Food Research 6 (Suppl. 2) : 23 - 31 (2022)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

FULL PAPER

Incorporation of soybean curd residue (*okara*) and its effects on nutritional and organoleptic properties of cassava crisp (*opak*) for healthy snacking

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Article history:
Received: 17 August 2021
Received in revised form: 26 September 2021
Accepted: 9 November 2022
Available Online: 8 December 2022

Keywords:
Cassava crisp (*opak*),
D-optimal mixture design,
Organoleptic properties,
Snack,
Soybean curd residue (*okara*)

DOI:
https://doi.org/10.26656/fr.2017.6(S2).020

Abstract

Soybean curd residue (SCR) or *okara* is a by-product generated during the production of soy milk or tofu. It contains high dietary fiber and protein that are beneficial for the maintenance of normal bowel function and also for building and repairing body tissues. However, it is used as stock feed and fertilizer or dumped in landfills. Therefore, this study was conducted to incorporate the SCR into traditional cassava crisp (*opak*) to produce healthier snacks and add value to this nutritious waste. Thirteen formulations with different proportions of grated cassava/SCR powder/tapioca flour were generated by D-optimal Mixture Design. Dietary fiber, protein content and sensory scores were the responses. Higher proportions of SCR increased the protein and dietary fiber content but decreased the organoleptic scores. Thus, the optimum formulation (85% grated cassava, 6% SCR powder and 6% tapioca flour) was selected for the high dietary fiber content and the highest scores of sensory properties (taste, texture and overall acceptability). Incorporation of the SCR powder in the final product enhanced the dietary fiber and protein content of the traditional *opak* and reduced the fat content by approximately three, six and 1.5 times. Hence, this improved formulation of *opak* will be a better choice for consumers for their healthier snacking.

1. Introduction

Soybean curd residue (SCR) or *okara* is the by-product from soymilk and tofu processing obtained after extracting the water or milk fraction. Approximately, 1.1 to 1.2 kg of this white or yellowish insoluble part of soybean also known as soy pulp or tofu dregs is produced from every kilogram of soybeans (Khare *et al*., 1995). The fresh SCR has high moisture content (~80%), which makes it easily deteriorate and therefore; it is normally used as animal feed, fertilizer or dumped in a landfill. However, this waste is rich in nutritional value as it contains high dietary fiber (~50%) and protein (~25%), unsaturated fatty acids, monosaccharides and oligosaccharides, considerable vitamins, minerals and isoflavones (Li *et al*., 2012). Various health functions of SCR were reported by researchers and the main focus was its dietary fiber which can prevent constipation and colon cancer, lower blood pressure, reduce the level of cholesterol in the blood, regulate blood sugar levels, and also protect against coronary heart disease (Li *et al*., 2013). Due to its health benefits, many studies have been conducted to incorporate SCR in different food and medical industry application such as bakeries, extruded snack foods, and also as natural immobilizer (Josephine and Rubiyah, 2018).

Despite various definitions of snack foods proposed in the literature, Hess *et al*. (2016) concluded it as energy -dense, nutrient-poor foods that are consumed between regular meals. A range of products are in this category and one of them is chips (British) or crisps (Americans). Although chips or crisps are generally known as thinly sliced fried potatoes, the same terms are used for such products from different sources of starchy tubers (i.e., cassava or sweet potato). On the other hand, snack food manufacturers produce two types of crisps which are the

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eISSN: 2550-2166 /
Published by Rynnye Lyan Resources

typical sliced fried crisps from fresh tubers and also restructured crisps from paste or dough of the tubers with other ingredients incorporated such as starches and flour. The latter are molded into shapes by pressing or extruding before frying or baking (Pedreschi *et al*., 2018). Both of them have different flavor and textural characteristics. In fact, most people distinguish these two products by naming them as chips for the former and crisps for the latter.

Opak is a traditional cassava crisp that is popular among Javanese people. This snack is also known as Samiyer or Miler. Its preparation is quite meticulous and involved grating the cassava and mixing with other ingredients (salt or spices) to form a paste. Then, it is shaped round and flatted as thin as possible before drying under the sunlight and deep fried (Herminingrum, 2019). Due to these quite thorough preparation steps, it is commonly produced by old folks or village communities and was unfamiliar to the younger generations and urban populations. A review by Hess *et al*. (2016) showed that snacks are consumed by all ages for different reasons that are influenced by social culture, food culture and socioeconomic status; and crisps or chips are always one of their choices. Findings from a recent study conducted among 2013 respondents from Malaysian primary and secondary students exhibited that 95% of them ate one to three times of snacks a week (Man *et al*., 2020). Consumption of crisps or chips that are categorized and considered as unhealthy snacks (energy-dense with high oil or fat and lack of fiber and protein as well as micronutrients) are accounted for a deleterious diet which mitigated cognitive ability, linked to higher risks of having metabolic syndrome and also weight gain (Bellisle, 2014; Smith and Rogers, 2014; Hess *et al*., 2016; Man *et al*., 2020; Mehlhose *et al*., 2021). Hence, this study was conducted to incorporate SCR into an *opak* (cassava crisp) and investigate its effect on nutritional and organoleptic properties for healthy snacking.

