Cooling System with the chamber gas of helium and nitrogen. The temperature range of the system was from −100 °C to 450 °C. In the Pyris Manager software, the Method Editor window was entered and the details were filled in accordingly. The method was created by entering the starting and final temperature, i.e., 30 °C to 500 °C, as well as the heating rate at 10 °C/min. The scanning may immediately run prior to switching the gas [20].

2.10. Hierarchical Scoring

The best rice noodle product treatment subjected to several drying procedures was determined by the hierarchical scoring scheme which was usually adopted in sensory evaluation test [21,22]. The hierarchical score was calculated for each quality analysis (texture, color, fat content, and starch gelatinization, and an overall ranking on the basis of the results was provided. The scale values can be found in Table 1.

Table 1. Scale values of hierarchical scoring of rice noodle sample.

Quality Analysis	Scale Values 14 → 1
Texture	Low → High
Colour	High → Low
Fat Content	High → Low
Starch Gelatinization	High → Low

2.11. Statistical Analysis

The results presented were three times more exposed on average to the one-variance (ANOVA) [23]. Minitab's confidence level of 95% of the differences across property ranges was recognized ($p < 0.05$). Difference in means is marked with "a" letter in figures.

3. Results

Figure 1 reveals that the rice noodle undergoing pre-treatment and temperature in its texture analysis was significantly different. Tukey's post-hoc test, as observed with the different letters in the figure, has shown that there is a statistically significant difference ($p < 0.05$) in pre-treatment and temperature to the texture analysis of rice noodle.

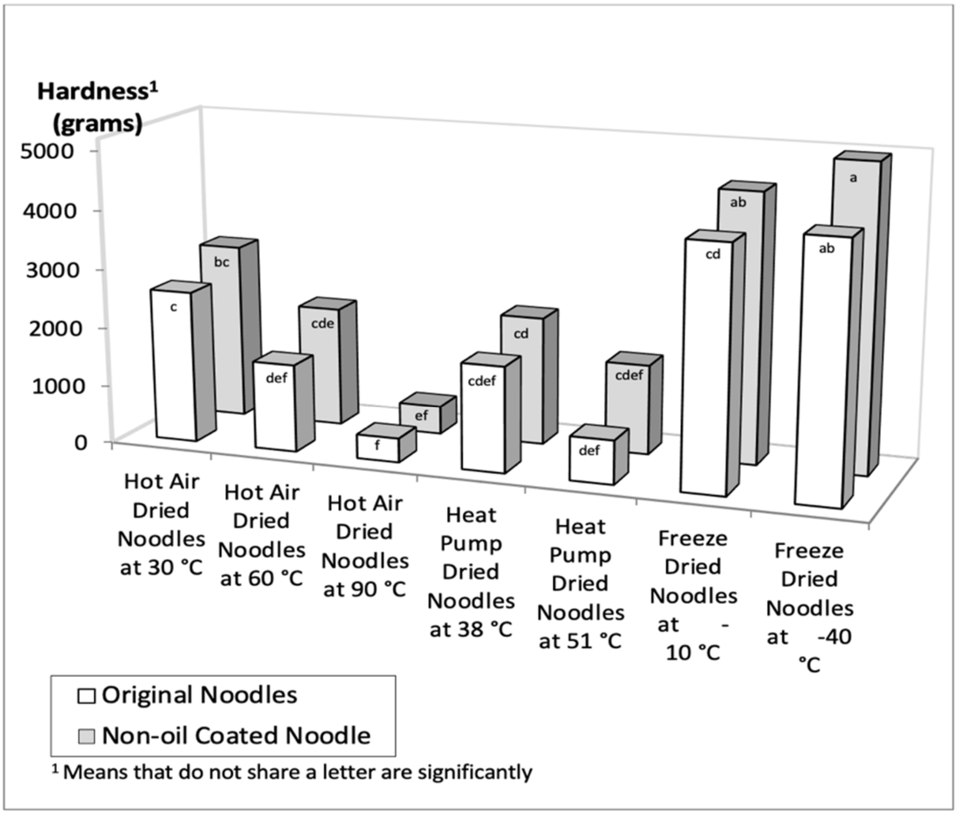


Figure 1. Hardness test of rice noodle at hot air drying (HAD), heat pump drying (HPD) and freeze drying (FD). Means of hardness test that do not share a letter in the figure are significantly different.

