https://doi.org/10.17221/196/2023-CJFS

Study of substitution of beef and tapioca flour with tuna meat and purslane flour on meatball quality

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Citation: Tiven N.C., Simanjorang T.M. (2024): Study of substitution of beef and tapioca flour with tuna meat and purslane flour on meatball quality. Czech J. Food Sci., 42: 64–70.

Abstract: Tuna meat (*Thunnus atlanticus* – blackfin tuna) and purslane flour (*Portulaca oleracea* L.), which contain high protein and polyunsaturated fatty acids but are low fat and cholesterol, are used to substitute beef and tapioca flour to produce quality meatballs. This study aims to determine the effect of substituting beef and tapioca flour with tuna meat and purslane flour on meatballs' chemical, physical, and sensory quality. The beef was substituted with 40% tuna meat, and tapioca flour was substituted with 0, 10, and 20% purslane flour. The data obtained were analysed using a complete randomised design, with three treatments and five replications, respectively, and further tested with the Duncan test. The results showed that increasing the level of purslane flour can increase ($P < 0.01$) the chemical quality (water, protein, fat, ash, and omega-3) but decrease ($P < 0.01$) the cholesterol of the meatballs. Physical quality (water holding capacity and sensory quality (colour) of meatballs were increased ($P < 0.01$), but taste and acceptability were decreased ($P < 0.01$). It can be concluded that substituting beef and tapioca flour with tuna meat and purslane flour can increase the chemical and physical quality.

Keywords: chemical quality; cholesterol; fatty acids; physical quality; sensory quality

Meatballs are one of Indonesia's favourite foods and are popular worldwide, made from meat-based ingredients, namely beef, chicken, fish, and pork (Orbayinah et al. 2020; Lestari et al. 2022). Beef meatballs are more popular in Indonesia, made by mixing finely ground beef with tapioca flour, salt, and sodium tripolyphosphate (STTP) so that it becomes a dough, then shaped round and boiled until cooked (Kartikawati and Purnomo 2019).

Making beef-based meatballs is relatively expensive due to the high price of beef, minimal availability, and long supply chains (Ningsih et al. 2022). In addition, the fat content of beef is considered relatively high (7.93%) (Hammad et al. 2019), with a relatively high cholesterol content, namely 62 mg·100 g^{-1} (Ahmad et al. 2018) to 180 mg·100 g^{-1} (Bulkaini et al. 2022). Consumption of beef meatballs with high fat and cholesterol content may cause atherosclerosis, which is the formation of plaque inside the arteries due to the accumulation of fat and cholesterol, thus clogging blood flow, leading to heart disease and stroke (Singh et al. 2023). This situation causes consumers to prefer to consume fish balls because they are considered safer.

Making fish balls can be done using several types of fish meat, including cob meat (*Euthynnus affinis*) (Zamili et al. 2020), mackerel fish meat (*Scomberomorus ommerson*) (Andhikawati et al. 2022), and yellowfin tuna meat (*Thunnus albacares*) (Alamsyah et al. 2021).

Supported by the Ministry of Education, Culture, Research, and Technology through National Competitive Basic Research (Grant No. 046/E5/PG.02.00.PL/2023).

https://doi.org/10.17221/196/2023-CJFS

Tuna meat for making meatballs is relatively expensive for specific regions. Still, following the potential of Indonesia's territory, most of which (2/3) is the sea (Ranggang et al. 2022), tuna meat can be well available. In addition, the fat and cholesterol content of tuna meat is relatively low, but the protein content is relatively high at more than 20% (Dina et al. 2020). Red meat and white meat in some types of tuna contain 20.22–25.35% protein, but the fat content is 0.60–1.26% fat, with 49.91–73.94% PUFAs (Karunarathna and Attygalle 2010). The cholesterol of tuna meat ranges from 13–60 mg·100 g^{-1}, which varies according to the type of tuna and how it is processed (Das 2019). Based on these various potentials, tuna meat will be used to substitute beef to produce quality meatballs.

Tapioca flour will be substituted with purslane flour (*Portulaca oleracea* L.) to improve the functional properties of nutrients in meatballs. The use of purslane flour is based on its relatively high protein content (32.90%), with a complete content of essential amino acids, but has a low-fat content (1.88%) (Rayan et al. 2023). Purslane is rich in omega-3 (59.87%) and omega-6 (16.99%) dry matter (DM) (Udin et al. 2014), which are functional. Purslane works on many metabolic syndrome pathways, including lowering lipids, blood sugar, body weight, and total cholesterol, so it can be used as an anti-metabolic syndrome herbal plant (Aini et al. 2022).

