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Effect of duration and steaming cycle on nutritional value and functional properties of instant fried corn rice

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Abstract

Food is not only seen as products for nutritional needs but also as products with functional properties that are beneficial for health. Corn has the potential benefit of local food to be developed as an alternative staple food. In addition to having good nutritional value and functional properties, the availability of corn in certain areas is ubiquitous. This study aimed to observe variables consisting of a different method of steaming on the characteristics of nutritional value and functional properties of Instant Fried Corn Rice. Data were analysed in triplicates using a completely randomized design and post analysed using Duncan's multiple range test. The results showed that the steaming time of 30 mins for 1, 2, and 3 times has a shorter cooking time, greater rehydration ratio, and water absorption and tends to be lower in volume expansion compared to 15 mins, 20 mins, and 25 mins of steaming time. The treatment with 1-cycle of steaming had a dietary fibre content of 13.80% db, significantly higher than the 2-cycle and 3-cycle steaming process. The 2-cycle treatment had a carotene content of 61.79 µg/g, higher than 1-cycle and 3-cycle.

1. Introduction

In recent years, people prefer food with less duration of cooking time. Instant rice is one of the main courses that consumers easy to prepare and eat (Chen *et al*., 2022). For example, the flavoured rice that is often consumed is fried rice. Fried rice is made from steamed rice that is stir-fried with the addition of some spices, vegetables, chicken, fish, and salad (Ankar-Brewoo *et al*., 2020). For increasing the nutritional value of fried rice, corn rice is used as the base material.

Corn (*Zea mays* L.) is a cereal plant that is rich in carbohydrates other than rice and wheat. Corn production in Indonesia tends to increase every year. As recorded in 2015, Indonesia yielded 20 million tons of corn and had been projected to reach 24.10 million tons in 2019 (BAPPENAS, 2017). The main composition of corn is starch 74-88%, consisting of amylose 26-28% and amylopectin 72-74% (Lutfi *et al*., 2021). Corn also contains high protein 19-24% (Zhang *et al*., 2021). In addition, corn contains fat as much as 4.5 g/100 g material, higher than rice (0.7 g/100 g material). Corn fat consists of 82.1% unsaturated fatty acids, which provides good benefits in improving the lipid profile of subjects with hypercholesterolemia. Corn is also a good source of minerals, such as sodium, calcium, phosphorus, zinc, manganese, iron, copper, and magnesium (Maki *et al*., 2015; Prasanthi *et al*., 2017). In addition, corn contains bioactive compounds such as phenolic acids (ferulic acid, coumaric acid, syringic acid), carotenoids, and dietary fibre. Other than improving digestive health, consuming corn can reduce the risk of chronic diseases such as cardiovascular disease, type 2 diabetes, and obesity (Siyuan *et al*., 2018).

Food product innovation continues to develop to market demand. Making instant fried corn rice is one of the efforts to develop local products with Indonesian tastes that are popular in the community. The addition of typical Indonesian spices is expected to improve the sensory quality of the product, making the product more attractive to consume. This study aimed to further examine the effect of different steaming methods on cooking quality, nutritional value, and functional properties of instant fried corn rice.

2. Materials and methods

2.1 Materials

The raw material that is used is local white corn obtained from farmers in the Grobogan area, Central

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Java, Indonesia. Spices that use in this fried rice are fried onion, garlic powder, salt, pepper, and frying oil. The chemicals used were purchased from Sigma (USA).

2.2 Experimental design

The experimental design of this research uses two factors, duration and steaming cycle. The duration of steaming decided into four-level, there are 15, 20, 25, and 30 mins. The cycle consisted of three-level; 1-cycle, two-cycle and 3-cycle of the steaming process. The combination of two factors generates 12 units of the experiment.

