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Physicochemical properties and sensory evaluation of gluten-free rice egg roll with hydrocolloids addition

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Abstract

The growing prevalence of gluten-intolerance disorder causes increasing demand for gluten-free products. This study was carried out to evaluate the quality parameters of gluten-free egg roll in terms of physical, chemical and sensory acceptability. Rice flour was utilized as a gluten-free source to replace wheat flour for the preparation of gluten-free egg roll. Hydrocolloids like carboxymethylcellulose (CMC) and xanthan gum were added at 0.4 g to enhance the quality characteristic of gluten-free egg roll made of rice flour. The results of proximate analyses revealed that the addition of hydrocolloids significantly ($p<0.05$) increased the moisture content, ash content, crude protein, crude fat, and total carbohydrate content of gluten-free egg roll compared to egg roll made of rice flour without hydrocolloids. The addition of hydrocolloids significantly ($p<0.05$) increased the lightness (L^*) value, but egg roll added with xanthan gum significantly ($p<0.05$) decreased the a^* and b^* values. The inclusion of hydrocolloids did not have a significant effect on hardness, but egg roll added with xanthan gum significantly increased the fracture strength as compared to rice flour containing egg roll. Among the hydrocolloids, egg roll added with xanthan gum resulted in a significant improvement in overall acceptability. Thus, rice flour and hydrocolloid (i.e., xanthan gum) could be suitable ingredients in producing the best quality egg roll and could provide benefits to gluten intolerance patients.

1. Introduction

Egg roll is a popular biscuit among the public for its sweet taste and thin crispy texture. Egg roll which is also called "kuih kapit" in Malaysia, egg biscuits in Vietnam, and Phoenix egg roll in Macau, is a biscuit prepared by spreading a thin layer of wheat flour batter on a hot circular iron mould that is held over a charcoal fire, next, folding the cooked batter in one-quarter to the opposite side to produce a triangle shape or rolling the biscuits around a flat to produce a flaky egg roll (Chan *et al*., 2020). Egg roll falls under the categories of cookies or biscuits and the ingredients used to make egg roll are wheat flour, egg, coconut milk, and sugar (Tsai and Liu, 2022). In order to produce a gluten-free egg roll that is comparable to the commercial one, it is extremely significant to incorporate the correct raw ingredients so that those materials are able to stimulate the behaviour of wheat flour and its components (Di Cairano *et al*., 2018). The gluten proteins in wheat flour are an essential component of baking products as they play a role in providing the elasticity, cohesiveness and viscosity properties of the dough (Klunklin and Savage, 2018a).

Despite the sweetness and distinct aroma of egg roll, there are several individuals who cannot enjoy the taste of egg roll as other people do. These genetically susceptible persons are unable to consume any cereal gluten proteins and this condition is known as celiac disease (Stamnaes and Sollid, 2015). According to Agarwal *et al*. (2020), with growing recognition and diagnosis, the number of celiac disease patients in Asia is expected to increase remarkably even though it was once considered as a rare disease. This situation is becoming a concern considering the fact that individuals suffering from celiac disease can only consume non-gluten food products which excludes bakery products since most bakery goods are prepared from gluten sources. Since egg roll contain wheat flour as one of the major ingredients, people suffering from celiac disease cannot consume these cookies due to the gluten presence in the flour. Moreover, gluten which is the causative agent of celiac disease may damage the small bowel as well as contribute to serious malnutrition (Benkadri *et al*., 2018).

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To date, the only cure for patients with this gluten-sensitive enteropathy condition is a long-term constancy to a strict non-gluten diet (Deora *et al*., 2015). Therefore, gluten-free products are becoming of great interest to celiac disease sufferers since they are sensitive to gluten-containing foods. Gluten-free products are defined as food products that are specifically manufactured using gluten-free flour to substitute wheat flour (Di Cairano *et al*., 2018). There are plenty of non-gluten flours that can be used as an option to replace wheat flour in the manufacture of bakery products which includes rice flour. Rice flour is suitable to be used in gluten-free bakery products as it is tasteless, has white colour and most importantly, does not contain gluten (Phongthai *et al*., 2017). Nevertheless, the functional characteristics of rice flour are inadequate to establish a stable dough structure (Villanueva *et al*., 2018). Since rice flour does not possess viscoelastic properties as in wheat flour, the addition of hydrocolloids is necessary since hydrocolloids are able to form comparable structures as in those gluten protein networks (Benkadri *et al*., 2018).