Figure 2 presents the fat content of rice noodles under various drying processes. It has shown that there is a statistically significant difference ($p < 0.05$) in pre-treatment and temperature to the fat content analysis of rice noodle. Difference in means of value is indicated with "a" letter in figures.

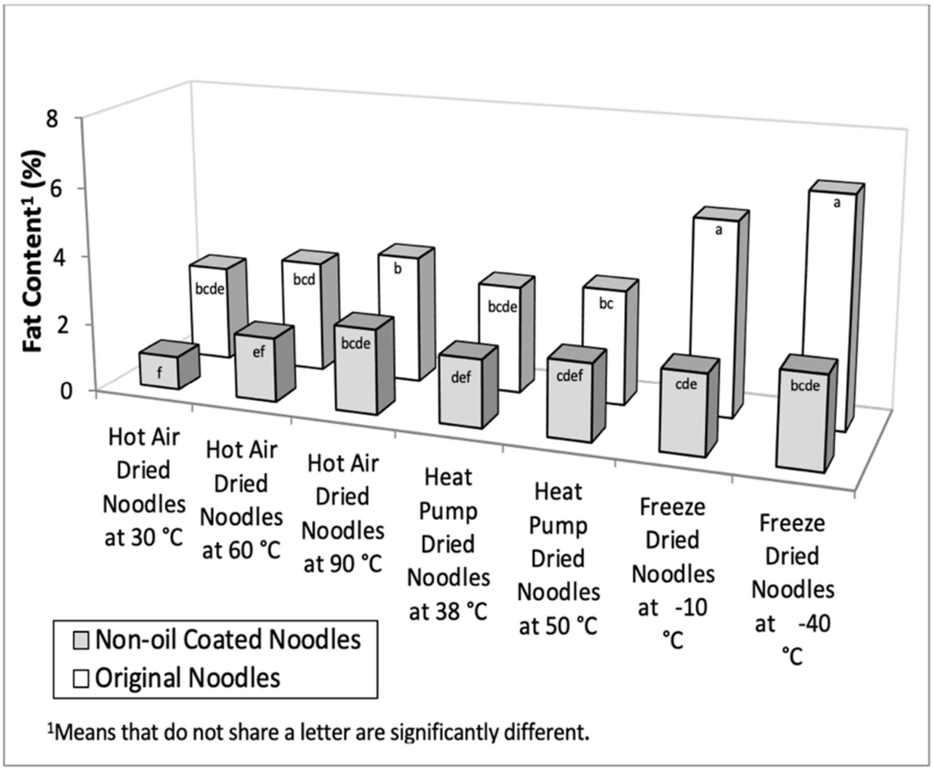
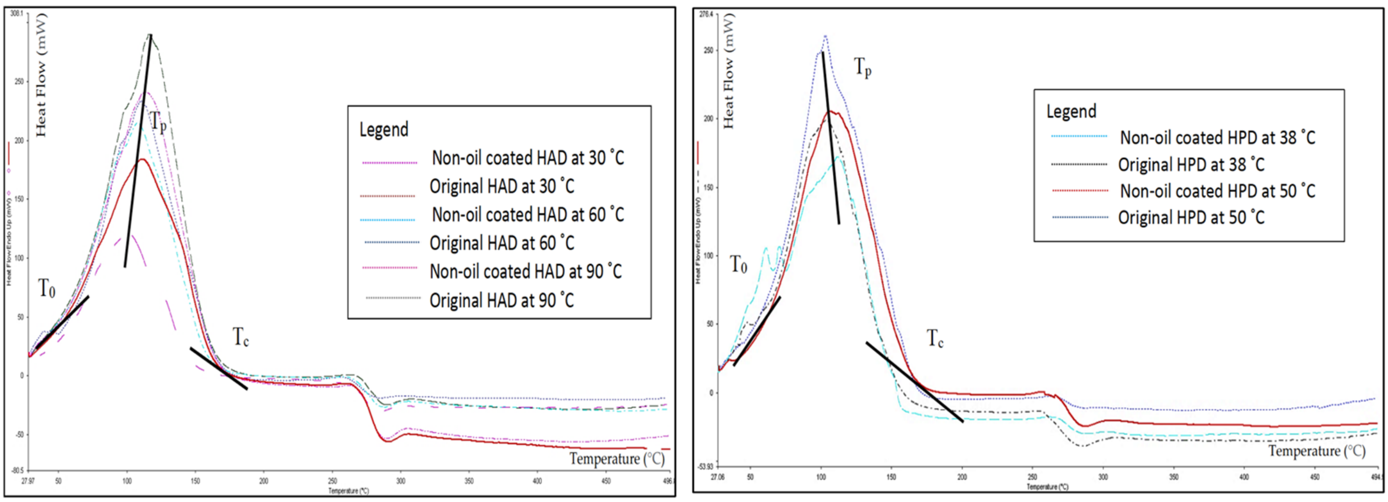