This study aims to determine the effect of substituting beef and tapioca flour with tuna meat and purslane flour on meatballs' chemical, physical, and sensory quality. The results of this study are expected to produce good-quality meatballs so that they can be used as additional food ingredients for school children in areas with high stunting conditions in Maluku Province.

MATERIAL AND METHODS

Meatballs processing. Meatballs are made according to Berutu et al. (2010), modified by Tiven et al. (2023). The meatballs are made with 60% beef, 20% tapioca flour, 16% ice cubes, 2% salt, 1.2% garlic, 0.5% ground peppercorns, and 0.3% egg whites. The beef was substituted with 40% tuna meat (*Thunnus atlanticus*) so that the composition of meat becomes 20% beef and 40% tuna meat. Tapioca flour was substituted with purslane flour, with treatments of 0, 10, and 20%. Beef and tuna meat are ground until smooth, then put the prepared spices, a mixture of tapioca flour and purslane flour, and ice cubes little by little, then ground and mixed until homogeneous. The dough is formed into small circles with a diameter of ± 2 cm. Three pans are prepared (according to 3 purslane flour treatments) and filled with ± 2 L water; then each pan is heated with a Hock stove 12 wicks until boiling. The meatball circles are put in a boiling pan filled with boiling water (one treatment, one boiling pan) and then boiled until cooked (floating meatballs), then removed, drained, and prepared for the testing process.

Meatballs quality test. Meatballs prepared are tested for chemical, physical, and sensory quality. The chemical quality tested are water content with gravimetry method, protein content with the Kjeldahl method, fat content with the Soxhlet method, ash content with gravimetry method, cholesterol content and fatty acid composition with gas chromatography-flame ionisation detection (GC FID) method [Association of Official Analytical Chemists (AOAC 2005)]. The physical quality tested, namely pH (AOAC 2005), elasticity with an universal penetrometer H-1200 (Humboldt, USA) (Tiven et al. 2007), and water holding capacity with press method according to Hamm (Swatland 1984).

The sensory quality of meatballs is tested according to Tiven et al. (2023). Sensory quality, namely colour, aroma, elasticity, texture, taste, and acceptability, was tested by 25 untrained panellists from the Department of Animal Husbandry, Faculty of Agriculture, Pattimura University. Panelists were asked to see, smell, hold/touch, and taste each sample, then complete a questionnaire according to Table 1 to test meatballs' sensory quality.

Statistical analysis. The data obtained were analysed using a complete randomised design, with three purslane flour treatments (0, 10, and 20%), each with five replications. The differences between treatments were further tested with Duncan's test (Gupta et al. 2016).

Table 1. Scores and parameters of sensory quality of meatballs

Score	Colour	Aroma	Elasticity	Texture	Taste	Acceptable
1	very white	very fishy	very not chewy	very rough	very not tasty	very unaccepted
2	white	fishy	not chewy	rough	not tasty	unaccepted
3	slightly grey	slightly meaty	a bit chewy	rather smooth	rather tasty	slightly accepted
4	grey	meaty	chewy	smooth	tasty	accepted
5	very grey	very meaty	very chewy	very smooth	very tasty	very accepted

https://doi.org/10.17221/196/2023-CJFS

RESULTS AND DISCUSSION

Chemical quality. The chemical quality of meatballs substituted for tuna meat and purslane flour can be seen in Table 2.

The statistical analysis shows that substituting beef and tapioca flour with tuna meat and purslane flour significantly differs ($P < 0.01$) on the water, protein, fat, and meatball content. An increase in purslane flour levels can increase ($P < 0.01$) meatballs' water, protein, fat, and

Table 2. The average chemical quality of beef meatballs substituted with tuna meat and purslane flour with different levels