Several studies have investigated the physicochemical and sensory properties of gluten-free bakery products prepared from different flours and various gums. A research performed by Kaur *et al*. (2015) using buckwheat flour along with the incorporation of various gums such as xanthan, guar gum, gum tragacanth, and gum acacia in gluten-free biscuits production. The finding showed that the addition of different gums into the gluten-free biscuits formulation greatly increased the sensory scores. Moreover, there was another study conducted by Benkadri *et al*. (2018) on the preparation of gluten-free biscuits from composite rice-chickpea flour added with xanthan gum. The results of these studies proved that the preparation of gluten-free biscuits that possess similar quality characteristics to biscuits made with wheat flour is possible even by using non-gluten flour with the help of hydrocolloids or gum.

To our knowledge, there is no published data on the gluten-free egg roll made of rice flour added with hydrocolloids (i.e., carboxymethylcellulose (CMC) and xanthan gum). Therefore, this research aims to produce gluten-free egg roll using rice flour with the addition of various hydrocolloids that include CMC and xanthan gum as binding agents. The physicochemical and sensory properties of the gluten-free egg roll were compared with those prepared from wheat flour.

2. Materials and methods

2.1 Materials

Bakery ingredients such as wheat flour, rice flour, sugar, salt, carboxymethylcellulose (CMC) and xanthan gum were purchased from Ekoko Enterprise, Jerteh, Terengganu. Meanwhile, coconut milk and eggs were purchased from Giant Superstore Jerteh, Jerteh, Terengganu, Malaysia.

2.2 Egg roll preparation

The egg roll were prepared using wheat flour or rice flour, CMC or xanthan gum, coconut milk, water, sugar, salt and eggs. The formulations used to prepare egg roll are shown in Table 1. Control egg roll was made with 100% wheat flour meanwhile gluten-free egg roll were made of 100% rice flour without hydrocolloids or added with CMC or xanthan gum (i.e., RF, RF+CMC and RF+XG respectively).

Table 1. Formulation of gluten-free egg roll.

Ingredients	Mass of ingredients (g)			
	Control	RF	RF+CMC	RF+XG
Wheat flour	100.00	0.00	0.00	0.00
Rice flour	0.00	100.00	100.00	100.00
Coconut milk	60.00	60.00	60.00	60.00
Water	120.00	120.00	120.00	120.00
Sugar	100.00	100.00	100.00	100.00
Salt	1.42	1.42	1.42	1.42
Egg	100.00	100.00	100.00	100.00
CMC	0.00	0.00	0.40	0.00
Xanthan gum	0.00	0.00	0.00	0.40

A 100 g egg was whisked by using a hand mixer (5-Speed Turbo HR1459, Philips, Malaysia) at 3rd speed for 5 mins until foaming. Then, coconut milk (60 g), water (120 g), sugar (100 g), and salt (1.42 g) were added into the mixture and mixed until fully dissolved followed by the addition of hydrocolloids (i.e., CMC or xanthan gum). The next step was the addition of pre-sifted rice flour (100 g) which was slowly poured into the mixture to prevent lumps and then mixed until a homogenous batter was obtained.

For the preparation of egg roll mould, the egg roll maker (Panalux PSM-301, Shah Alam, Malaysia) was preheated to the temperature of 80°C for about 3 mins. Next, approximately 15 mL of the batter was poured into the preheated mould. The lid of the mold was closed to allow the egg roll to be cooked for approximately 1 min and 30 s. After that, the egg roll turned into light brown in colour which indicates that it is cooked. Then, the biscuit was rolled around a flat immediately to produce an egg roll. The egg roll was allowed to cool at room temperature for 20 mins before being packed into a

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zipper bag and stored in an air-tight container for further analysis.

2.3 Analysis of proximate composition

The proximate compositions of the samples were determined according to the official method as described by AOAC (1995). Oven drying (AOAC Official Method 977.11), dry ashing (AOAC Official Method 923.03), Kjeldahl (AOAC Official Method 955.04), Soxhlet (AOAC Official Method 960.39), and gravimetric methods (AOAC Official Method 991.43) was used to determine moisture, ash, crude protein, crude fat, and crude fibre contents, respectively.

2.4 Computation of total carbohydrates

The percentage of total carbohydrates was calculated by subtracting the total percentage of moisture, ash, crude protein, and crude fat from 100%. [% total carbohydrates = 100 - (moisture + ash + crude protein + crude fat)] (Giri and Sakhale, 2019).

