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Quality of the sticky rice paper affected by carboxymethyl cellulose supplementation

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Abstract

Rice paper or wrapper was a common product in Asian cuisine. This product was usually processed from starch-based materials like wheat flour, rice flour, mung bean flour, cassava starch, and other ingredients. The mechanical attributes of rice paper greatly contributed to the customer's acceptance. In Vietnam, rice flour was used as the main material for rice paper making. Rice flour had poor resistance to shear force and low elastic gel-forming capability; therefore, reinforcement of mechanical properties was very important. Carboxymethyl cellulose (CMC), a polysaccharide with numerous functional properties, was used in the food industry to improve the physical strength of starch-based films. This research evaluated the incorporation of CMC in different proportions (0-2%) on the moisture content, strained intensity, elongation at disrupting, and fracture hardness of the edible glutinous rice paper. Results showed that CMC supplementation increased moisture content and strained intensity while decreasing elongation at disrupting and fracture hardness. 1.5% CMC was adequate to intensify the mechanical attributes of the edible sticky rice paper.

Keywords

polysaccharide, edible glutinous wrapper, elongation at disrupting, fracture hardness, incorporation, moisture, strained intensity

Introduction

Carboxymethyl cellulose (CMC) was an anionic linear polysaccharide that originated from cellulose widely applied in food processing and preservation to minimize starch retrogradation, retain moisture, enhance the taste and limit sugar crystallization, regulate the rheological function of dough, accelerate swelling volume (1). CMC was mostly utilized because it showed high viscosity, non-toxicity and non-allergen. The abundant hydroxyl and carboxylic groups in CMC allowed moisture-holding capacity. CMC hydrogel had a high moisture content, perfect biodegradability and versatility due to its competitive price (2). CMC showed a great ability to enhance the physical attributes of starch-based films (3).

The edible sticky rice paper was a popular product in Asian cuisine with a great variety manufactured from rice flour, wheat flour, mung bean flour, cassava starch and other ingredients like flaxseed oil, sesame oil, coconut powder, egg white albumin, depending on the purposes of cooking and culture style (4-7). Rice flour was an available main ingredient to process the edible sticky rice paper due to its low cost, flexible flavour, opaque appearance, high content of digestible carbohydrates, and hypoallergenic properties (8-11). However, rice flour also revealed shortcomings like fairly inferior functional characteristics in interacting and forming a cohesive network (12). Flour from high-amylopectin rice had great potential for preparing edible sticky rice paper (13).

Most rice paper distributed on the market is prepared from non-sticky rice. The purpose of our study is to examine the feasibility of making the edible sticky rice paper from the sticky rice flour and other ingredients with the incorporation of CMC in different proportions. The physical properties such as moisture content, strained intensity, elongation at disrupting and fracture hardness of the edible sticky rice paper would be carefully observed to define the optimal CMC ratio supplementation.

Materials and Methods

Material

Sticky rice flour, cassava starch, egg white, sodium chloride, saccharose and coconut powder were obtained from the local market of Soc Trang province, Vietnam. Carboxymethyl cellulose was supplied from a grocery additive store in Soc Trang province, Vietnam. All ingredients were all food grade.

Researching method

500g sticky rice flour, 100 g cassava starch, 35g egg white, 5g sodium chloride, 6g saccharose, and 4g coconut powder were mixed thoroughly with 650 ml water to form a diluted dough. Five dough formulas were prepared as follows: G1: control consisting of 500g sticky rice flour, 100g cassava starch, 35g egg white, 5g sodium chloride, 6g saccharose, 4 g coconut powder, and 650 ml water; G2: 6.5g CMC + G1; G3: 13g CMC + G1; G4: 19.5 g CMC + G1; G5: 26g CMC + G1. Dough batches were individually steamed in a water bath in a high pot and covered with a cloth over the mouth. An aliquot of 20ml of the dough was scooped by coconut shell, spread evenly, and then closed the lid. The rice paper would be cooked with hot vapour for 30s. To take out the rice paper, a sharp bamboo was used. The rice paper was gently set on woven bamboo and dried under the sun for 6 hrs. The edible sticky rice papers were conditioned in a plastic bag for 24 hrs, ready for physical tests.