2. Materials and methods

2.1 Materials

Cassava *var.* Sri Pontian was obtained from a farm in The Permanent Food Park (TKPM), Ayer Hitam Agriculture Institute, Batu Pahat, Johor. Soybean curd residue was collected from a tofu factory in Johor Bahru (Biovital Marketing). Other ingredients such as tapioca flour, table salt and sugar as well as the commercial traditional *opak* were purchased from local market. All chemicals for nutritional analyses were of ACS reagent grade and purchased from local distributors.

2.2 Sample preparation

2.2.1 Preparation of soybean curd residue (okara) powder

Collected SCR was instantly steamed for fifteen mins as a pre-treatment step to delay the degradation. Then, it was flattened on a tray and placed in a cabinet dryer (Model 6031, Taiwan) at a temperature of 80°C for about 8 to 10 hrs until the moisture content reaches 5 to 7%. After that, the dried SCR was ground into powder using an industrial mixer grinder (Model MX-AC210S, India) and kept in air tight containers till further use.

2.2.2 Preparation of grated cassava

Due to rapid post-harvest deterioration, the cassava (*var*. Sri Pontian) obtained from the farm was processed promptly. Soil and dirt were removed from the roots. Then, the outer and inner skins were peeled and they were thoroughly washed. After soaking in tap water for approximately 10 mins to drain out the excess starch, the cassava was grated using PX cutting disk of Dito Sama Vegetable slicer (Model TR21, France). Next, it was packed in a nylon polyethylene bag and submitted to blast freezing before stored at -18°C until use.

2.3 Experimental design

Three variables (% grated cassava; % tapioca starch and % SCR powder) and five responses (dietary fiber and protein content and sensory evaluation scores for taste, texture and overall acceptance) were chosen to optimize the formulation of the *opak*. The selected appropriate ranges of variables (Table 1) were determined from preliminary studies. Thirteen formulations were generated from D-optimal mixture design using Design-Expert version 6.0 software as shown in Table 2.

Table 1. Parameters (variables) studied in optimization of the opak formulation

Code	Parameters (Variables)	Low level	High Level
A	Percentage of grated cassava	80	90
B	Percentage of SCR powder	6	12
C	Percentage of tapioca starch	0	6

2.4 Preparation of opak

Opak was prepared using traditional method described by Che Rahani (2005) with some modifications. All the ingredients with the proportions in Table 2 were mixed in a mixer (Model TS-108, Taiwan) and the dough was sheeted on a table-top dough sheeter (Model 450A, Taiwan) to get a uniform thickness (~1 mm). Next, the sheet was steamed for 2 mins and directly cut manually into round shapes using a fabricated stainless steel mould (diameter: 5.5 cm). After that, the *opak* was deep-fried at 160 to 170°C for 30 s

https://doi.org/10.26656/fr.2017.6(S2).020

with the ratio of *opak* to oil was 1:10 using MSM 5.5L Countertop Single tank fryer timer (Model DFT-3000, Malaysia). Then, the oil was drained using oil expeller (Model BL-10, Taiwan) and seal packed in aluminum/ OPP bag for further analyses.

Table 2. Percentage composition of *opak* (100%)

Formulation	A	B	C	Salt*	Sugar*
F1	80.0	11.0	6.0	1.2	1.8
F2	82.5	10.3	4.3	1.2	1.8
F3	87.5	6.0	3.5	1.2	1.8
F4	80.0	11.0	6.0	1.2	1.8
F5	85.0	6.0	6.0	1.2	1.8
F6	85.0	12.0	0.0	1.2	1.8
F7	90.0	6.0	1.0	1.2	1.8
F8	90.0	6.0	1.0	1.2	1.8
F9	82.5	8.5	6.0	1.2	1.8
F10	85.0	6.0	6.0	1.2	1.8
F11	87.5	9.5	0.0	1.2	1.8
F12	85.0	9.0	3.0	1.2	1.8
F13	82.5	12.0	2.5	1.2	1.8

*Percentage of salt and sugar were fixed

2.5 Nutritional analysis

Total dietary fiber was analyzed by the enzymatic-gravimetric method (AOAC 985.29), and protein content by the Kjeldahl method with a conversion factor of 6.25 (AOAC 991.22), and fat content by Soxhlet extraction (AOAC 945.39). Carbohydrate and energy were calculated according to the Guide to Nutrition Labeling and Claims (Expert Committee on Nutrition, Health Claims and Advertisement, 2010). All analyses were done in triplicates.

2.6 Sensory evaluation

Sensory evaluation was carried out by 35 untrained panelists (n = 35). Four sessions were conducted with three or four different coded samples given to the panelists for each session. They were asked to rate the taste, texture and overall acceptability of the samples based on hedonic liking scales (1 for dislike very much, 2 for dislike, 3 for slightly dislike, 4 for neither like nor dislike, 5 for slightly like, 6 for like, 7 for like very much). Plain water was provided to rinse their mouth before evaluating each sample.