2.5 Computation of calorie value

The total calorie value was determined by using specified energy factors and the value was expressed in kcal. The calorie values of all samples were calculated by multiplying protein, total carbohydrates, and fat by the factors of 4, 4 and 9, respectively (Giri and Sakhale, 2019).

2.6 Analysis of water activity

The water activity of the samples was measured by using Aqualab Water Activity Meter, model 4TE. Egg roll crumbs (about 2 g) were evenly put into the plastic cells. The samples were allowed to equilibrate in the sealed chamber's headspace (Ho and Abdul Latif, 2016).

2.7 Analysis of colour

The colour measurement of the samples was analyzed by Chroma meter (Konica Minolta CR-400/410, Tokyo, Japan). The colour of egg roll was measured in terms of Lightness (L: 100 = white, 0 = black), Chroma a* [green chromaticity (negative value) to red (positive value)], and b* [blue chromaticity (negative value) to yellow (positive value)]. The Chromameter was calibrated by using Konica Minolta calibration plate before analysis.

2.8 Measurement of texture profile

The texture of the egg roll such as hardness and fracturability was determined by using a texture analyzer (Stable Micro System, TA-XTPlus, Surrey, United Kingdom). The egg roll was measured by using probe HDP/3PB set at a pre-test speed of 1.00 mm/sec, test speed of 1.00 mm/s, post-test speed of 10.00 mm/s, and 30.00 mm of compression distance.

2.9 Sensory evaluation

The sensory evaluation was performed for all the prepared egg roll by forty untrained panellists. The samples were offered to the panellists in random order and labelled with three-digit random codes. The panellists were provided with four different types of egg roll coded with three-digit random number, a cup of plain water and a sheet of sensory form. The panellists were asked to rinse their mouths with plain water before proceeding with the next sample to cleanse their palate. The attributes that were used to evaluate the samples were colour, hardness, crispness, aroma, mouthfeel, sweetness, and overall acceptability. The panellists scored their evaluation on the scale for each attribute based on their degree of liking by using 7-point hedonic scale (1 = dislike very much, 2 = dislike moderately, 3 = dislike slightly, 4 = neither like nor dislike, 5 = like slightly, 6 = like moderately, 7 = like very much) (Watts *et al*., 1989).

2.10 Statistical analysis

The data obtained in this research were analysed by using the one-way analysis of variance (ANOVA). The significant difference among the mean values was established at a significance level of $p<0.05$ using Duncan's tests and all measurements were carried out in triplicate (n = 3).

3. Results and discussion

3.1 Proximate compositions of egg roll

Table 2 presents the proximate compositions, calorie content, and water activity value of gluten-free egg roll. From Table 2, the results indicate that egg roll made of rice flour without the addition of hydrocolloids resulted in a significant ($p<0.05$) lower moisture content (1.67%) compared to the other egg roll samples (2.18-3.16%). Nevertheless, the moisture content significantly ($p<0.05$) increased when CMC and xanthan gum were added. This was attributed to the hydrocolloid (i.e., CMC and xanthan gum) with its negative charge having more tendency to form intermolecular hydrogen bonds with water through hydrogen bonds (Encina-Zelada *et al*., 2018). Moreover, a high number of branches of hydrocolloids has also contributed to an increased interaction with water. Whereby, the higher the molecular weight, the greater the water holding capacity due to the higher the radius of water around the hydrocolloid (i.e., gyration) (Horstmann *et al*., 2018). Hence, this results in an increase in the moisture content of egg roll with added CMC and xanthan gum. The same

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Table 2. Proximate compositions and water activity of egg roll.

Compositions	Control	RF	RF+CMC	RF+XG
Moisture (%)	3.16±0.03[a]	1.67±0.02[d]	2.18±0.05[c]	2.39±0.07[b]
Ash (%)	0.11±0.01[a]	0.07±.00[c]	0.09±0.01[b]	0.09±0.01[b]
Crude Protein (%)	10.40±0.06[a]	9.23±0.04[c]	9.01±0.06[d]	9.40±0.09[b]
Crude Fat (%)	10.98±0.61[a]	8.84±0.27[c]	10.05±0.06[b]	9.23±0.11[c]
Crude Fibre (%)	1.82±0.97[a]	0.03±0.01[b]	0.44±0.43[b]	0.34±0.53[b]
Total Carbohydrate (%)	77.10±0.08[c]	78.27±0.09[b]	79.88±0.27[a]	77.87±0.53[b]
Calorie (Kcal)	433.07±0.68[c]	440.40±0.54[b]	435.12±1.17[c]	447.83±3.08[a]
Water Activity	0.46±0.01[a]	0.46±0.01[a]	0.4 ±0.00[a]	0.46±0.00[a]

