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CHARACTERISTICS OF COOKIES FORTIFIED WITH DIFFERENT CONCENTRATIONS OF COMMON CARP FLOUR

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ABSTRACT

Common carp (Cyprinus carpio) is a freshwater fish that can be converted into protein-rich flour for food fortification. This study investigated the effects of incorporating common carp flour at different concentrations on the physicochemical and sensory properties of cookies and identified the preferred formulation. A completely randomised design was used with four treatment levels: 0%, 10%, 15%, and 20% common carp flour. Analyses included hedonic acceptance, moisture, ash, protein, fat, carbohydrates, hardness, colour, and amino acid profiles. Increasing flour inclusion affected protein, ash, fat, texture, and colour. The 20% treatment was identified as the preferred formulation and remained acceptable to panellists. It produced yellowish-brown cookies with a firmer texture, sweet aroma, and savoury taste. The formulation contained 14.57% protein, 1.49% ash, and 2.43% fat and had a hardness of 2,691.50 gf. The reported colour coordinates were L* = 35.89, a* = 4.55, and b* = 30.92. Common carp flour improved the protein content of cookies without eliminating sensory acceptability at the investigated inclusion levels.

KEYWORDS: Cookies; common carp; fish flour; fortification; sensory acceptability.

1. INTRODUCTION

Common carp (Cyprinus carpio) is a major freshwater fishery commodity in Indonesia, with production reaching 531,233 tonnes in 2022, according to the Ministry of Marine Affairs and Fisheries. This fish contains 17–18% protein and a complete essential amino acid profile, making it a potentially valuable animal-protein source (Afifah et al., 2014).

Common carp flour provides protein, essential amino acids, omega-3 fatty acids, and important minerals; its low moisture content also supports storage stability (Mikdarullah et al., 2020; Ananda et al., 2022).

Its high protein content (49–67%) may improve the nutritional value of processed foods, although fishy odour and lipid oxidation are potential limitations. Previous research indicates that fish-flour substitution can increase the protein content of food products (Nilmalasari & Asih, 2017). Cookies are popular baked products because of their pleasant taste, convenience, and relatively long shelf life (Damayanti et al., 2020). Cookies are widely consumed snacks, but conventional formulations generally have relatively low protein content. Sariani et al. (2019) describe cookies as biscuit products primarily made from low-protein wheat flour. The incorporation of fishery resources into cookies remains limited. Common carp flour can enhance their nutritional value. Nurfaidah (2022) reported that carp-meat flour contains 81.75% protein, 7.26% fat, 1.116% carbohydrates, and 8.82% moisture, whereas Putra et al. (2017) reported 65.21% protein in three-spot gourami flour. However, increasing fish-flour concentrations may reduce sensory acceptability, especially in colour, aroma, and taste, because consumers may dislike a pronounced fishy odour. Different incorporation levels also produce distinct finished-product characteristics. This study aimed to determine the effects of common carp flour addition on cookie characteristics and to identify the most suitable incorporation concentration.

2. MATERIALS AND METHODS

2.1 Materials and Equipment

The primary raw material was fresh common carp purchased from a fish seller at Rejomulyo Market, Semarang, Central Java, Indonesia. Wheat flour, butter, sugar, eggs, baking powder, and vanilla essence were obtained from local markets in Semarang, Central Java, Indonesia.

2.2 Preparation of Common Carp Flour

Common carp flour was prepared with reference to Arza and Tirtavani (2017). Fresh carp were cleaned and filleted, and the flesh was immersed in lime juice for 30 min. The flesh was steamed for 15 min, reduced in size, and oven-dried at 60°C for 20 h. The dried fish was subsequently ground and passed through an 80-mesh sieve to obtain common carp flour.

2.3 Preparation of Cookies with Common Carp Flour

Cookie preparation followed Ardian et al. (2022). Butter, brown sugar, granulated sugar, and vanilla essence were mixed, after which eggs were added and mixing continued until homogeneous. A mixture of wheat flour, common carp flour, and baking powder was incorporated and blended uniformly. The dough was shaped to approximately 1 cm thickness and arranged on a baking tray lined with baking paper. The shaped cookies were baked at 160°C for 20 min.

Table 1. Cookie formulations with different common carp flour concentrations.

Ingredients (%)	K	A	B	C
Common carp flour	0	10	15	20
Wheat flour	37,3	27,3	22,3	17,3
Butter	20,4	20,4	20,4	20,4
Brown sugar	13,7	13,7	13,7	13,7
Sugar	11,8	11,8	11,8	11,8
Eggs	15,7	15,7	15,7	15,7
Baking powder	0,39	0,39	0,39	0,39
Vanilla essence	0,78	0,78	0,78	0,78

Note: K = cookies without common carp flour; A = cookies containing 10% common carp flour; B = cookies containing 15% common carp flour; C = cookies containing 20% common carp flour.

2.4 Hedonic Evaluation

Hedonic testing followed Palimbong et al. (2023) to determine consumer preference and product acceptability. Responses were recorded using a five-point scale: 1 = strongly dislike, 2 = dislike, 3 = neutral, 4 = like, and 5 = strongly like. Appearance, taste, aroma, and texture were evaluated by semi-trained panellists who were not specialists but had received instruction in recognising organoleptic attributes. Overall acceptability was considered important for evaluating the product's potential acceptance by consumers.

2.5 Proximate Analysis

Proximate composition was analysed by determining moisture using the thermogravimetric method, ash by incineration, protein by the Kjeldahl method, fat by Soxhlet extraction, and carbohydrates by difference (AOAC, 2005).