2.7 Data analysis and optimization

Data was analyzed using Design-Expert 6.0 and Minitab 16 statistical software (Minitab Inc., State College, PA, USA). D-optimal mixture design was used to optimize the formulation by selecting the best-fitted model according to its analysis of variance (ANOVA). Any significant differences between samples were determined by Tukey test.

3. Results and discussion

3.1 Selection of variables and generation of formulations by D-Optimal Mixture Design

The percentage of grated cassava, SCR powder and tapioca flour in Table 1 were obtained from preliminary studies by fixing one factor at a time. Formulation of traditional *opak* suggested by Zakaria (2005) was used as the basis for this study. The low and high levels of the variables were selected based on their taste and texture. Since the aim of SCR incorporation into the *opak* formulation was to increase its nutritional values, SCR powder was used rather than wet or fresh SCR. This is due to higher total dietary fiber and protein content in the former than the latter, approximately seven and five times, respectively (Table 3). This observation was in line with previous findings on the increase of their protein and fiber content after drying (Sengupta *et al*., 2012; Ahlawat *et al*., 2018; Kamble and Rani, 2020). D-optimal mixture design was chosen to optimize the formulation as it is an effective and reliable technique for determining the optimum blends of mixture components (Sahin *et al*., 2016). Consumer acceptance is the most important factor in developing new food products and one of the key successes in marketing. Therefore, good sensory or organoleptic properties are crucial in optimizing the product formulation. Thus, besides total dietary fiber (TDF) and protein content, taste, texture and overall acceptability were included in the responses for D-optimal mixture design. Although color and aroma are among the important factors in a sensory test, they are not selected to be in the design because of the insubstantial results during the preliminary study. This may be due to the difficulty in giving a score as the difference between samples is not noticeable. Therefore, 13 different combinations of formulations were generated by the design for the three variables and five responses (Table 2).

Table 3. Total dietary fiber (TDF) and protein content in wet and dried SCR or *okara*

SCR or okara	TDF (g/100 g)	Protein (g/100 g)
Wet	4.7±0.27	2.4±0.21
Dried	37.1±0.31	13.8±0.29

Values are presented as mean ± standard deviation of triplicate determination.

3.2 Analysis of the experimental data

Table 4 shows the experimental data for the thirteen formulations. All responses were affected by different combinations of the factors. However, the significant factors were investigated by statistical analysis using Design-Expert 6.0.10 software. Analysis of the variance of the responses in Table 5 indicated that only the models of total dietary fiber (TDF), texture, and overall acceptability were significant at $p<0.05$. Among them,

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Table 4. Values for the responses of the 13 formulations

Formulation	Total dietary fibre (TDF)[a] (g/100 g)	Protein[a] (g/100 g)	Sensory evaluation[b]		
			Taste score	Texture score	Overall acceptability score
F1	14.3±0.32	3.3±0.18	4.53±1.23	3.77±1.50	4.13±1.24
F2	15.1±0.24	3.3±0.20	4.47±1.36	4.03±1.47	4.13±1.25
F3	9.9±0.21	3.3±0.17	5.00±1.42	4.30±1.47	4.87±1.39
F4	14.3±0.33	3.3±0.13	4.53±1.46	4.33±1.61	4.13±1.24
F5	10.6±0.36	2.9±0.14	6.00±1.44	5.40±1.39	5.67±1.50
F6	15.7±0.28	3.4±0.21	4.97±1.52	4.67±1.61	4.93±1.42
F7	11.4 ±0.37	3.5±0.15	3.93±1.28	4.47±1.40	3.90±1.17
F8	11.1±0.32	2.6±0.11	5.47±1.21	4.60±1.30	4.90±0.98
F9	12.2±0.26	3.8±0.23	4.37±1.52	3.37±1.63	3.90±1.36
F10	10.1±0.25	2.4±0.13	5.67±1.60	5.17±1.89	5.37±1.86
F11	13.7±0.29	3.9±0.19	4.03±1.59	3.67±1.48	3.73±1.63
F12	13.1±0.34	3.3±0.12	4.17±1.74	3.80±1.75	4.07±1.59
F13	16.2±0.33	4.2±0.22	4.17±1.65	4.03±1.78	3.93±1.85

[a]Values are presented as mean ± standard deviation of duplicate determination

[b]Values are presented mean ± standard deviation of 35 untrained panelists. The scores range from 1 for dislike very much to 7 for like very much.

Table 5. Analysis of variance (ANOVA) for the responses of the 13 generated formulations from D-optimal mixture design

	TDF	Protein	Taste score	Texture score	Overall acceptability score
Model	Significant	Not significant	Not significant	Significant	Significant
Lack-of-fit	Not significant	Not significant	Not significant	Not significant	Not significant
R^2	0.9563	0.4040	0.6949	0.7650	0.7761
Adjusted R^2	0.9476	0.2848	0.4769	0.5971	0.6162
Predicted R^2	0.9306	-0.0836	-0.0320	0.3259	0.1140
p value	<0.0001	0.0752	0.0813	0.0361	0.0310
F value	109.54	3.39	3.19	4.56	4.85
C.V. %	3.84	12.56	12.82	11.40	11.39
Adequacy precision	24.493	4.906	5.281	6.099	6.109