Values are presented as mean±SD of triplicates. Values with different superscripts within the same row are statistically significantly different ($p<0.05$). Control: egg roll made of 100% wheat flour, RF: egg roll made of 100% rice flour without incorporation of hydrocolloids, RF+CMC: egg roll made of 100% rice flour with incorporation of CMC, RF+XG: egg roll made of 100% rice flour with incorporation of xanthan gum.

finding was reported by Kaur *et al*. (2015), whereby the study indicates that the incorporation of xanthan gum in buckwheat biscuits produced biscuit with maximum moisture retention (4.21 g/100 g). A similar pattern was observed by Benkadri *et al*. (2018), in which the research showed that the moisture content of gluten-free biscuits was significantly ($p<0.05$) increased when xanthan gum was added. According to Habibi and Khosravi-Darani (2017), when xanthan gum is combined with other dry elements, it hydrates quickly and uniformly and thus it assists with the even distribution of moisture and stabilization of air cells, resulting in an increased volume of the final product. As mentioned by Afifah and Ratnawati (2017), the shelf life of the product will be shortened as the moisture content increases. Therefore, in the present study, the decrease in moisture content of the egg roll made of rice flour will present a longer shelf life than control egg roll.

From Table 2, the results showed that the ash content of egg roll prepared from rice flour without the addition of hydrocolloids significantly ($p<0.05$) decreased (0.07%) compared to control (0.11%) and egg roll prepared from rice flour added with xanthan gum (0.09%). A study conducted by Gül *et al*. (2018) demonstrates that the ash ratio of gluten-free cookies improved statistically with the increasing concentration of xanthan gum from 0.68% to 0.91%. According to the research performed by Kaur *et al*. (2015) on gluten-free cookies, the presence of mineral content in the hydrocolloids may contributed to the slight increases in the amount of ash in the cookies. Furthermore, ash content can be an index of mineral contents that are present in the food material (Sugumaran *et al*., 2019). Hence, the incorporation of hydrocolloids might improve the amount of minerals present in the gluten-free egg roll. However, further determination of mineral content in the prepared gluten-free egg roll might be warranted.

In terms of crude protein, there was a significant ($p<0.05$) decrease in the crude protein content of the three egg roll samples made of rice flour (i.e., RF, RF+CMC, and RF+XG) (9.40% to 9.01%) as compared to control egg roll which was highest (10.40%) (Table 2). This may be attributed to the lower protein content of rice flour (6.14-7.30 g/100 g) as compared to wheat flour (9-13 g/100 g) (Stantiall and Serventi, 2018). Nurminah *et al*. (2019) reported that egg roll prepared from purple flesh sweet potato flour had a low amount of protein compared to the egg roll made of wheat flour in which the value decreased from 7.26% to 6.35%. This is probably due to the high content of gluten protein present in wheat flour.

There was a significant ($p<0.05$) decrease in the crude fat content of egg roll produced from rice flour with or without the incorporation of hydrocolloids (8.84-10.05%) compared to egg roll prepared from wheat flour (10.98%). According to the research completed by Rai *et al*. (2014) on gluten-free cookies, the fat content of control cookies made of wheat flour was higher than gluten-free cookies made from rice flour. Rai *et al*. (2014) also revealed that the fat content of wheat flour is 0.9% while the fat content of rice flour is 0.4%. Thus, rice flour can help to decrease the fat contents of the egg roll due to the lower amounts of fat present.

There was a significant ($p<0.05$) decrease in the percentage of crude fibre of all the egg roll containing rice flour (0.03-0.44%) compared to the control egg roll (1.82%). The same trend was observed in a study conducted by Altindag *et al*. (2015), where the gluten-free cookies prepared from rice flour had the lowest fibre value (0.78%) compared to those prepared from buckwheat and corn flour (0.96% and 1.51% respectively). This may be due to the low value of protein, sodium, fat, and fibre present in rice flour (Wongklom *et al*., 2016). Moreover, Păucean *et al*. (2015) also reported that rice flour is deficient in vitamins, minerals, and fibre, all of which are necessary for celiac patients to have a well-balanced diet. Nonetheless, the inclusion of CMC into the gluten-free egg roll in the present study slightly improved the fibre value from 0.03% to 0.44%. This can be linked to the synthesis of CMC that comes from numerous sources such as raw cellulose, paper sludge, wood residue, and also fibres which may contribute to the high fibre content of rice-based egg roll (Mondal *et al*., 2015).