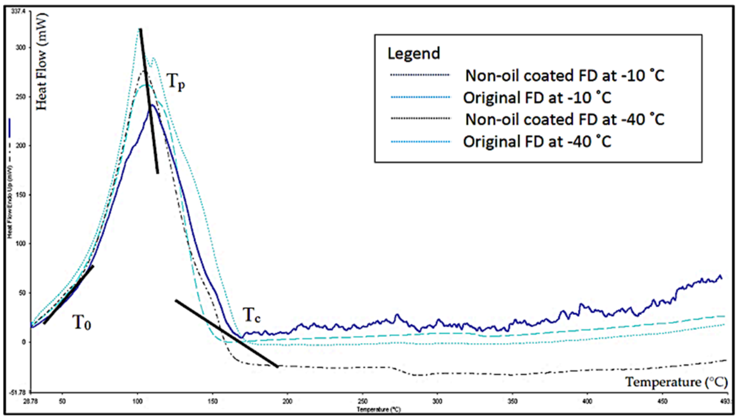
Figure 2. Fat content of rice noodle at hot air drying (HAD), heat pump drying (HPD) and freeze drying (FD). Means of fat content that do not share a letter in the figure are significantly different.

The overall gelatinization process can be described by three temperatures: the start of gelatinization (T_o), a peak temperature (T_p), and when gelatinization ceased (T_c), as shown in the temperature (°C) against heat flow (mW) in Figure 3.



(**a**) (**b**)

Figure 3. *Cont.*



(**c**)

Figure 3. DSC results on starch gelatinization of (**a**) HAD (**b**) HPD and (**c**) FD of rice noodle. The starch gelatinization behaviour can be described by lines of different colours which represented the drying procedures.

4. Discussion

4.1. Effect of Pretreatment, Temperature, and Drying Procedures on Texture

The hardness value for rice noodle subjected to hot air drying at 30 °C was at 2997.6 ± 491.1 g for non-oil coated sample and at 2591.6 ± 529.8 for the original sample. A higher hardness value of 2187.2 ± 155.5 g was recorded for the non-oil coated sample, and 1806.3 ± 230.0 g was observed with rice noodle subjected to heat pump drying at 38 °C.

The non-oil coated rice noodle undergoing freeze drying recorded the higher hardness value of 4572.6 ± 1193.3 g at −10 °C and 4108.9 ± 550.0 g for the original noodle. The trend is consistent throughout drying parameters to indicate that pretreatment recorded harder texture as it registers higher hardness value. This is because pretreatment helped to reduce excessive shrinkage during drying by replacing the removed oil coating during the process [17,24].

In textural analysis, the hardness test defines the level of brittleness of the dried noodle strand to break subjected to a particular extent of force. A higher hardness value describes higher stability of the texture at the point when the sample breaks. A higher hardness value was recorded by the sample undergoing lower drying temperature [25,26]. The sample employed to hot air drying at 30 °C reported a hardness value of 2997.6 ± 491.1 g for non-oil coated sample and 482.5 ± 111.3 g for the same sample at 90 °C.

A higher temperature recorded a lower hardness value which suggests that noodle strand is easily breakable and very fragile. A higher drying temperature lowered the activity of gel formation to cause a weaker gel structure. The excessive temperature can overly dehydrate the solid surface, so that its pores shrink and almost close. Indeed, the compressed noodle surface is due to the high drying speed of the noodle core in hot air drying which occurred simultaneously to the external surface [27–29].

The texture of rice noodle subjected to freeze drying was significantly higher ($p < 0.05$) than other drying parameters at a hardness value of 5069.8 ± 755.6 g at −40 °C. The sub-zero temperature environment as well as long desorption procedure in freeze drying has produced large internal pores. Indeed, such a slow and gentle drying approach gives a uniform drying to create an intact texture. In addition to that, the formation of more open microstructures leads to high porosity which results in the high stability of noodle texture [30,31].