TDF had the highest coefficient of determination (R^2), while the other two responses were quite low. Their predicted R^2 was not close to the adjusted R^2 which indicated a large block effect or a possible problem with the model and/or the data. This occurrence was most probably due to the data provided by untrained panelists from different sessions of sensory evaluations that led to the halo effect and proximity error (Losó *et al.*, 2012; Sharif *et al.*, 2017). Nevertheless, the lack-of-it of texture and overall acceptability scores were not significant which suggested that the models were fit. Besides that, the values of adequacy precision for both responses were greater than 4 which were desirable and considered adequate. On the other hand, the *p* values of protein content and taste score designated that their models were insignificant. The low amount of protein in the *opak* and no noticeable difference in taste among the samples were most likely the reason for these results. Hence, further discussions will focus on the effects of the variables on the significant terms. In addition, emphasis will also be given to the SCR powder as the main factor in developing the value-added *opak*.

3.3 Effects of soybean curd residue powder to the total dietary fiber content of the opak

The contour diagram in Figure 1(a) shows a linear relationship between TDF and the deployed component variables. Its final equation is [TDF = 0.061543A + 0.90746B – 0.064547C] (Equation 1) where A is the grated cassava, B is the SCR powder and C is the tapioca flour. The diagram and equation (1) clearly demonstrated that SCR powder is the main factor that contributes to the TDF content in the *opak*. A study by Hawa *et al.* (2018) also observed a significant difference ($p<0.05$) for both the linear and quadratic effect on the fiber content of their cookies prepared by the combinations of *okara* with red teff and wheat. As described in various studies, a major constituent of SCR especially in its dried form is total dietary fiber dominated by the insoluble fiber (IDF) (O'Toole, 1999; Lu *et al.*, 2013; Colletti *et al.*, 2020). The amount of TDF in SCR depends on the soybean cultivar and also the amount of water phase extracted during the tofu or soymilk processing (O'Toole, 1999; Li *et al.*, 2012). It is depicted in Figure 1(a) that the grated cassava imparts a small portion to the TDF content while the tapioca flour acted conversely. Proximate analysis on cassava flesh reported a low amount of crude fiber (Idris *et al.*, 2019) while starch

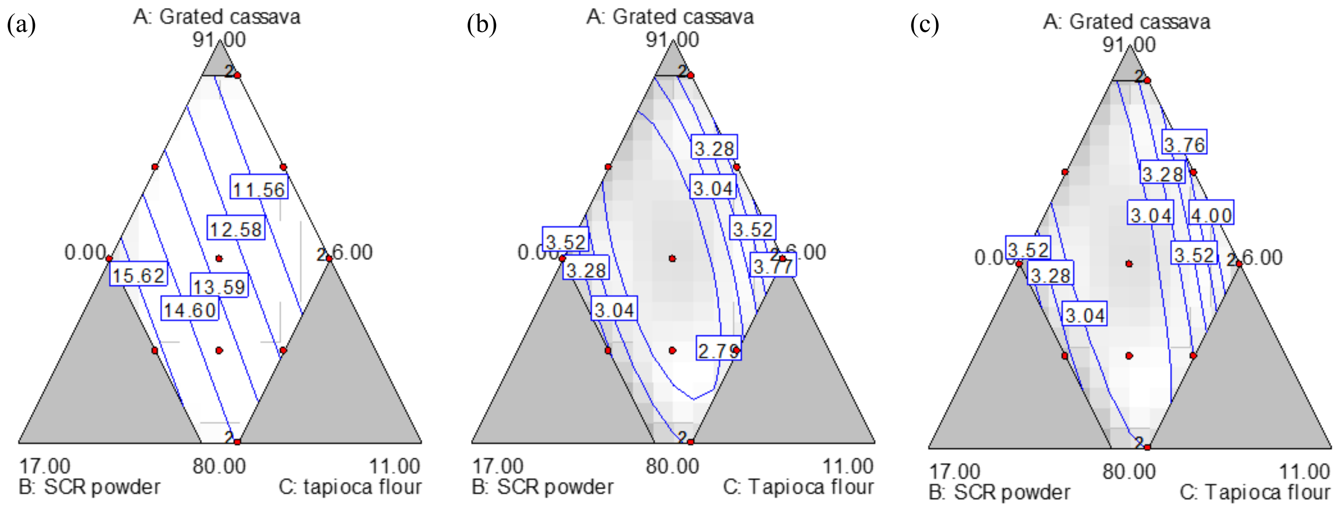

Figure 1. Contour diagrams of relationships between variables and significant responses; (a) TDF, (b) texture score, (c) overall acceptability score

was the main composition of tapioca flour (Dini *et al.*, 2014).