From Table 2, the percentage of total carbohydrates of the three egg roll samples made of rice flour (i.e., RF, RF+CMC, and RF+XG) significantly ($p<0.05$) increased compared to those made of wheat flour (control). According to Păucean *et al*. (2015), rice flour is one of the most widely utilized ingredients in gluten-free baked goods because of its high level of easily digested carbohydrates. In addition, the utilization of rice flour in the manufacturing of snacks is advantageous and beneficial due to its carbohydrate content (Folorunso *et al*., 2016). Therefore, the substitution of rice flour for wheat flour in the production of gluten-free egg roll will provide more health benefits for individuals due to its high carbohydrate content.

The substitution of rice flour for wheat flour in a gluten-free egg roll added with xanthan gum yielded a significant ($p<0.05$) increase in the calorie content (447.83 Kcal) over the control egg roll (433.07 kcal) (Table 2). A study conducted by Omran and Hussien (2015) on gluten-free cookies prepared from sweet potato flour indicates that the total caloric value of gluten-free cookies produced from broken rice flour was higher (489.45 kcal) than those prepared from sweet potato flour (479.00 - 485.34 Kcal). According to Mohamad Yazid *et al*. (2018), the main source of calories and nutrients for Asian people comes from rice (*Oryza Sativa* L.). Thus, the utilization of rice flour in this present study to produce gluten-free egg roll slightly increased the value of the calories.

A low water activity of a product will slow down the microbial growth thus making the medium unsuitable for the reproduction of microbe (Montes *et al*., 2015). The water activity value of all the egg roll in Table 2 showed that the substitution of wheat flour with rice flour in producing the egg roll gave no significant ($p>0.05$) difference. Benkadri *et al*. (2021) recorded that the increase in the amount of xanthan gum significantly increased the water activity of the biscuits in comparison to the biscuits added with locust bean gum. This study further revealed that the variation in the effect of each gum on the biscuit's water activity may be due to their various water affinities, which appear to be related to the biscuit texture (Benkadri *et al*., 2021). However, the pattern was not found in this present study. The insignificant difference in the water activity value might be due to the small amount of CMC and xanthan gum added (0.4 g) which did not influence the water activity content. According to Igo and Schaffner (2021), food with a water activity of 0.6 or below can inhibit the growth of microbial proliferation, mould and yeast. Therefore, all the egg roll produced in this present study can be considered as shelf-stable food products and safe during storage.

3.2 Colour properties of egg roll

One of the most essential aspects in the selection and purchasing of baked goods is colour (Klunklin and Savage, 2018b). Table 3 summarizes the colour (L^*, a^* and b^*) properties of the gluten-free egg roll. The colour analysis results showed that there was a significant ($p<0.05$) increase in the lightness (L^*) value of egg roll made of rice flour (26.68) and with the addition of CMC (23.25) or xanthan gum (27.56) compared to control egg roll (17.76). According to Nammakuna *et al*. (2016), the darker colour of samples containing wheat flour is due to its high level of protein content which resulted in more free amino acids available to engage in Maillard reaction. The currently obtained results were in agreement with the results recorded in Table 2, whereby, the egg roll made of 100% wheat flour (control) had significantly ($p<0.05$) higher crude protein than the egg roll made of 100% rice flour without or with the addition of CMC or Xanthan gum (i.e., RF, RF+CMC, and RF+XG). Therefore, yielded a significant ($p<0.05$) darker colour of the control sample than the other egg roll samples. As for the increased L^* value of egg roll incorporated with xanthan gum, similar results were obtained from the research conducted by Singh *et al*. (2016), where the incorporation of xanthan gum

Table 3. Colour properties of egg roll.

	Control	RF	RF+CMC	RF+XG
L^*	17.76±3.06^c	26.68±5.90^a	23.25±3.85^b	27.56±4.85^a
a^*	4.05±2.66^a	2.64±1.71^b	5.32±1.82^a	2.68±1.66^b
b^*	18.18±2.02^a	14.94±2.18^b	15.51±2.54^b	14.26±0.90^b

Values are presented as mean±SD of triplicates. Values with different superscripts within the same row are statistically significantly different ($p<0.05$). Control: egg roll made of 100% wheat flour, RF: egg roll made of 100% rice flour without incorporation of hydrocolloids, RF+CMC: egg roll made of 100% rice flour with incorporation of CMC, RF+XG: egg roll made of 100% rice flour with incorporation of xanthan gum.