2.3 Sample preparation

The corn was milled into 20 mesh to make the corn rice. The corn rice was soaked in water for 2 hrs and drained. Then milled again and dried at 70°C for 4 hrs. Dried corn rice was sieved at 60 mesh and then carried out the steaming process. The treatment was separate based on the steaming cycle and steaming duration (Table 1). Steamed corn rice dried at 45°C for 6 hrs to produce instant corn rice. Instant fried corn rice is made from the stirred mix of instant corn rice, frying oil, fried onion, garlic powder, salt, and pepper.

Table 1. The method of instant corn rice steaming process

Steaming Cycle	Steaming duration (mins)
1	15
1	20
1	25
1	30
2	15
2	20
2	25
2	30
3	15
3	20
3	25
3	30

2.4 Proximate analysis

The proximate analysis consists of water content analysis, ash content, total protein content, and fat content according to the method (AOAC, 1995). Carbohydrate content was calculated based on by difference method with the following equation:

Carbohydrate% = 100% - (%water + %protein + %fat + %ash)

2.5 Dietary fibre

Dietary fibre content was analyzed by referring to the method of Asp *et al.* (1983). The dry sample was extracted for fat with petroleum ether at room temperature for 15 mins and then dried. Fat-free sample (1 g) was put into Erlenmeyer and then added 25 mL of 0.1 M phosphate buffer pH 6 and made into suspension. The sample was added 0.1 mL termamyl and covered with aluminium foil. The sample was incubated at 100°C for 15 mins and cooled down. Distilled water (20 mL) was added to the sample and adjusted pH to 1.5 by adding 4 M HCl. The mixture was added with pepsin, covered, and incubated at 40°C for 60 mins while being agitated. The samples were added to 20 mL of distilled water and the pH was adjusted to 6.8. 100 mg of pancreatin was added, close, and incubated at 40°C for 60 mins while being agitated. Finally, the pH was adjusted with HCl to 4.5. the residue was obtained by filtration using a crucible containing celite (dry weight). The residue was then washed with 20 mL of distilled water, 20 mL of 95% ethanol, and 20 mL of acetone. The residue was dried at 105°C to a constant weight (about 12 hrs) and weighed after cooling in a desiccator. The residue was then ashed in the furnace at 525°C and cooled in a desiccator to the weighed. The blank value was obtained in the same way but without using a sample.

2.6 Total carotene

Total carotenoids were measured using the PORIM (1995) method with slight modification. The sample was weighed about 0.1 g and was put into a 25 mL measuring flask. The sample was dissolved with hexane till the mark, by shaking until it is completely homogenous. The sample absorbance was measured at 446 wavelength nm using a spectrophotometer.

2.7 Total phenolic content

Analysis of total phenolic compound refers to the Folin-Ciocalteau by Roy *et al*. (2009). A hundred and twenty-five microlitres reagent of Folin Ciocalteu, 125 µL sample dilution, and 250 µL distilled water were put into a test tube. The mixture was shaken with vortex and left for 5 mins at room temperature. An amount of 125 µL Na_2CO_3 (7%) was added to 1 mL of distilled water. The mixture was shaken with a vortex and incubated at room temperature for 90 mins. The total phenolic determines used spectrophotometer at λ 760 nm. Gallic acid was used as standard, and total phenolic content was determined in terms of the equivalent amount of gallic acid (GAE/g) sample.

2.8 Antioxidant activity

Antioxidant activity was analyzed based on the ability to scavenge free radicals (% RSA) based on the method of Sompong *et al*. (2011), with few modifications. A total of 200 µL sample or standard was mixed with 1 mL reagent DPPH 0.1 mM and vortexed. After incubation in the darkroom for 60 mins, the

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solution was calibrated at the maximum wavelength (λ 515 nm).

2.9 Rehydration ratio

The rehydration ratio was measured following the method of Obeta *et al*. (2019). Approximately 100 mL of water at 95°C was put into 10 g of instant rice. Excess water was removed by drying and samples were weighed every 2 mins for 40 mins.

2.10 Volume expansion

The volume expansion of instant rice was measured following the method of Obeta *et al*. (2019) with slight modification. A sample of 10 g instant rice was placed in a volumetric cylinder and the volume was recorded. Water at 95°C was added and increased volume was measured after 40 mins.