The heat pump drying at 51 °C recorded a smaller hardness value of 1537.1 ± 73.7 g in the dried rice noodle than the parallel relative humidity of hot air drying at 60 °C at 2043.9 ± 543.8 g. The faster air speed in heat pump drying was essentially the reason for this lower hardness value. The circulating heat pump kept the temperature low by condensing air to cause rapid moisture removal on the noodle surface. The internal moisture was released immediately to the atmosphere giving porous stress to the dried surface in an abrupt manner [15,32].

4.2. Effect of Pretreatment, Temperature, and Drying Methods on Colour

The color variations in the rice noodle under different drying procedures are presented in Table 2 whereby the differences were indicated by the letters. Rice noodles undergoing hot air drying at 30 °C have registered a less significant color variation in the non-oil coated sample at 28.367 ± 3.092 and in the original noodle at 35.100 ± 2.307. The drying temperature at 60 °C recorded color changes of 35.900 ± 5.242 for the non-oil coated noodle and 36.767 ± 5.918 for the original noodle. The colour changes were apparent at 43.033 ± 2.307 for the non-oil coated noodle and 43.867 ± 1.498 for the original noodle applied to hot air drying at 90 °C.

Table 2. Colour parameters of rice noodle sample at different drying procedures. Means of total colour change that do not share a letter in the superscripts are significantly different.

Treatment			Total Colour Change, ΔE
Hot Air Drying	30 °C	Non-oil Coated	28.367 ± 3.092 ^{cd}
		Original	35.100 ± 2.307 ^{bc}
	60 °C	Non-oil Coated	35.900 ± 5.242 ^{abc}
		Original	36.767 ± 5.918 ^{abc}
	90 °C	Non-oil Coated	43.033 ± 2.307 ^{ab}
		Original	43.867 ± 1.498 ^{ab}
HPD	38 °C	Non-oil Coated	41.233 ± 4.302 ^{ab}
		Original	42.267 ± 4.912 ^{ab}
	50 °C	Non-oil Coated	43.000 ± 2.821 ^{ab}
		Original	45.667 ± 3.500 ^{a}
Freeze Drying	−10 °C	Non-oil Coated	23.033 ± 1.290 ^{de}
		Original	18.033 ± 3.099 ^{e}
	−40 °C	Non-oil Coated	19.333 ± 1.124 ^{de}
		Original	18.400 ± 1.473 ^{de}

From the results, pre-treatment causes a lower total color change in rice noodle at different drying procedures. Pre-treatment tends to remove all the initial impurities, especially oil, from the sample before the molecules being replaced by distilled water. During the dehydration process, the rice noodle is shrinking together with the pre-treated surface. The dehydrated non-oil coated sample tends to obtain a fairer color with higher saturation to cause a lower total color change than the original rice noodle [33,34].

The respective total color changes (41.243 ± 4.302) and (42.267 ± 5.912) were found for the original noodle and non-oil coated noodle subjected to heat pump drying at 38 °C. The total color change of non-oil coated noodle and the original noodle undergoing heat pump drying at 50°C is 43.000 ± 2.821 and 45.667 ± 3.500, respectively. The overall color change in the noodle sample undergoing heat pump drying is larger than in hot air drying, because of the increased air speed that created a greater disturbance of the sample color.

The total color change of noodle sample applied to hot air drying is at 43.033 ± 2.307 at 90 °C and 35.900 ± 5.242 at 60 °C. Higher temperature increases the respective total color change of the samples to induce enzymatic browning to the products due to the stronger heating effect in the Maillard reaction. However, less discoloration at 30 °C is driven solely by the enzyme activation at warm temperatures which causes a foreign odor formation, particularly when the main drying is very long [35].

In parallel, the increasing temperature of heat pump drying recorded higher total color changes in the samples. Heat pump drying deployed a higher air velocity which eventually degrades the overall food color quality. Higher air speeds are likely to further promote oxidative reactions to the dried sample, owing to the Maillard reaction, and resulting in enzymatic browning. The Maillard reaction was caused by an enzyme-free browning reaction between amino acids and the sugar reduction (starch) in the noodle [18,36,37].