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increased the L^* value of crusts and crumbs of gluten-free muffin. According to Cai *et al*. (2019), the powder colour of xanthan gum was close to white which may be attributed to the higher value of lightness.

Results in Table 3 indicate that there was a significant ($p<0.05$) decrease in the a^* value for egg roll made of rice flour (2.64) and with the inclusion of xanthan gum (2.68) compared to the control egg roll (4.05) and egg roll added with CMC (5.32). The a^* value of the egg roll showed positive values which means that the colour of the egg roll was more towards red colour and indicates that green hues were not present. According to Nammakuna *et al*. (2016), wheat-based food contains a higher quantity of non-enzymatic browning products, resulting in a more reddish-brown appearance. Nevertheless, it can be seen from the results that the a^* values for egg roll prepared with rice flour incorporated with CMC were closest to the control egg roll. This might be attributed to the carbonyl group present in CMC that reacts with free amino groups of proteins to create the Maillard reaction in the presence of heat (Abdullah and Zulkifli, 2021).

Table 3 indicates that egg roll made of rice flour and with the incorporation of CMC or xanthan gum yielded a significant ($p<0.05$) decrease (14.94, 15.51, and 14.26 for RF, RF+CMC and RF+XG respectively) in the b^* values compared to control egg roll (18.18). This was associated with the presence of carotenoid pigment in the wheat flour. The carotenoid pigment adds to the high yellowness value of wheat-based products by producing a high intensity of yellow pigment contained in wheat flour (Ho and Pulsawat, 2020). The present obtained results are in agreement with the findings by Singh *et al*. (2016), whereby the authors noticed that the incorporation of xanthan gum lowered the b^* value of the gluten-free muffin. Overall, egg roll made of rice flour (RF) and added with xanthan gum (RF+XG) showed similar properties for all the colour attributes (i.e., L^*, a^*, and b^*). According to Bulbul *et al*. (2019), xanthan gum has a pale or white in colour appearance. Hence, this indicates that the addition of xanthan gum did not influence the colour of the rice-based egg roll.

3.3 Texture profile of egg roll

The textural characteristics of baked products are a significant aspect in determining the product's quality. Klunklin and Savage (2018b) define hardness as one of the fundamental elements that determine the textural features of food products and is evaluated as the peak force required to pierce through the food products. Table 4 indicates the textural profile of the egg roll. Based on the results obtained, there was no significant ($p>0.05$) difference among all the egg roll samples for hardness value which ranged from 528.97 g to 693.71 g. A study performed by Nammakuna *et al*. (2016) revealed that gluten-free crackers made of rice flour added with xanthan gum exhibited a lower hardness value than wheat-based crackers but higher than the crackers made of rice flour without the addition of xanthan gum. A similar finding was reported by Lu *et al*. (2020), whereby the inclusion of xanthan gum enhanced the hardness of cassava flour biscuits from 2535.89 g to 3537.58 g. In this present study, the control egg roll (i.e., egg roll with wheat flour) exhibited the highest mean value of hardness compared to the gluten-free egg roll (i.e., RF, RF+CMC, and RF+XG). This might be due to the presence of higher protein content in wheat flour (Altindag *et al*., 2015). Wheat gluten acts on the structure of the product by retaining the formation of gas in the food system resulting in a better texture of the product (Kim *et al*., 2015).

The results of fracturability (Table 4) indicate that gluten-free egg roll added with xanthan gum was significantly ($p<0.05$) higher (43.02 mm) than gluten-free egg roll without hydrocolloids (28.79 mm). Fracturability encompasses crispness and is referred to as the force at which a sample breaks, fractures or shatters (Janve *et al*., 2015). Hence, the higher fracturability value indicates that the sample is less brittle (Hwang *et al*., 2016). Referring to the results reported by Gül *et al*. (2018), the fracturability of gluten-free cookies significantly ($p<0.01$) increased from 35.46 to 43.82 mm as the amount of xanthan gum in the cookies increased. The results also revealed that the closest hardness and fracturability values of gluten-free cookies that were comparable to control cookies were achieved with the incorporation of 3% and 4% of xanthan gum.