2.11 Data analysis

Data analysis used analysis of variance (ANOVA) and significant difference test using Duncan multiple range test with 95% level using SPSS 25.0 software. The results shown are the average of repetition.

3. Results and discussion

3.1 Raw material characteristics

The main material of this research is corn, therefore, the component present in corn must be analyzed. The chemical composition of white corn kernels is shown in Table 2. The results of this study showed that white corn contains 13.56% water content, 0.68% ash content, 9.13% protein content, 1.55% fat content, and 88.64% carbohydrate content. In addition, 100 g of corn kernels contain calories of 350.25 kcal. Besides having good nutritional content, corn has the potential to be developed as a functional food, with a total dietary fibre content of 20.54%. Mora *et al*. (2013) also found that the dietary fibre content of corn was 26.56%. Dietary fibre is carbohydrate polymer with 10 or more monomer units, which are not hydrolyzed by endogenous enzymes in the human small intestine.

Dietary fibre consumption is associated with gut health, weight control, and metabolic health. Dietary fibre intake can also reduce the risk of cardiovascular disease, prevent colon cancer, and improve colon health (Barber *et al*., 2020). The nutritional content and phytochemical compounds of corn include vitamins (A, B, E, and K), minerals (Mg, P, and K), phenolic acids (ferulic acid and coumaric acid), carotenoids, flavonoids, and dietary fibre. Regular consumption of corn has been studied to reduce the risk of chronic diseases such as cardiovascular disease, type 2 diabetes, and obesity, as well as improve digestive health (Siyuan *et al*., 2018). White corn contains total carotene of 2.00 g/g and a total phenolic of 24.87 mg GAE/100 g with antioxidant activity of 6.41 %db.

Table 2. Corn kernel chemical composition

Parameter	Content
Moisture Content (%wb)	13.53±0.08
Ash Content (%db)	0.68±0.01
Protein Content (%db)	9.13±0.05
Fat Content (%db)	1.55±0.02
Carbohydrate Content (bdf) (%db)	88.64±0.03
Total Calories (kcal)	350.25±0.41
Total Dietary Fibre (%db)	20.54±0.16
Total Carotene Content (µg/g)	2.00±0.02
Total Phenolics (mg GAE/100 g)	24.87±3.66
Antioxidant Activity (%db)	6.41±0.20

Values are presented as mean±SD of triplicates. db: dry basic, wb: wet basic.

3.2 Physical properties of instant corn rice

Some of the physical properties of instant corn fried rice observed were cooking time, rehydration ratio, water absorption, and volume expansion. Cooking time testing is done by heating three parts of water until it boils, after that one part of instant corn rice is cooked until it's done. The results of cooking time observations are shown in Table 3. Table 3 shows the cooking time of steaming 1-cycle > 2-cycle > 3-cycle. This can be affected due to different steaming methods that can affect the cooking time of instant rice products, which may also be because of differences in the porosity of instant rice. A porous structure can increase water absorption. In addition, precooking by steaming can cause pre-gelatinization and cause a faster rate of water absorption that reduces cooking time. Steaming at high temperatures can result in lower cooking times (Piyawanitpong *et al*., 2018).

The molecular characterization of instant rice that has undergone gelatinization and drying is irreversible. As a result, dry components could reabsorb large quantities of water (rehydration). Therefore, instant rice's rehydration property is used to facilitate water reabsorption (Sasmitaloka *et al*., 2019). The value of the rehydration ratio of instant corn fried rice with the one-cycle steaming process was 2.11-2.58 and 2.11-2.58 lower than the two-cycle and three-cycle steaming process. The gelatinization process, which is heating with high water content, produces melting accompanied by hydration and irreversible dilation. When the instant corn rice is re-cooked, the hydrogen bonds between amylose molecules are released and bind more water molecules, then the amorphous characteristic assists velocity the rehydration. Gelatinization is a process in