Moisture content (%) was determined by the gravimetric method. Samples were heated at 105°C to constant weight in Kett FD720 infrared moisture analyzer. Moisture content (%) = (Initial weight (g)– sample weight after heating (g)) x 100%/ Initial weight (g). Strained intensity, elongation at disrupting and fracture hardness of the edible sticky rice paper were examined by a texture analyzer (Stable Micro Systems, model: TA.XT*plusC*). The edible sticky rice paper was shaped into scattering pieces (4 × 4 cm). The corners of each piece were clipped between cover tweezers fixed by double-side glue ribbon such that the end zone was 34 × 200 mm with a load cell of 30kg. The first tweezer detachment of the strained mode was set up at 200 mm; force (N) and elongation (mm) were monitored during extension at 50 mm/ min up to disrupting. From the outcome forced-time curve, strained intensity (N/mm^2), elongation at disrupting (%), and fracture hardness ($N/mm^{3/2}$) were evaluated.

Statistical analysis

The experiments were run in triplicate with different groups of samples. The data were presented as mean±standard deviation. Statistical analysis was performed by the Statgraphics Centurion version XVI.

Results and Discussion

The more incorporation (0–2%) of CMC, the higher moisture content (35.07±0.03 to 42.29±0.00%) of the edible sticky rice paper was obtained. There was no significant difference in moisture content by 1.5% CMC and 2% CMC incorporation (Fig. 1). This accumulation of moisture content in the edible sticky rice paper by incorporation of CMC might be relevant to the property of CMC to bind free moisture (14). Gelation was the establishment of a three-dimensional network through hydrogen bonds between proteins contributing to the immobilization of moisture in the gel texture. This property contributed to the moisture keeping potential by the formed gel network (15).

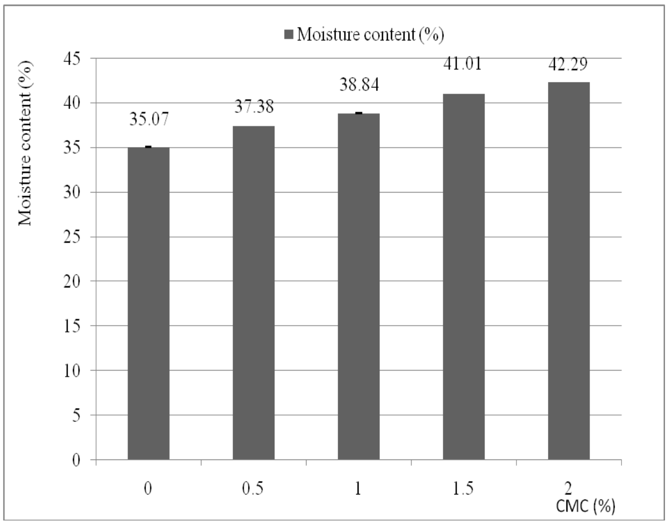

Fig. 1. Effect of CMC (%) incorporation on the moisture content (%) of the edible sticky rice paper.

The data showed that the strained intensity significantly improved (0.19±0.01 to 0.77±0.02 N/mm^2) in the edible sticky rice paper supplemented by CMC (0–2.0%) with a specific strength. There was no significant difference in the strained intensity by incorporation of 1.5% CMC and 2.0% CMC (Fig. 2). That guaranteed its durability and the resistance to disruption, particularly in preservation to minimize mistakes like pinholes and fissures (16, 17). The interaction between starch and protein improved the strained intensity, leading to increased protein network density and elastic starch improvement (15). The high proportion of CMC was proven to enhance strained intensity in the biodegradable cassava starch-based film (18). The ascending strained intensity of the edible sticky rice paper with a high proportion of CMC was likely due to the establishment of intermolecular interaction between the hydroxyl group of starch and the carboxyl group of CMC (19). During thermal treatment, the initial hydrogen bonds created between starch molecules could be substituted by emerging hydrogen bonds established between the hydroxyl groups in starch particles and the hydroxyl and carboxyl groups in CMC (20). CMC incorporation enhanced intermolecular binding within the starch and thereafter improved the strained intensity of the edible biodegradable wrapper (21).