A total color change for rice noodle subjected to freeze drying at −10 °C was observed at 23.033 ± 1.290 for the non-oil coated sample and at 18.033 ± 3.099 for the original sample. Pre-treatment gave a higher total color change in freeze drying which induces more ice deposit during freezing due to soaking process. The connected ice pores formation eventually disturbed the total color difference of freeze-dried noodle to support the highest hardness value recorded by freeze drying [14,38,39].

A total color change for rice noodle subjected to freeze drying at lower temperature was observed at 23.033 ± 1.290 for −10 °C and at 19.333 ± 1.124 for −40 °C. Lower sub-zero temperatures do not induce a browning effect to the noodle which preserves the white color to be closer to the fresh product sample [40]. This slight color change is further enhanced by the slow and gentle desorption process in freeze drying. A lower temperature indicates more gentle moisture removal process through vacuum [11,41].

4.3. Effect of Pretreatment, Temperature, and Drying Methods on Fat Content

The noodle was treated to hot air drying at 30 °C with decreased fat at 0.9800 ± 0.1992% compared to the original noodle at 2.78 ± 1.0096%. Fat content in the noodle primarily depends on the type of raw materials used, specific ingredients, and its processing method. The trend suggested that pre-treatment helps to lower the fat content in rice noodle by removing the oil coating from the noodle surface through soaking, which is in agreement with the results of color attributes [18,42].

Rice noodle is compulsorily coated with palm oil for the purpose of packaging and shelf life. The rice noodle subjected to drying procedures gave a higher fat content because it merely produced concentrated stability of the coated oil particularly on the original noodle [43]. This is because fresh rice noodle is generally low in fats which are then concentrated by the drying process itself [44]. As moisture content was removed during the process, a dehydrated rice noodle was produced with a more concentrated source of calories and nutrients compared to the fresh rice noodle.

Non-oil coated samples undergoing hot air drying recorded a fat value of 0.9800 ± 0.1992% at 30 °C, 1.8833 ± 0.3717% at 60 °C, and 2.4800 ± 0.4900% at 90 °C. Original and non-oil coated samples that were applied to heat pump drying at a temperature of 50 °C extracted higher fat content than at 38 °C. The increment of temperature in hot air drying has observed the increment in fat content which is consistent for all drying procedures. Oil at higher temperatures results in accelerated noodle falls, which may prevent oil from escaping during the drying phase [25,45,46].

Noodle samples undergoing freeze drying reported a higher percentage of fat content. The sample subjected to freeze drying at −10 °C recorded fat content of 2.3100 ± 0.2030% for the non-oil coated noodle and 5.6200 ± 0.1997% for the original noodle. The non-oil coated noodle recorded a fat percentage of 2.6500 ± 0.7674%, while the original noodle recorded a higher fat content of 6.6200 ± 0.5303% for freeze drying at −40 °C. The high fat content, particularly in the original noodle, was because freeze-drying retains most nutrients which do not degrade monosaturated fats at low collapse temperature.

The fat content of rice noodle recorded by hot air and heat pump drying is in the range of 1.0–3.0% which is similar to the figure reported in the literature [47]. The differences in fat contents of the samples tested in this study could be due to gains during different drying processes. Many studies have shown that the fat content of different consumables differs considerably in terms of duration, raw materials, and storage cycles [48,49].

4.4. Effect of Pretreatment, Temperature, and Drying Methods on Starch Gelatinization

The starch in rice noodle was gelatinized with the presence of water and heat to indicate the preference of cooking time. Starch gelatinization is an endothermic reaction describing the dissociation of intermolecular bonds of starch molecules. This is to allow hydrogen-bonding sites to take on more water. The heat transported through aqueous medium in gelatinization and the gelatinization temperature range were observed by the differential scanning calorimetry (DSC). This irreversible gelatinization process dissolved the starch granule in water.

The DSC thermograms of rice noodle subjected to different drying procedures were illustrated; consistent shapes of different endotherms corresponded very closely to the endotherm of corn, potato, pasta, and native rice. A single endothermic transition was exhibited by all rice noodle variance when heated under minimal water contents.

Figure 3a shows the DSC results of the hot air drying of rice noodle. The noodle sample produces a well-defined endothermic peak ranging from 101.25 °C to 115.91 °C which reflects the overall gelatinization event. The onset of the transition occurs at the inflection point of 52.55 °C and a high temperature peak is retrieved at 158.86 °C. Since the sample projected normal biphasic endothermic transition, it is thus suggested that this peak might reflect the swelling effects during the gelatinization of such noodle [30,50].