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Table 3. Physical properties of instant fried corn rice with different steaming conditions

Rehydration ratio				
Cycle	Duration			
	15 mins	20 mins	25 mins	30 mins
1	1.74±0.00^{aA}	1.87±0.02^{bA}	1.92±0.01^{cA}	2.05±0.01^{dA}
2	2.31±0.00^{aB}	2.55±0.02^{bB}	2.59±0.01^{cB}	2.62±0.01^{dB}
3	2.44±0.02^{aC}	2.61±0.03^{bC}	2.74±0.02^{cC}	2.80±0.02^{dC}
Volume extension (%)				
Cycle	Duration			
	15 mins	20 mins	25 mins	30 mins
1	318.75±1.75^{bB}	318.75±2.88^{bB}	312.50±1.31^{aB}	312.50±1.40^{aB}
2	312.50±2.07^{cA}	305.50±2.08^{bA}	300.00±0.67^{aA}	300.00±0.66^{aA}
3	312.50±2.56^{bA}	303.75±3.65^{aA}	300.00±1.89^{aA}	300.00±2.14^{aA}

Values are presented as mean±SD of triplicates. Values with different superscripts are statistically significant different ($p<0.05$) where lowercase superscript were compared within the duration while uppercase superscript were compared within the cycle.

which the amylose component in starch is transformed into a gel. A gel network is formed due to the reduction of hydrogen bonds between amylose randomly. Gel on starch is able to form a matrix that can hold water (Olawoye *et al*., 2022). Table 3 shows the value of the treatment volume expansion with a steaming time of 15 mins > 20 mins > 25 and 30 mins. It could be caused by the differences in the molecular structure of starch. Gelatinized starch granules have been deformed, causing their properties to not return to their original form. The water absorption capacity of corn starch that has granule modification can absorb more water. But swelling power ability of modified corn starch was lower at temperatures of 50-60°C (Oyeyinka *et al*., 2021). It indicates that fried corn rice is more compact, requiring less packaging space.

One of the most significant parameters in the production of instant food products is texture. The texture of instant fried corn rice is affected by the steaming procedure for various duration and stages (Hardness, Cohesive, Springiness, and Adhesion). In general, the steaming time is inversely proportional to the hardness value, the longer the steaming time, the smaller the hardness value. According to Table 4, the hardness value increases as the duration and stages of steaming increase. However, at the 3-cycle steaming process, 20 mins to 25 mins steaming showed a decrease in hardness value and then an increase again in duration 30 mins steaming process. This is feasible because white corn has a higher amylose content (31.05%) than regular corn (27%), and so has a harder texture. The presence of gelatinized starch in the rice kernel will undergo retrogradation if it is at a lower temperature, this greatly determines the nutritional and texture attributes of ready –to–eat rice Gelatinized starch inside the rice kernel is thus going through the retrogradation process, which can largely determine the nutritional and textural attributes of cooked rice (Li *et al*., 2022). The decrease in hardness at cycle 3 duration of 25 mins was attributable to increased water absorbed during the gelatinization process, like free water that was previously outside the starch granules diffused into the starch. An increase in the hardness level of starch is associated with a decrease in water holding capacity, a decrease in insoluble protein, and an increase in salt content (Samuelsen *et al*., 2013). The amount of water that enters the starch granules increases as the steaming time increases, softening the texture. According to Phukasmas (2019), the texture value will decrease during the steaming process.

The cohesive showed an increase in yield at the 3-cycle steaming 20 mins duration treatment. This is consistent with the results of water absorption, which increases with the length of steaming, causing the mass of the material's strength or cohesiveness to reduce. Springiness is a parameter that represents the ability of a material to return to its initial position. The quantity of amylopectin in a product has a significant impact on its characteristics, particularly texture. According to Wang *et al*. (2020), the presence of amylopectin in starch is around 70 – 88% which plays an important role in the formation of the crystal structure of starch granules and affects the physicochemical properties of rice.