Variable	Level of purslane flour (%)		
	0	10	20
Water (%)	64.33[c] ± 0.32	66.98[b] ± 0.62	67.97[a] ± 0.27
Protein (%)	14.61[c] ± 0.18	15.43[b] ± 0.17	16.23[a] ± 0.44
Fat (%)	0.09[c] ± 0.01	0.16[b] ± 0.01	0.18[a] ± 0.01
Ash (%)	1.17[b] ± 0.07	2.31[a] ± 0.10	2.24[a] ± 0.07
Cholesterol (mg·100 g^{-1})	70.68[a] ± 0.53	38.83[c] ± 0.78	48.07[b] ± 0.94
Fatty acid (%):			
C4:0	0.38 ± 0.29	0.22 ± 0.10	0.24 ± 0.09
C6:0	0.30 ± 0.35	0.41 ± 0.50	0.61 ± 0.09
C8:0	0.72 ± 0.44	0.39 ± 0.34	0.34 ± 0.14
C10:0	0.39 ± 0.18	0.22 ± 0.21	0.13 ± 0.13
C12:0	0.33[a] ± 0.09	0.00[b] ± 0.00	0.00[b] ± 0.00
C13:0	0.36 ± 0.11	0.19 ± 0.17	0.18 ± 0.31
C14:0	0.92 ± 0.27	2.89 ± 0.23	2.29 ± 1.79
C14:1	1.89 ± 1.64	0.00 ± 0.00	1.06 ± 0.84
C15:0	0.00 ± 0.00	0.47 ± 0.41	0.25 ± 0.44
C16:1	26.36[b] ± 1.46	30.19[a] ± 0.39	28.82[ab] ± 1.89
C17:0	2.65[ab] ± 0.24	2.21[b] ± 0.29	2.84[a] ± 0.12
C17:1	1.88 ± 0.11	1.41 ± 1.22	0.71 ± 1.23
C18:0	0.00 ± 0.00	0.36 ± 0.62	0.00 ± 0.00
C18:1 omega-9	2.89 ± 5.01	0.00 ± 5.34	3.27 ± 5.66
C18:1 omega-9	20.67 ± 6.55	23.45 ± 0.85	22.29 ± 3.48
C18:2	28.09[a] ± 1.16	24.83[b] ± 0.46	23.12[c] ± 0.73
C18:3 omega-3	0.50 ± 0.16	0.48 ± 0.49	0.12 ± 0.22
C20:0	6.27[a] ± 0.79	4.59[b] ± 0.80	3.81[b] ± 0.81
C20:4 omega-6	1.20 ± 0.45	1.52 ± 0.44	1.69 ± 0.38
C20:5 omega-3	0.94 ± 0.43	1.30 ± 0.27	1.70 ± 0.37
C22:6 omega-3	3.25[b] ± 1.43	4.69[ab] ± 0.40	6.33[a] ± 1.43
C24:1 omega-9	0.00 ± 0.00	0.18 ± 0.30	0.20 ± 0.34
SFA	12.33 ± 0.15	11.96 ± 0.95	10.69 ± 2.20
MUFA	53.69 ± 2.01	55.23 ± 1.60	56.35 ± 3.28
PUFA	33.99 ± 2.16	32.82 ± 0.97	32.97 ± 1.28
Omega-3	4.69[b] ± 2.02	6.46[ab] ± 0.18	8.16[a] ± 1.60
Omega-6	1.20 ± 0.45	1.52 ± 0.44	1.69 ± 0.38
Omega-9	23.56 ± 2.66	23.63 ± 0.77	25.76 ± 2.09
Total	100	100	100

[a,b] Different superscripts in the same row indicate significant differences at $P < 0.01$; SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids

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ash content. This increase is due to the presence content of water and protein. fat, and ash on purslane flour. According to Rayan et al. (2023), purslane flour contains 8.09% water, 32.9% protein, 1.88% fat, and 5.84% ash. The high ash content in purslane flour is caused by the content of potassium, magnesium, calcium, phosphorus, and iron, but the most abundant is potassium (Srivastava et al. 2023). However, the high protein and mineral content in purslane flour has not significantly increased the protein and minerals of meatballs. The water content of meatballs in this study ranged from 64.33–67.97%, protein content 14.61–16.23%, fat content 0.09–0.18%, and ash content 1.17–2.31%. According to Vebrianty et al. (2021), the addition of water spinach (*Ipomoea aquatica* forsk) flour in making beef meatballs obtained a meatball water content with a range of 69.80–70.50%, protein content of 13.80–14.38%, fat content of 0.49–0.61%, and ash content of 2.09–2.23%. Beef meatballs substituted lamtoro have a moisture content of 73.76%, protein of 11.66%, fat of 0.15%, and ash of 1.94% (Wulandani et al. 2022). In SNI 3818:2014, the quality requirements for meatballs and combination meat are a maximum content of moisture 70%, fat 10%, ash 3%, and minimum protein content of 8% (NSA 2014). In SNI 7266:2014, the quality requirements for fish balls are a maximum water content of 65%, a minimum protein content of 7%, and a maximum ash content of 2% (NSA 2014). Based on the two SNIs, according to SNI provisions, the chemical quality of beef meatballs substituted tuna meat and purslane flour with different levels.