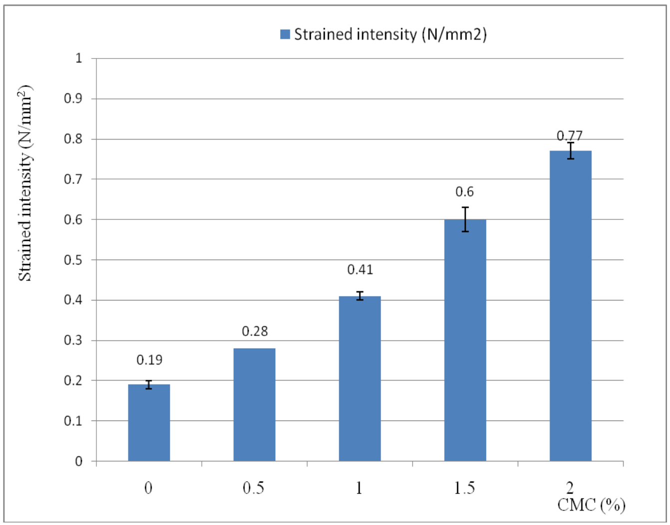

Fig. 2. Effect of CMC (%) incorporation on the strained intensity (N/mm²) of the edible sticky rice paper.

The supplementation of CMC (0–2%) decreased the elongation at disrupting (58.4±0.34 down to 38.29±0.06 %) of the edible sticky rice paper. There was no significant difference in the elongation at disrupting by incorporation of 1.5% CMC and 2.0% CMC (Fig. 3). This reinforcement of mechanical properties might be relevant to the property of CMC to control the rheological characteristics of dough, improve the swelling volume and prevent starch retrogradation (22). Rice paper with lower elongation disrupting values normally needed a higher load to make rice paper breakage (23). This could be explained by the texture change of the starch matrix by water led to higher flexibility in the polymer structure. More supplementation of CMC led to less elongation at disruption in the biodegradable cassava starch-based film (18). The elongation to the breakage accelerated with the more percentage of CMC (24-25).

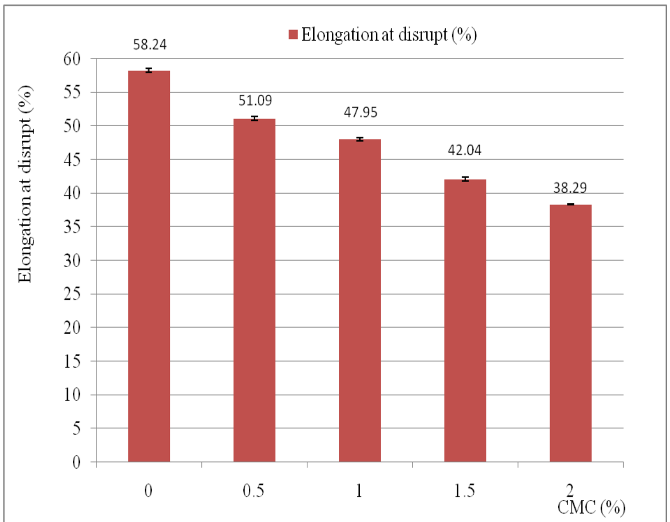

Fig. 3. Effect of CMC (%) incorporation on the elongation at disrupting (%) of the edible sticky rice paper.

The incorporation of CMC (0–2%) induced the declined fracture hardness (3.97±0.03 down to 2.04±0.03 N/mm$^{3/2}$) of the edible sticky rice paper. There was no significant difference in the fracture hardness by incorporating 1.5% CMC and 2.0% CMC (Fig. 4). The decreasing fracture hardness could be explained by the fact that the hydrocolloid gave elastic potential so that the force necessary for film deformation became lesser. CMC supplementation could minimize the porosity of the crumb texture (26). The ester bonds were mainly created between the hydroxyl groups in amylopectin branches of starch and carboxylic acid groups of CMC, making a durable cross-linked texture (27).