Table 4. Texture profile of egg roll.

	Control	RF	RF+CMC	RF+XG
Hardness (g)	693.71±76.62^a	528.97±92.76^a	543.79±290.43^a	612.44±123.90^a
Fracturability (mm)	41.42±1.18^a	28.79±1.79^b	30.66±2.84^b	43.02±1.40^a

Values are presented as mean±SD of triplicates. Values with different superscripts within the same row are statistically significantly different ($p<0.05$). Control: egg roll made of 100% wheat flour, RF: egg roll made of 100% rice flour without incorporation of hydrocolloids, RF+CMC: egg roll made of 100% rice flour with incorporation of CMC, RF+XG: egg roll made of 100% rice flour with incorporation of xanthan gum.

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Furthermore, the highly branched structure of xanthan gum as well as its ability to interact with other components to create links contributes to the increased fracturability of the cookies (Gül *et al*., 2018).

3.4 Sensory attributes of egg roll

Table 5 summarizes the sensory evaluation scores for colour, aroma, crispness, hardness, sweetness, mouthfeel, and overall acceptability for egg roll done by 40 untrained panellists. Based on the ANOVA results, there was no significant difference in the colour attributes among the egg roll. However, it can be observed that egg roll prepared from rice flour with the addition of xanthan gum received the highest mean score (5.85) compared to the other egg roll (5.43-5.50). Research conducted by Kaur *et al*. (2015) on gluten-free biscuits prepared from buckwheat flour indicates that the sensorial score for colour attribute of the buckwheat biscuit added with xanthan gum was significantly ($p<0.05$) lower than wheat-based biscuits but significantly ($p<0.05$) higher than the other gluten-free biscuits. The same pattern was observed in the study performed by Gül *et al*. (2018), whereby the incorporation of 3% xanthan gum is the best level for improving the colour properties of gluten-free biscuits. In this present study, although the results for colour from Table 3 showed significance by means of physical analysis, the panellists still can accept the egg roll with beige (high L* for RF+XG) to brown (low L* for control).

For the aroma attribute, there was insignificant ($p>0.05$) difference among all the egg roll samples. According to Olawoye and Gbadamosi (2020), the panellists' sense of scent is influenced by the raw materials and ingredients utilized in cookie production. However, the results obtained from the present study revealed that the substitution of rice flour for wheat flour in the egg roll for the aroma attribute did not affect the product with rated "like slightly" for all the tested egg roll.

For the crispness of egg roll with rice flour, egg roll made of rice flour added with xanthan gum received a significant ($p<0.05$) highest score (6.05) compared to egg roll without any addition of hydrocolloids (5.30). According to Nammakuna *et al*. (2016), the texture of rice crackers is largely due to starch gelatinization, as rice dough cannot hold the gas released during fermentation, resulting in a crumbly rice cracker. The author further explained that the presence of hydrocolloids assisted in the retention of gas in the crackers during baking. Thus, the crispness of gluten-free rice crackers added with hydrocolloids was not solely dependent on starch gelatinization and hence the crackers were less crumbly. Therefore, panellists perceived gluten-free egg roll incorporated with xanthan gum as "like moderately" due to the less crumbly texture of the egg roll which was more favourable compared to gluten-free egg roll without hydrocolloids.

Regarding hardness attribute, there was no significant ($p>0.05$) difference between the wheat-based egg roll and rice flour-containing egg roll (i.e., RF, RF+CMC, and RF+XG) which ranged from 5.30 to 5.83. This data can be supported by the hardness (g) reading obtained from the present study; whereby no significant difference in hardness value was found among the sample (Table 4).

The replacement of rice flour for wheat flour did not influence the sweetness of the gluten-free egg roll (i.e., RF, RF+CMC, and RF+XG). The mean scores for the sweetness of egg roll ranged from 5.63 to 5.83. According to Benkadri *et al*. (2018), rice flour is white in colour and has a bland flavour, but the flavour can be enhanced by combining rice flour with other flour. The study conducted by Mancebo *et al*. (2016) on gluten-free sugar-snap cookies revealed that there were no significant differences in taste between the cookies produced from 100% rice flour and cookies made of a combination of rice, maize and pea protein flour.

For the mouthfeel attribute, it shows insignificant

Table 5. Sensory attributes of egg roll.