3.4 Effects of soybean curd residue powder to the texture score

Figure 1(b) shows a quadratic relationship between the selected variables and texture score. The final equation of its fitted model is [Texture score = 0.10688A + 7.76520B + 2.55017C – 0.096715AB – 0.024175AC – 0.145BC] (Equation 2). SCR powder (B) was again the main factor that affecting the texture scores as observed on the Equation 2 and the contour diagram. However, its interaction effect with A (grated cassava) and C (tapioca flour) decreased the texture score. This contour pattern exhibited that there is an optimum point for the best combination of the variables to get the considerable texture score. The texture is an important organoleptic property for the quality of *opak* that relates to its crispiness. According to Roudaut *et al.* (2002) and Tunick *et al.* (2013), higher water and dietary fiber content in a food product will decrease its crispiness. The quadratic effect showed in Figure 1(b) proved their reports. Adding SCR powder to the *opak* formulation reduced the water content but also increased its fiber. The interaction of these factors influenced the crispiness of the final product and also the texture score. On top of that, different processing methods and ingredients also affect the texture (Roudaut *et al.*, 2002). Thus, the addition of SCR or *okara* in molded sweet biscuit (Grizotto *et al.*, 2010) and wheat bread (Ostermann-Porcel *et al.*, 2017) necessarily gave different results.

3.5 Effects of soybean curd residue powder to the overall acceptability score

Overall acceptability includes all the evaluated attributes in a sensory test. This score summarizes the panelists' acceptance or preference of the product. Mostly the same relationship trend with the variables was discovered in this response as in the texture score (Figure 1(c)). Final equation for this model is [Overall acceptability = 0.085170A + 6.05550B + 1.95498C – 0.074711AB – 0.015289AC – 0.13718BC] (Equation 3). Its linear effect also demonstrated that the SCR powder had the most influence on the overall acceptability of the developed *opak* formulation. Even so, the SCR addition at a certain level will reduce its impact on the overall acceptability as exhibited in the contour diagram; (Figure 1(c)) expressed by its quadratic effect. As described earlier, high dietary fiber will lessen the crispiness. Furthermore, it also will impart high beany flavor to the *opak* that might be unacceptable by some of the panelists (Ahmed *et al.*, 2018). Although addition of SCR powder in cookies, noodle, bun, bread and snacks from previous studies reported lower acceptability than the control samples; they still presented a great acceptability with the inclusion of certain amount of SCR or *okara* (Wickramarathna and Arampath, 2003; Yaseen *et al.*, 2009; Grizotto *et al.*, 2010; Ostermann-Porcel *et al.*, 2017; Ahmed *et al.*, 2018; Bhavya and Jamuna, 2018; Pan *et al.*, 2018; Lee *et al.*, 2020; Uzo-Peters and Ola, 2020). In spite of that, a recent study by Priulli *et al.* (2021) presented that the tasters who were involved in an affective sensory test preferred the tapioca that was formulated with 30% SCR or *okara* rather than the standard formulation; and it was statistically significant at $p<0.05$. This remarkable discovery revealed that an optimum level of SCR will produce the best product with good sensory properties. All these observations supported the findings in current study.

3.6 Optimization and validation of the model

Optimization of the formulation was carried out by the software. The goals for each response were set. The design generated 85% of grated cassava, 6% of SCR powder and 6% of tapioca flour as the optimum

https://doi.org/10.26656/fr.2017.6(S2).020

formulation. Even though this result gave high desirability (0.883); verification of the data is needed. Percentage of relative standard error (% RSE) between the actual and predicted values was calculated. All responses showed insignificant difference (p>0.05) while their % RSE were less than 10% (Table 6). Thus, the finalized equations (Equation 1, 2, and 3) are acceptable to be used in *opak*-SCR formulation (Sileshi, 2015).

Table 6. Predicted and actual values of TDF, texture, and overall acceptability score with their %RSE

Responses	Predicted value	Actual value	%RSE	*p*-value
TDF	14.09	14.42	2.34	0.231
Texture score	4.10	4.33	5.61	0.942
Overall acceptability score	4.48	4.37	2.46	0.844

3.7 Nutritional composition of final soybean curd residue-opak and its comparison with the traditional opak

Opak was developed using the optimum formulation. It was clearly demonstrated that addition of SCR improved its nutritional values (Table 7). Total dietary fiber and protein content were significantly increased by approximately three and seven times; respectively. In contrast, total fat and energy were significantly reduced in the final *opak*. Only its carbohydrate content was comparable with the traditional *opak*. Since the main composition of SCR powder is dietary fiber and protein (Li *et al*., 2013; Ahlawat *et al*., 2018); its incorporation into product formulations will assuredly raise their amount. This fact was exhibited in most of the conducted studies (Wickramarthna and Arampath, 2003; Yaseen *et al*., 2009; Ostermann-Porcel *et al*., 2017; Lee *et al*., 2020; Uzo-Peters and Ola, 2020). Their consideration of SCR as a functional ingredient with health-promoting effects may be the main reason for its use in previous works.

Table 7. Nutritional composition of final and traditional *opak*

Nutrient	Unit	Value	
		Final opak (with SCR)	Traditional opak (no SCR)
Energy	kcal	438±3.4[a]	497±2.7[b]
Carbohydrate	g/100 g	72.1±1.4[a]	73.0±1.3[a]
Protein	g/100 g	4.2±0.2[a]	1.3±0.3[b]
Total fat	g/100 g	14.8±0.3[a]	22.4±0.4[b]
Total dietary fiber	g/100 g	14.4±0.4[a]	2.4±0.3[b]

Values are presented as mean ± standard deviation of triplicate determinations. Values with different superscript within the same row are significant difference at p<0.05.