The results show indefinite differences between the samples and the endothermic peak indicates the melting of the starch. This is due to the nature of these samples which is solely reliable on the origin of food sources. Amylopectin and amylose make up the hydrogen bond arrangement. This makes it hard for water to permeate such unbroken granules of starch. The granules began to expand to observable gelatinization as the water was heated. DSC measured the temperature at which there were irreversible changes.

The starch endotherm, as in Figure 3b, showed that gelatinization in rice noodle undergoing heat pump drying occurred between 35 °C and 154 °C, with the onset at 42°C. The plot of difference against temperature, symbolized as ΔH, exhibited a drastically reduced enthalpy difference between 103 and 154 °C. According to the theory of polymer solution, the starch immediately dissolves once the free moving energy becomes theoretically negative. In fact, starch polymers may have dissolved in the range of gelatinization temperatures [7,51,52].

The DSC curves for rice noodle subjected to freeze drying were determined, as in Figure 3c. Endothermic peaks were recorded in the lower range of 29 °C to 142 °C, and the onset, peak, and gelatinization temperatures of each sample were monitored. The inflection point temperatures were exactly located between the onset and peak temperatures. The role of water is vital by assisting the melting of the starch crystallites. The starch behavior in excessive water degraded in contrast to that of solely water [8,53,54].

The lowest temperature, $T_{p,}$ recorded by rice noodle subjected to freeze drying is attributed to the process itself that preserved the structural changes to the sample so that it may gelatinize faster. The disturbance (long-range structure) in the crystalline arrangement or the decrease in double helical structures (short-range structure) frequently occurs after freezing drying. Therefore, the temperature of the sample has to constantly maintain below its collapse temperature to keep the ice crystals from melting and to sub-gelatinize but sublime at the right operating condition [55].

4.5. Hierarchical Method

The results of the texture analysis, color analysis, oil content, and starch gelatinization of rice noodle subjected to hot air drying, heat pump drying, and freeze drying were discussed in the above section and summarized in Table 3. In terms of rice noodle overall performance by taking into account three quality attributes discussed earlier, the noodle of high quality must have radiant color, great texture, low oil content, and cooking characteristics. The noodle samples were ranked according to the mentioned attributes and the marks were then tabulated [24,25].

Rice noodles under freezing circumstances irrespective of drying conditions were among the best grades in the overall quality assessment [56]. The optimum drying process for rice noodles was the pre-treatment for freeze drying, especially at −10 °C and −40 °C, due to their higher qualities [57]. The rice noodle undergoing hot air drying pretreatment at 30 °C follows closely, ranking higher scores in any quality aspect. The rice noodle, which was treated to hot air drying pre-treatment with 30 °C, had parallel quality features in texture, color, and content of oil, and gelatinized for the freeze drying at −10 °C and −40 °C, respectively.

Table 3. The ranking scores for rice noodle quality at different drying procedures.

Drying Procedures			Texture Analysis	Colour Analysis	Oil Content	Starch Gelatinization	Average	Ranking
Hot Air Drying	30 °C	Non-oil Coated	1	5	1	5	4	3
		Original	8	6	8	6	6.5	8
	60 °C	Non-oil Coated	2	8	2	8	6.25	6
		Original	10	10	10	10	9.5	11
	90 °C	Non-oil Coated	6	12	6	12	10.75	12
		Original	12	14	12	14	13.25	14
Heat Pump Drying	38 °C	Non-oil Coated	3	7	3	7	6.5	7
		Original	9	9	9	9	9.25	9
	50 °C	Non-oil Coated	4	11	4	11	9.25	10
		Original	11	13	11	13	12.5	13
Freeze Drying	−10 °C	Non-oil Coated	5	2	5	2	3.25	2
		Original	13	4	13	4	5.5	4
	−40 °C	Non-oil Coated	7	1	7	1	3	1
		Original	14	3	14	3	5.5	5

5. Conclusions

This study presented a successful application of pre-treatment on better quality traits in dried rice noodle in relation to texture, color, fat content, and gelatinization. The work provided fundamental diffusivity into how non-oil-coated rice noodle can be pre-treated and prepared to produce higher quality dried noodle. Thus, the study recommends the consumer to always subject the noodle product to pretreatment for a better noodle quality experience.

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