Attribute	Control	RF	RF+CMC	RF+XG
Colour	5.50 ± 1.09^{a}	5.43 ± 1.22^{a}	5.50 ± 1.30^{a}	5.85 ± 1.10^{a}
Aroma	5.65 ± 1.23^{a}	5.55 ± 1.24^{a}	5.40 ± 1.24^{a}	5.45 ± 1.13^{a}
Crispness	6.15 ± 1.25^{a}	5.30 ± 1.51^{b}	5.80 ± 1.09^{ab}	6.05 ± 1.06^{a}
Hardness	5.83 ± 1.22^{a}	5.30 ± 1.34^{a}	5.58 ± 1.15^{a}	5.80 ± 1.09^{a}
Sweetness	5.83 ± 0.84^{a}	5.63 ± 1.08^{a}	5.63 ± 1.08^{a}	5.70 ± 1.09^{a}
Mouthfeel	5.93 ± 0.89^{a}	5.45 ± 1.13^{a}	5.68 ± 1.00^{a}	5.63 ± 1.13^{a}
Overall acceptability	5.98 ± 0.80^{a}	5.43 ± 1.01^{b}	5.75 ± 1.08^{ab}	6.03 ± 1.14^{a}

Values are presented as mean±SD of triplicates. Values with different superscripts within the same row are statistically significantly different ($p<0.05$). Control: egg roll made of 100% wheat flour, RF: egg roll made of 100% rice flour without incorporation of hydrocolloids, RF+CMC: egg roll made of 100% rice flour with incorporation of CMC, RF+XG: egg roll made of 100% rice flour with incorporation of xanthan gum.

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($p>0.05$) difference among the control egg roll and rice-based egg roll (i.e., RF, RF+CMC, and RF+XG). Mouthfeel is linked to the fat content of the product, and it is affected by lubrication (i.e. fat droplets) (Ho and Pulsawat, 2020). Hence, the reduction of fat droplets in a food product eliminates the desired mouthfeel feature. However, the distinction of the mouthfeel of the gluten-free egg roll is minimal.

The overall acceptability of gluten-free egg roll added with xanthan gum was significantly ($p<0.05$) higher (6.03) than gluten-free egg roll without hydrocolloids (5.43) as shown in Table 5. This indicates that xanthan gum has improved the overall sensorial of the egg roll prepared using rice flour. Based on the study performed by Kaur *et al*. (2015) on gluten-free biscuits, the panellists scored the biscuits added with xanthan gum as having the highest overall acceptability compared to the rest of the biscuits incorporated with other gums (i.e., gum acacia, guar gum, and gum tragacanth). In addition, another research on gluten-free cookies conducted by Gül *et al*. (2018) also reports similar findings. The authors reported that gluten-free cookies incorporated with a 3% concentration of xanthan gum had the highest rating in overall acceptance (Gül *et al*., 2018). Hence, the inclusion of xanthan gum in this present study to produce gluten-free egg roll may enhance some quality properties of egg roll and can be accepted by consumers.

4. Conclusion

The proximate composition results indicate that gluten-free egg roll incorporated with hydrocolloids (RF+CMC and RF+XG) significantly improved the moisture content, ash content, crude protein (except RF+CMC), crude fat, and total carbohydrate content as compared to those prepared from rice flour only (RF). Egg roll made of rice flour with or without hydrocolloids (i.e., RF, RF+CMC, and RF+XG) influenced the colour of egg roll by producing a lighter colour than the control egg roll but egg roll added with xanthan gum (RF+XG) significantly lowered the $a*$ and $b*$ values. Apart from that, egg roll made of rice flour added with hydrocolloids did not significantly affect the hardness value, but egg roll added with xanthan gum (RF+XG) significantly increased the fracture strength as compared to rice flour containing egg roll (RF). For sensory evaluation, egg roll added with xanthan gum significantly improved the crispness and overall acceptability as compared to those made of rice flour only. Gluten-free egg roll added with xanthan gum received sensorial scores that are comparable to egg roll prepared with wheat flour.

Overall, the incorporation of hydrocolloids particularly xanthan gum could improve all the quality criteria of gluten-free egg roll. Rice flour as a gluten-free source and the inclusion of gums can thus be utilized to prepare a good quality gluten-free egg roll. Therefore, rice flour incorporated with hydrocolloids particularly, xanthan gum could be served as a potential ingredient in producing the best gluten-free egg roll with a good source of carbohydrate which might be beneficial for celiac disease sufferers.

Conflict of interest

All authors declare there is no conflict of interest in this research article.

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