Lu *et al*. (2013) reported that the addition of 25%, 15% and 10% of SCR powder to their noodle, steamed bread and bread, respectively have increased their TDF and protein but lowered the available carbohydrate. These samples together with their controls (no SCR) were then tested for their glycemic index (GI) to study their hypoglycemic activities. It showed that the blood glucose levels of the subjects involved in this in vivo study were lower after eating the samples with SCR than the control foods. The results revealed that the samples had lower GI values than the controls and can be considered as low GI foods (GI<55).

The significant decrease of total fat in the SCR-*opak* in this current study was similar to the findings by Bavya and Jamuna (2018). The *okara* enriched buns appeared to have lesser fat content than the control. However, Uzo-Peters and Ola (2020) found the opposite result in their sorghum-*okara* snack or sosa. This could be explained by the difference in preparation technique of the samples. SCR-*opak* was deep-fried while sosa was baked which affect the oil uptakes of the final product. In comparison with the control, addition of SCR powder reduced the water content of the dough. This condition lead to less water loss during the deep frying and also reduced oil absorption; which contributes to low fat content in the final product (Lumanlan *et al*., 2019). On top of that, adding fiber in deep-fry products will also reduce the oil uptakes (Yadav and Rajan, 2012). Moreover, the energy was also reduced as the fat decreased.

3.8 Sensory acceptance on the final soybean curd residue-opak

Figure 2 demonstrates the sensory acceptance for the final SCR-*opak* prepared using the optimum formulation. The sensory scores for all attributes (aroma, taste, texture and overall acceptability) were in the range of like moderately to like. It shows that the developed SCR-*opak* was acceptable in terms of its sensory attributes. No significant difference between the final SCR-*opak* and

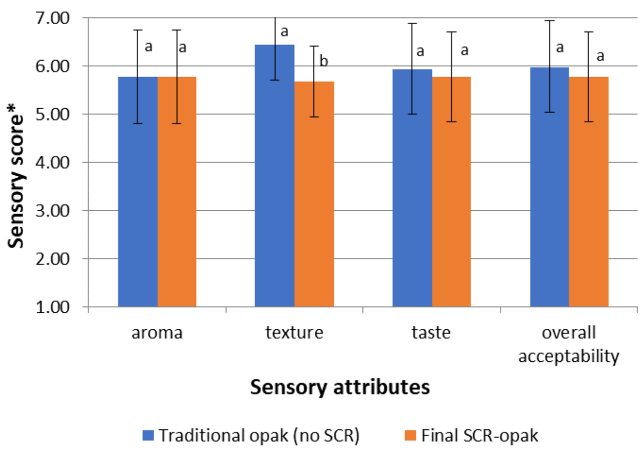

Figure 2. Sensory acceptance of the final SCR-*opak* and its comparison with the traditional opak (n = 35). Bars with different notations are significantly different at p<0.05.

the traditional *opak* (no added SCR) on its aroma, taste and overall acceptability except for its texture. Panelists rated the lower score for the final SCR-*opak* texture most likely because of its harder and less crispy texture due to the high dietary fiber content (Laguna *et al*., 2014). Similar outcomes were presented by Lee *et al*. (2020) in their study on the incorporation of *okara* in biscuits. They also discovered significantly higher hardness on the increase in *okara* in the samples and considered it too hard by the tasters in the sensory evaluation test. Nevertheless, this final SCR-*opak* was considered acceptable as the score for the texture and other attributes were more than 5 (like moderately).

4. Conclusion

The results obtained in this study showed that the addition of SCR in the *opak* formulation enhanced its nutritional properties. The acceptability of the organoleptic properties of the *opak* also demonstrated that this developed SCR-*opak* can be suggested to be one of the good healthy snack options for consumers.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

Researchers were gratefully acknowledged Malaysian Agricultural Research and Development Institute (MARDI) for the financial support under MARDI Research Fund.

References

Ahlawat, D., Poonia, D., Ahlawat, M. and Ahlawat, S.S. (2018). Effect of drying techniques on functional and physico-chemical properties of okara. *International Journal of Current Microbiology and Applied Sciences*, 7(5), 582-590. https://doi.org/10.20546/ijcmas.2018.705.072

Ahmed, H., Satheesh, N. and Dibaba, K. (2018). Functional, physical and sensory properties of cookies prepared from okara, red teff and wheat flours. *Croatian Journal of Food Science and Technology*, 10(1), 23-32. https://doi.org/10.17508/CJFST.2018.10.1.05

AOAC (Association of Official Analytical Chemists) (1995). Official methods of analysis. 16th ed. Arlington, USA: AOAC.

Bellisle, F. (2014). Meals and snacking, diet quality and energy balance. *Physiology and Behaviour*, 134, 38-43. https://doi.org/10.1016/j.physbeh.2014.03.010

Bhavya, S.N. and Jamuna, P. (2018). Nutritional and sensory quality of buns enriched with soy fibre (okara). *Journal of Engineering and Processing Management*, 10, 23-31. https://doi.org/10.7251/JEPM181002023B

Che Rahani, Z. (2005). Processing of cassava products: Notes for Village Women's Day. Malaysia: MARDI Internal Circulation.