The highest springiness results were found in the steaming duration of 30 mins on both samples 2-cycle and 3-cycle. This treatment resulted in increased heat and excess water causing the amylose molecules to diffuse out of the granules and continued until all amylose diffused out, leaving amylopectin. While the adhesion showed a decrease with the increasing steaming cycle. In the gelatinization process, starch granules are hydrated, amylose dissolves, and the bond strength in the starch granules decreases, followed by stronger bonds between granules and an increase in viscosity (Wang *et*

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Table 4. Texture value of instant fried corn rice with different steaming conditions

Hardness (g)				
Cycle	Duration			
	15 mins	20 mins	25 mins	30 mins
1	1722.50±41.42^{aA}	1959.75±60.46^{aA}	2340.5±47.19^{aA}	3395.5±58.80^{bB}
2	3620.13±61.15^{aA}	3624.75±75.31^{aA}	3749.5±10.61^{aA}	4156.5±75.36^{aB}
3	3129±77.07^{bA}	3332.25±13.60^{bB}	2151.25±32.69^{aB}	4135.25±72.18^{cC}
Cohesiveness				
Cycle	Duration			
	15 mins	20 mins	25 mins	30 mins
1	0.50±0.50^{bA}	0.44±0.03^{bA}	0.31±0.06^{aA}	0.27±0.04^{aA}
2	0.42±0.06^{abA}	0.39±0.01^{abA}	0.49±0.02^{bB}	0.37±0.03^{aB}
3	0.52±0.03^{abA}	0.63±0.04^{cB}	0.57±0.01^{bcB}	0.49±0.01^{aC}
Springiness				
Cycle	Duration			
	15 mins	20 mins	25 mins	30 mins
1	1.80±0.40^{aA}	2.20±0.20^{aA}	1.70±0.30^{aA}	2.45±0.05^{aA}
2	2.65±0.25^{aA}	2.40±0.20^{aA}	2.30±0.00^{aA}	2.70±0.00^{aB}
3	2.50±0.30^{aA}	2.50±0.20^{aA}	2.00±0.20^{aA}	2.65±0.05^{aB}
Adhesiveness (g.s)				
Cycle	Duration			
	15 mins	20 mins	25 mins	30 mins
1	1.97±0.60^{aA}	1.85±0.16^{aC}	4.07±0.81^{aB}	4.28±0.04^{aC}
2	1.08±0.02^{aA}	0.81±0.03^{aB}	0.74±0.23^{aAB}	1.74±0.05^{cB}
3	0.61±0.37^{aA}	0.29±0.03^{aA}	0.32±0.11^{aA}	0.73±0.01^{aA}

Values are presented as mean±SD of triplicates. Values with different superscripts are statistically significant different ($p<0.05$) where lowercase superscript were compared within the duration while uppercase superscript were compared within the cycle.

al., 2015) The increase in viscosity causes the texture of the material to become denser and more compact, furthermore, the adhesion decreases. However, there was an increase in the adhesive value at 30 mins of steaming time in each cycle. This can be influenced by a decrease in the proportion of short amylopectin chains and amylose chains, causing a decrease in adhesion (An *et al*., 2021).

3.3 Nutritional content of instant corn fried rice

The utilization of corn as instant corn fried rice is one of the efforts to optimize agricultural products and support food security. Corn has the potential to be developed into a processed food for instant corn fried rice since it provides nutrients and phytochemical components that are beneficial to human health. Table 5 shows the nutritional value of instant corn-fried rice.