The statistical analysis results show that the substitution of beef and tapioca flour with tuna meat and purslane flour is significantly different ($P < 0.01$) in the cholesterol content of meatballs. Increasing purslane flour levels can cause meatball cholesterol levels to fluctuate ($P < 0.01$). The cholesterol content of this study ranged from 38.83–70.68 mg·100 g^{-1}. When compared, an increase in purslane flour level at 10% will drastically reduce cholesterol, thought to be caused by high polyunsaturated fatty acids (PUFA) and low cholesterol in purslane flour. Purslane flour is a source of PUFA and non-animal omega-3 (Aini et al. 2022), an excellent source of alpha-linolenic acid (ALA) and gamma-linolenic acid (LNA, 18:3 omega-3) (Uddin et al. 2014). According to Zhou et al. (2015), the cholesterol content of purslane flour is very low, with only phytosterols and several types of sterols, namely β-Sitosterol and Daucosterol. Phytosterols can serve as safe and potential drugs for treating lung cancer (Rajavel et al. 2017). Increasing the level of purslane flour to 20% will increase the cholesterol content of meatballs. However, this increase is relatively harmless because of the types of sterols present in purslane flour, namely β-Sitosterol and Daucosterol.

The results of statistical analysis show that the substitution of beef and tapioca flour with tuna meat and purslane flour is significantly different ($P < 0.05$) on omega-3, but no significant differences in saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), PUFA, omega-6, and omega-9 of meatballs. An increase in purslane flour can increase ($P < 0.01$) omega-3, due to an increase in ($P < 0.05$) C22:6 omega-3 – Docosahexaenoic acid (DHA). According to Udin et al. (2014), purslane contains omega-3 (59.87%) DM. Although not significant, when viewed from the change in value, increasing the level of purslane flour can reduce SFA but increase MUFA, omega-6, and omega-9 in meatballs. The decrease in SFA is due to a decrease ($P < 0.05$) of C12:0 (lauric acid) and C20:0 (arachidic acid). The increase in MUFA is due to an increase ($P < 0.05$) of C16:1 (palmitoleic). An increase in omega-6 is due to an increase in C20:4 omega-6 (eicosatetraenoic acid), while an increase in omega-9 is due to an increase in C18:1 omega-9 (trans and cis-9-oleic acid) and C24:1 omega-9 (nervonic acid). When compared with the omega-3 fatty acid content of beef, which is only 0.84%, there is an increase in omega-3 beef meatballs by 4.10–5.10% due to beef and tapioca flour substituted with tuna meat and purslane flour. This study's SFA, MUFA, and PUFA content ranged from 12.50–13.13, 54.27–56.14, and 32.49–33.23%, respectively. The results of Öztürk and Turhan's (2020) research showed that the fatty acid composition of beef meatballs formulated with yellow pumpkin seed kernel flour at different levels obtained an SFA content range of 48.03–60.46%, MUFA 36.41–39.57%, and PUFA 3.13–12.40%. This shows that the fatty acid composition of beef meatballs substituted for tuna meat and purslane flour contains lower SFA but higher PUFA.

Physical quality. The physical quality of meatballs substituted for tuna meat and purslane flour can be seen in Table 3.

The statistical analysis results show that the substitution of beef and tapioca flour with tuna meat and purslane flour is significantly different ($P < 0.05$) on water holding capacity (WHC) but not significant in the pH and elasticity of meatballs. The increase in purslane flour level causes the WHC of meatballs to fluctuate ($P < 0.01$). The WHC increased at 10% purslane flour but decreased at 20%. This increase may be due to the

https://doi.org/10.17221/196/2023-CJFS

Table 3. The average physical quality of beef meatballs substituted with tuna meat and purslane flour with different levels

Variable	Level of purslane flour (%)		
	0	10	20
pH	6.09 ± 0.47	5.49 ± 0.24	5.70 ± 0.17
Elasticity/shear force (kg·cm^{-2})	6.53 ± 0.50	5.53 ± 0.50	5.87 ± 0.23
Water holding capacity (%)	35.07^{b} ± 0.53	41.82^{a} ± 0.12	35.29^{b} ± 0.69