Colletti, A., Attrovio, A., Boffa, L., Mantegna, S. and Cravotto, G. (2020). Valorisation of by-products from soybean (*Glycine max* (L.) Merr.) processing. *Molecules*, 25(9), 2129. https://doi.org/10.3390/molecules25092129

Dini, C., Daporto, M.C., Vina, S.Z. and Garcia, M.A. (2014). Cassava flour and starch as differentiated ingredients for gluten free products. In Molinari, F.P. (Ed.). Cassava, p. 88-114. New York, USA: Nova Science Publishers, Inc.

Expert Committee on Nutrition, Health Claims and Advertisement (2010). Guide to Nutrition Labelling and Claims, p. 18. Malaysia: Food Safety and Quality Division, Ministry of Health Malaysia.

Grizotto, R.K., Rufi, C.R.G., Yamada, E.A. and Vicente, E. (2010). Evaluation of the quality of a molded sweet biscuit enriched with okara flour. *Food Science and Technology (Campinas)*, 30(Suppl. 1), 270-275. https://doi.org/10.1590/S0101-20612010000500041

Hawa, A., Satheesh, N. and Kumela, D. (2018). Nutritional and anti-nutritional evaluation of cookies prepared from okara, red teff and wheat flours. *International Food Research Journal*, 25(5), 2042-2050.

Herminingrum, S. (2019). The genealogy of traditional Javanese cassava-based foods. *Journal of Ethnic Foods*, 6, 15. https://doi.org/10.1186/s42779-019-0015-5

Hess, J.M., Jonnalagadda, S.S. and Slavin, J.L. (2016). What is a snack, why do we snack, and how we choose better snacks? A review of the definitions of snacking, motivations to snack, contributions to dietary intake, and recommendations for improvement. *Advances in Nutrition*, 7(3), 466-475. https://doi.org/10.3945/an.115.009571

Idris, S., Rosnah, S., Nor, M.Z.M., Mokhtar, M.N. and Abdul Gani. S.S. (2019). Physicochemical composition of different parts of cassava (*Manihot esculenta* Crantz) plant. *Food Research*, 4(Suppl. 1), 78-84. https://doi.org/10.26656/fr.2017.4(S1).S33

Josephine, L.C.H. and Rubiyah, B. (2018). Okara usage in food industry and medical application. *Agricultural Research and Technology,* 16(2), 49-51. https://doi.org/10.19080/ARTOAJ.2018.16.555983

Kamble, D.B. and Rani, S. (2020). Bioactive components, in vitro digestibility, microstructure and application of soybean residue (okara): a review. *Legume Science*, 2(1), e32. https://doi.org/10.1002/leg3.32

Khare, S.K., Jha, K. and Gandhi, A.P. (1995). Citric acid production from okara (soy residue) by solid-state fermentation. *Bioresource Technology*, 54(3), 232-325. https://doi.org/10.1016/0960-8524(95)00155-7

Laguna, L., Sanz, T., Sahi, S. and Fiszman, S. (2014). Role of fibre morphology in some quality features of fibre-enriched biscuits. *International Journal of Food Properties*, 17(1), 163-178. https://doi.org/10.1080/10942912.2011.619024

Lee, D.P.S.L., Gan, A.X. and Kim, J.E. (2020). Incorporation of biovalorised okara in biscuits: Improvements of nutritional, antioxidant, physical, and sensory properties. *LWT-Food Science and Technology* 134, 109902. https://doi.org/10.1016/j.lwt.2020.109902

Li, B., Qiao, M. and Lu, F. (2012). Composition, nutrition, and utilization of okara (soybean residue). *Food Reviews International*, 28(3), 231-252. https://doi.org/10.1080/87559129.2011.595023

Li, S., Zhu, D., Li, K., Yang, Y., Lei, Z. and Zhang, Z. (2013). Soybean curd residue: Composition, utilization, and related limiting factors. *International Scholarly Research Notices Industrial Engineering* (3), 423590. https://doi.org/10.1155/2013/423590

Losó, V., Gere, A., Györey, A., Kókai, Z. and Sipos, L. (2012). Comparison of the performance of a trained and untrained sensory panel on sweetcorn varieties with the panel check software. *Applied Studies in Agribusiness and commerce*, 6(1-2), 77-83. https://doi.org/10.19041/APSTRACT/2012/1-2/10

Lu, F., Cui, Z., Liu, Y. and Li., B. (2013). The effect of okara on the qualities of noodle and steamed bread. *Advance Journal of Food Science and Technology*, 5 (7), 960-968. https://doi.org/10.19026/ajfst.5.3191

Lumanlan, J.C., Fernado, W.M.A.D.B. and Jayasena, V. (2019). Mechanisms of oil uptake during deep frying and applications of predrying and hyrocolloids in reducing fat content of chips. *International Journal of Food Science of Food and Technology*, 55(4), 1661-1670. https://doi.org/10.1111/ijfs.14435