Corn rice has a lower glycaemic index than rice and potatoes, therefore it can be used as a rice substitute. With the benefits of corn that can be used as a functional food and improvement for instant corn, rice products are required to make the products easier to consume. Instant corn fried rice has a water content of 7.93-9.76%, ash content of 0.55-0.57%, protein content of 8.74-8.88%, fat content of 3.06-3.2%, carbohydrate content of 87.41-87.64% with total calories of 373.1-381.03 kcal. The water content of the instant corn fried rice has met the quality standard of rice-based foods listed in SNI 6128:2015 which is a maximum of 14-15%. Corn has the main nutritional content in the form of starch (72-73%), with simple sugar content including glucose, fructose, and sucrose ranging from 1-3%, and protein 8-11%. Hidayat *et al*. (2017) studied the nutritional content of corn rice based on modified cornflour and modified cassava flour, with an ash content of 0.23%, fat of 1.82%, protein of 10.31%, total starch of 81.88%, and amylose of 43.91%. The 1-cycle and 30 mins steaming sample resulted in lower water content than the 2-cycle in the same duration time of steaming. This is related to the steaming method used. Sample 2-cycle of steaming had a greater water content after being steamed twice. An increase in the temperature of starch can increase swelling power, therefore it can absorb more water (Zhong *et al*., 2022). The increased water absorption of pre-gelatinized starch resulted in higher water content (Gatade and Sahoo, 2015). Meanwhile, the 3-cycle treatment of the steaming process showed a lower water content than the 2-cycle. This is possible because excessive heating can release more water.

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Table 5. Nutritional content of instant corn fried rice with different steaming conditions

Parameter	Steaming Condition (Cycle/Duration)		
	1/30 mins	2/30 mins	3/30 mins
Water Content (%wb)	7.93±0.06[a]	9.76±0.17[b]	8.00±0.10[a]
Ash Content (%db)	0.55±0.01[a]	0.57±0.02[a]	0.56±0.02[a]
Protein Content (%db)	8.75±0.03[a]	8.88±0.03[b]	8.74±0.01[a]
Fat Content (%db)	3.20±0.04[a]	3.14±0.08[ab]	3.06±0.10[b]
Carbohydrate Content (%db)	87.50±0.06[a]	87.41±0.07[a]	87.64±0.08[b]
Total Calories (kcal)	381.03±0.28[b]	373.1±0.99[a]	380.02±0.89[b]

Values are presented as mean±SD of triplicates. Values with different superscripts within the same row are statistically significant different ($p<0.05$).

3.4 Functional characteristics of instant corn fried rice

The difference in steaming treatment shows the effect on the functional properties of instant fried corn rice. The highest total dietary fibre obtained from 1-cycle steaming for 30 mins, there was 13.80 (%db), while the highest total carotene content was 61.79 (µg/g) obtained from 2-cycle treatment, the highest total phenolic was 43,74 (mg as. gallate/100 g) from 1-cycle treatment, and the highest antioxidant activity was 9.67 (%db) from 3-cycle treatment. These parameters make the instant fried corn rice product to be a potential functional food.

Corn is a commodity that contains high dietary fibre. Dietary fibre is divided into two types based on its capability to dissolve in water: soluble dietary fibre and insoluble dietary fibre. Soluble fibre include pectin, gum, β-glucan, cellulose, hemicellulose, and lignin (Oliveira Junior *et al*., 2014; Ai and Jane, 2016). Steaming intensity is inversely proportional to total dietary fibre. The more stages of steaming, the lower the total dietary fibre amount of instant fried corn rice. This happens because soluble dietary fibre migrates into the corn endosperm through water vapour. The longer the heat is applied, the more the migration fibre is forced out of the endosperm, reducing the total dietary fibre. Table 2 shows the total dietary fibre in corn kernels as much as 20.54 (%db). The steaming time process is possible to increase the dietary fibre content in food (Kalala *et al*., 2018; Andersson *et al*., 2022).