^{a,b} Different superscripts in the same row indicate significant differences at $P < 0.01$

level of 10% purslane flour, which can increase protein availability; the higher the level of purslane flour to substitute tapioca flour (20%), the lower the WHC may be caused by the ability to bind water to purslane flour is lower than tapioca flour. According to Kartikasari et al. (2020), the WHC of broiler meatballs without the addition of purslane flour was 46.41%, but after the addition of 18% purslane flour, the WHC of meatballs decreased to 39.43%. The WHC is also related to the pH and elasticity of meatballs. Increased WHC at 10% purslane flour level will decrease the elasticity and pH of meatballs, although not significant. The WHC of meatballs in this study ranged from 33.07–42.68%. The high WHC of meatballs may be due to the high protein in purslane flour because protein plays a role in WHC so it can increase the WHC of meatballs. According to Vebrianty et al. (2021), the WHC of beef meatballs with water spinach leaf flour ranges from 32.41–36.51%. The WHC in this study range from 35.07–41.82%. According to Kartikasari et al. (2020), the WHC of broiler meatballs with adding fish oil and purslane flour at different levels resulted in WHC with a range of 35.81–46.41%.

Sensory quality. The sensory quality of meatballs substituted for tuna meat and purslane flour can be seen in Table 4.

The statistical analysis results show that the substitution of beef and tapioca flour with tuna meat and purslane flour is significantly different ($P < 0.01$) in meatballs' colour, taste, and acceptance. Increasing the level of purslane flour will increase ($P < 0.01$) the meatballs' colour tends to be brown, caused by the colour of purslane flour being brown. This aligns with Vebrianty et al. (2021) that adding water spinach leaf flour will reduce the meat's brightness and redness and change the meatballs' colour to yellowish due to the chlorophyll content in water spinach leaves. According to Husain et al. (2021), increasing the composition of lindur fruit flour (*Bruguiera gymnorrhiza*) will reduce the colour of tuna meatballs due to the creamy, slightly brownish colour of lindur fruit flour, which, when heated, will be brown. This causes the meatballs' colour to be different from beef meatballs with tapioca flour without substituting purslane flour. The tapioca flour is white, and when heated, it will form a brighter amylopectin paste that can increase the appearance value of meatballs.

The highest meatball taste score of 3.80 (rather tasty, tends to be tasty) is at the 0% purslane flour level, while the lowest meatball flavour score of 2.75 (not tasty, tends to be rather tasty) is at the 20% purslane flour level. The highest meatball acceptance score of 4.00 (accepted) was at the 0% purslane flour level, while the lowest meatball receiving a score of 3.10 (slightly accepted) was at the 20% purslane flour level, but not significant from the purslane flour level of 10%. This

Table 4. The average sensory quality of beef meatballs substituted with tuna meat and purslane flour with different levels

Variable	Level of purslane flour (%)		
	0	10	20
Colour	2.90^{b} ± 1.17	3.80^{a} ± 0.70	4.05^{a} ± 0.89
Aroma	2.75 ± 1.25	3.05 ± 0.94	2.90 ± 0.85
Elasticity	2.95 ± 1.05	2.65 ± 0.81	2.75 ± 1.07
Texture	2.90 ± 0.79	2.85 ± 0.59	0.85 ± 0.81
Taste	3.80^{a} ± 0.62	2.80^{b} ± 0.77	2.75^{b} ± 0.85
Acceptance	4.00^{a} ± 0.56	3.15^{b} ± 0.37	3.10^{b} ± 0.31

^{a,b} Different superscripts in the same row indicate significant differences at $P < 0.01$

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suggests increasing purslane flour levels will decrease meatballs' taste and acceptance scores.

The decrease in taste score value was caused by the taste of purslane flour, which is rather tasty and tends to taste (3.80). Panelists are not familiar with the taste of these meatballs, thus lowering their assessment scores. This is in line with Husain et al. (2021), increasing the level of lindur fruit flour (*Bruguiera gymnorrhiza*) will decrease the taste of tuna as an ingredient in making meatballs, thus reducing the taste value of tuna meatballs. The decrease in the meatball acceptance score was more influenced by the colour and taste of meatballs, which changed relatively compared to meatballs in general, thus reducing the panelists' acceptability of meatballs.

CONCLUSION

This study showed that the substitution of beef with 40% tuna meat and tapioca flour with 10% and 20% purslane flour could increase the chemical quality (water, protein, fat, and ash content), increase physical quality (WHC) and decrease cholesterol content of meatballs. Increased levels of purslane flour cause meatballs to tend to be brown and tend to be less tasty, thus reducing meatball acceptance.

It is recommended that purslane flour with a level of 10% can be applied as a substitute for tapioca flour because it can minimise changes in sensory quality and significantly decrease meatballs' cholesterol.

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Received: November 23, 2023
Accepted: February 16, 2024
Published online: February 27, 2024