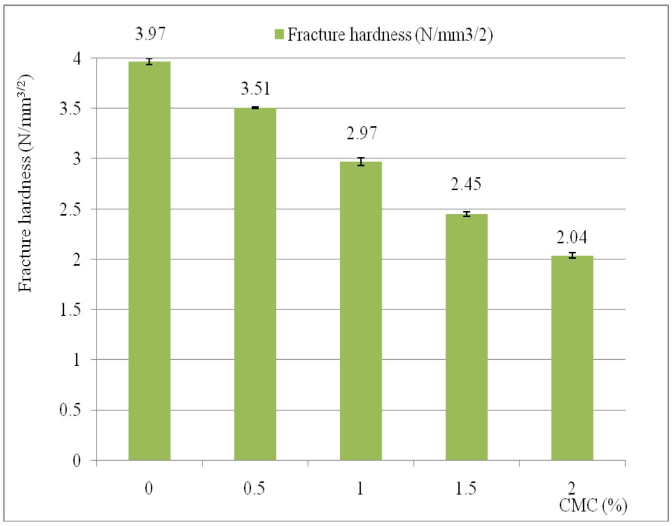

Fig. 4. Effect of CMC (%) incorporation on the fracture hardness (N/mm$^{3/2}$) of the edible sticky rice paper.

Bare rice flour had poor resistance to shear force and low elastic gel-forming capability. Pure starch had a remarkable trend in reducing its viscosity and thickening capacity in thermal treatment (28-30). The disadvantage of rice flour was the shortcoming of creating a cohesive mass and rigid network because it is gluten-free. By mixing rice flour, tapioca starch, egg white, and water together, the rice wrapper obtained cohesive and durable mass with high firmness, elongation at break, and moisture retention (7). It could be explained that rice flour was quite weak to establish cohesive mass and rigid structure because of its free-gluten. The formula and ingredient in each species greatly affected the properties of rice wrapper.

Cassava starch was widely utilized in food processing as a hydrocolloid thickener due to its low cost, availability and pleasant flavour. Cassava starch incorporation provided an elastic potential in a better gelatinization, resulting in an increasing cohesiveness (31). Cassava starch had a longer sequence of glucose unit polymers than rice starch, and therefore, it would enhance the structure of rice paper by upgrading the elasticity and moisture-keeping ability. The moisture keeping ability tended to accelerate with the gel durability, enhancing the strained intensity of the edible sticky rice paper. Cassava starch supplementation was proven to give a smoother texture to pizza dough.

Egg white played an important role in intensifying cohesiveness with better the protein-moisture couple by thermal-posed gel during thermal treatment of dough (32). Globular proteins in egg white participated in the three-dimensional network of protein gels with a sturdy and cohesive potential (33). These attributes facilitated higher moisture retention in the edible sticky rice paper. A combination of cassava starch and egg white as a binder could enhance the cohesiveness and structure rice wrapper (34). There was an increasing trend of the strained intensity of rice noodles with a high ratio of egg white (up to 50%) (35). Protein and amylose were gel formers donating to the rising of elongation at disrupting (7).

Conclusion

Mechanical properties such as moisture content, strained intensity, elongation at disrupting and fracture hardness of the edible sticky rice paper were significantly affected by the incorporation of CMC proportion. 1.5% CMC incorporation was appropriate to improve the physical attributes of this rice paper. A more proportion of CMC led to the establishment of intermolecular interaction between the hydroxyl group of starch and the carboxyl group of CMC. It's feasible to prepare starch-based film from a gluten-free source like rice flour with the support of CMC, a wonderful hydrocolloid.

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Authors contributions

Nguyen Phuoc Minh arranged the experiments and also wrote the manuscript.

Compliance with ethical standards

Conflict of interest: The author strongly confirmed that this research is conducted with no conflict of interest.

Ethical issues: None.

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