Total carotene levels showed an increase from the 1-cycle to the 2-cycle and then decreased at the 3-cycle treatment (Table 6). Thus, the total carotene concentration increases as the heating time increase but decreases once it reaches the optimum level, as in the three-time steaming treatment. This is in line with the research of Anggreini *et al*. (2018), total carotene levels in Licuala palm fruit peels increased with increasing temperature and heating time; however, total carotenoids declined after exceeding 110°C temperature and heating time used for more than 30 mins. Meanwhile, Nilasari *et al*. (2017) found that when the temperature of yellow pumpkin look was raised over 70°C for more than 90 mins, the total carotene content decreased. Due to the oxidation process at high temperatures, the carotene was degraded during the three times steaming procedures. When oxidation continues, volatile compounds will be formed, and the degradation of carotene compounds into aldehydes and ketones with lower molecular weights (Nilasari *et al*., 2017). Repeated steaming steps resulted in the carotene structure undergoing thermal isomerization into cis form. The cis-form has lower stability than the trans-form inducing the compound to be easily oxidized.

Total phenolic showed a decrease in direct proportion to the treatment with the addition of steaming repetitions. The 1- cycle treatment had the highest total phenolic content (Table 6). The intensity of compound interaction with the heating temperature increased with repeated steaming, leading to a decrease in total phenolic compounds in the 2-cycle and 3-cycle treatments. These results are in line with the research of Deng *et al*. (2018) and Maghsoudlou *et al*. (2019), increasing the intensity of the interaction of compounds with high temperatures causes a decrease in the total phenolic compounds due to structural damage. In the 2-cycle and 3-cycle treatments, repeated interaction with boiling water vapour occurs resulting in compound degradation and was considered to affect the stability of the phenolic compounds. Several elements, including pH, temperature, light, and oxygen, can affect the stability of phenolics (Ali *et al*., 2018).

Antioxidant activity is a parameter that describes the percentage of the ability of a food or food ingredient to inhibit free radicals. For example, Carotene and phenolic acids are antioxidants that help the body fight free radicals. Therefore, both can be used as antioxidant activity indicators. The antioxidant activity decreased at the 2-cycle and then rose at the 3-cycle treatment, as seen in Table 6. This is possible due to the decrease in phenolic compounds with increasing interaction with high temperatures in the repeated steaming process. Overheating allows a decrease in compounds that function as free radical scavengers (Anggraeni *et al*., 2015). However, the three-cycle sample shows a higher chance of an increase in the activity of other

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Table 6. Functional characteristic of instant corn fried rice with different steaming conditions

Parameter	Steaming Condition (Cycle/Duration)		
	1/30 mins	2/30 mins	3/30 mins
Total Dietary Fibre (%db)	13.80±0.08[a]	10.47±0.09[c]	12.15±0.05[b]
Total Carotene Content (µg/g)	59.44±0.76[b]	61.79±0.94[a]	55.97±0.44[c]
Total Phenolic (mg GAE/100 g)	43.74±0.51[a]	42.89±0.93[a]	40.57±0.64[a]
Antioxidant Activity (%db)	9.25±0.25[a]	9.05±0.17[a]	9.67±0.11[b]

Values are presented as mean±SD of triplicates. Values with different superscripts within the same row are statistically significant different ($p<0.05$).

antioxidants, such as carotene, which could enhance levels with increased temperature interaction but would decrease after reaching the optimum point. Heating treatment can cause carotene release from the food matrix (Hwang *et al*., 2012). Furthermore, the 3-cycle treatment can produce new antioxidant molecules, which can boost their effectiveness during treatment.

4. Conclusion

Steaming duration and steaming cycle have a significant effect on the rehydration value and volume expansion. The steaming duration of 30 mins gave a significantly higher rehydration ratio value ($p<0.05$) than other time duration. More steaming cycles also showed a higher rehydration ratio and lower extension volume. The 30 mins steaming duration showed a higher hardness value, and lower cohesiveness, but tended not to significantly differ in the springiness and adhesiveness value for the entire steaming duration treatment. The treatment with 1-cycle of steaming had dietary fibre content of 13.80% db, significantly higher than the 2-cycle and 3-cycle. The 2-cycle with 30 mins duration of the steaming sample had a carotene content of 61.79 µg/g, higher than the 1-cycle and 3-cycle.

Conflict of interest

The authors declare no conflict of interest.

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