Man, C.S., Salleh, R., Ahmad, M.H., Baharudin, A., Koon, P.B. and Aris, T. (2020). Dietary patterns and associated factors among adolescents in Malaysia: Findings from adolescent nutrition survey 2017. *International Journal of Environmental Research and Public Health*, 17(10), 3431. https://doi.org/10.3390/ijerph17103431

Mehlhose, C., Schmitt, D. and Risius, A. (2021). PACE labels on healthy and unhealthy snack products in a laboratory shopping setting: Perception, visual attention, and product choice. *Foods*, 10(4), 904. https://doi.org/10.3390/foods10040904

O'Toole, D.K. (1999). Characteristics and use of okara, the soybean residue from soy milk production-A Review. *Journal of Agriculture and Food Chemistry*, 47(2), 363-371. https://doi.org/10.1021/jf980754l

Ostermann-Porcel, M.V., Campderrós, M.E. and Rinaldoni, A. (2017). Effect of okara flour addition on the physical and sensory quality of wheat bread. *MOJ Food Processing and Technology*, 4(6), 184-190. https://doi.org/10.15406/mojfpt.2017.04.00111

Pan, W-C., Liu, Y-M. and Shiau, S-Y. (2018). Effect of okara and vital gluten on physico-chemical properties of noodle. *Czech Journal of Food Sciences*, 36(4), 301-306. https://doi.org/10.17221/329/2017-CJFS

Pedreschi, F., Cortés, P. and Mariotti, M.S. (2018). Potato Crisps and snack foods. In Reference Module in Food Science. Elsevier E-Book. https://doi.org/10.1016/B978-0-08-100596-5.21137-2

Priulli, E., Pereira, C.M.T., Oliveira, A.C. and Piries, C.R.F. (2021). Use of the quantitative descriptive analysis for sensory assessment of tapiocas with adding waste from soy processing. *Food Science and Technology (Campinas)*, 42, e08621. https://doi.org/10.1590/fst.08621

Roudaut, G., Dacremont, C., Vallès Pàmies, B., Colas, B. and Le Meste. M. (2002). Crispness: a critical review on sensory and material science approaches. *Trends in Food Science and Technology*, 13(6-7), 217-227. https://doi.org/10.1016/S0924-2244(02)00139-5

Sahin, Y.B., Demirtas, E.A. and Burnak, N. (2016). Mixture design: A review of recent applications in the food industry. *Pamukkale University Journal of Engineering Sciences*, 22(4), 297-304. https://doi.org/10.5505/pajes.2015.98598

Sengupta, S., Chakraborty, M., Bhowal, J. and Bhattacharya, K. (2012). Study on the effects of drying process on the composition and quality of wet okara. *International Journal of Sciences, Environment and Technology*, 1(4), 319-330.

Sharif, M.K., Butt, M.S., Sharif, H.R. and Nasir, M. (2017). Sensory evaluation and consumer acceptability. In Zahoor, T. and Butt, M.S. (Eds). Handbook of Food Science and Technology Vol. 1, p-361-386. Faisalabad, Pakistan: University of Agriculture.

Sileshi, G.W. (2015). The relative standard error as an easy index for checking the reliability of regression coefficients. Retrieved on July 8, 2021 from ResearchGate Website: https://www.researchgate.net/publication/281371440_The_relative_standard_error_as_an_easy_indexfor_checking_the_reliability_of_regression_coefficients/stats. http://dx.doi.org/10.13140/RG.2.1.2123.6968

Smith, A.P. and Rogers, R. (2014). Positive effects of a healthy snack (fruit) versus an unhealthy snack (chocolate/crisps) on subjective reports of mental and physical health: A preliminary intervention study. *Frontiers in Nutrition*, 1(10), 00010. https://doi.org/10.3389/fnut.2014.00010

Tunick, M.H., Onwulata, C.I., Thomas, A.E., Phillips, J.G., Mukhopadhyay, S., Sheen, S., Liu, C-K., Latona, N., Pimentel, M.R. and Cooke, P.H. (2013). Critical evaluation of crispy and crunchy textures: A Review. *International Journal of Food Properties*, 16(5), 949-963. https://doi.org/10.1080/10942912.2011.573116

Uzo-Peters, P.I. and Ola, S.T. (2020). Proximate composition and functional properties of composite sorghum-okara flour and sensory evaluation of local snack product (*SOSA*). *Agrosearch*, 20(1), 158-167. https://doi.org/10.4314/agrosh.v20i1.14S

Wickramarathna, G.L. and Arampath, P.C. (2003). Utilization of okara in bread making. *Ceylon Journal of Science (Biological Science)*, 31, 29-33.

Yadav, D.N. and Rajan, A. (2012). Fibres as an additive for oil reduction in deep fat fried *poori*. *Journal of Food Science and Technology*, 49(6), 767-773. https://doi.org/10.1007/s13197-010-0218-7

Yaseen, A.A., Shouk, A.A. and Abousalem, F.M. (2009). Effect of okara addition on bread quality. *Journal of Agricultural Sciences, Mansoura University*, 34(12), 11147-11155. https://doi.org/10.21608/jfds.2009.115828

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