2.6 Hardness

Hardness was measured using a Brookfield CT3 Texture Analyzer. The instrument was first calibrated, and a cylindrical TA41 probe was selected. The CT3 instrument was connected to the power supply; the cylindrical probe (3.5 mm in diameter) was then installed and positioned close to the sample before testing (Kidnem et al., 2023).

2.7 Colour Measurement

Colour was assessed by photographing samples with a mobile-phone camera in a light box measuring 24 × 27.5 × 33 cm, equipped with controlled illumination. White paper was placed on the base to improve image contrast. The camera was held in a fixed position above the sample, at a distance of 23 cm. Digital photographs were analysed using the MATLAB Image Processing Toolbox. Images were first converted to grayscale and then into binary images for segmentation and extraction of the sample's red, green, and blue (RGB) values. RGB data were transformed into hue–saturation–value (HSV) and CIELAB (L*, a*, b*) colour spaces. CIELAB was selected because it separates lightness from chromatic information and facilitates image segmentation (Saputra et al., 2024).

3. RESULTS AND DISCUSSION

Table 2. Hedonic scores of cookies containing common carp flour.

Parameter	K	A	B	C
Appearance	$3,77 \pm 0,68^{a}$	$4,20 \pm 0,71^{b}$	$3,93 \pm 0,69^{ab}$	$4,20 \pm 0,61^{b}$
Texture	$3,67 \pm 0,71^{a}$	$4,00 \pm 0,69^{a}$	$4,23 \pm 0,63^{b}$	$4,60 \pm 0,56^{c}$
Aroma	$3,77 \pm 0,50^{a}$	$4,03 \pm 0,56^{ab}$	$3,77 \pm 0,68^{a}$	$4,30 \pm 0,65^{b}$
Taste	$3,97 \pm 0,72^{a}$	$3,97 \pm 0,67^{a}$	$3,87 \pm 0,78^{a}$	$4,40 \pm 0,77^{b}$

Note: Different lowercase superscript letters indicate significant differences at the 5% level. K = control; A = 10% common carp flour; B = 15% common carp flour; C = 20% common carp flour.

3.1 Hedonic Properties

For appearance, treatment K did not differ significantly from B but differed from A and C; treatments A and C did not differ significantly. Mean appearance scores ranged from 3.77 to 4.20, indicating that the cookies were generally liked. Preferred cookies were yellowish-brown, whereas controls appeared brownish-yellow. Increasing flour addition produced darker colours with more pronounced red and yellow components. According to Setyaningrum et al. (2023), yellow-brown colours during baking arise from the Maillard reaction between carbohydrates and amino compounds under heating.

For texture, treatment K was not significantly different from A but differed from B and C; A also differed from B and C, and B differed from C. Mean texture scores ranged from 3.67 to 4.60, indicating favourable acceptance. Cookies receiving higher scores had denser, firmer, and less crumbly textures, whereas control cookies were crisp, fragile, and light. Safitri et al. (2023) noted that increasing fish-flour addition may increase dough viscosity and product thickness. Water-binding capacity also affects firmness in dry products; greater moisture content may reduce crispness.

For aroma, treatment K did not differ significantly from A or B but differed from C, whereas A did not differ significantly from B or C. Mean aroma scores ranged from 3.77 to 4.30, indicating that the aroma was generally acceptable. Preferred cookies had a sweet aroma combined with savoury, characteristic fish notes. Control cookies had a sweet, mildly savoury aroma without a fishy odour. Trisyani and Syahlan (2022) explained that food aroma results from combinations and relative proportions of volatile components and strongly influences palatability.

For taste, treatments K, A, and B did not differ significantly, whereas each differed from C. Mean taste scores ranged from 3.97 to 4.40, suggesting favourable acceptance. The preferred fish-flour cookies had a more pronounced savoury fish flavour that tended to mask the cookies' sweetness. In control cookies, sweetness remained dominant, with only a mild savoury note. Firanida et al. (2023) explained that sensory flavour perception is shaped by the food's overall appearance, aroma, taste, texture, and serving temperature; perceived taste also reflects the appropriateness of ingredient proportions.

3.2 Proximate Composition

Table 3. Proximate composition of cookies containing common carp flour.

Sample	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Carbohydrates (%)
K	$5{,}13 \pm 0{,}10^{d}$	$1{,}07 \pm 0{,}55^{a}$	$7{,}76 \pm 0{,}50^{a}$	$1{,}75 \pm 0{,}08^{a}$	$84{,}30 \pm 0{,}55^{d}$
A	$4{,}63 \pm 0{,}07^{c}$	$1{,}24 \pm 0{,}04^{b}$	$11{,}22 \pm 0{,}71^{b}$	$1{,}96 \pm 0{,}06^{b}$	$80{,}94 \pm 0{,}72^{c}$
B	$4{,}11 \pm 0{,}09^{b}$	$1{,}38 \pm 0{,}04^{c}$	$13{,}03 \pm 0{,}45^{c}$	$2{,}15 \pm 0{,}06^{c}$	$79{,}31 \pm 0{,}35^{b}$
C	$3{,}35 \pm 0{,}10^{a}$	$1{,}49 \pm 0{,}03^{d}$	$14{,}57 \pm 0{,}46^{d}$	$2{,}43 \pm 0{,}11^{d}$	$78{,}15 \pm 0{,}60^{a}$

Note: Different lowercase superscript letters indicate significant differences at the 5% level. K = control; A = 10% common carp flour; B = 15% common carp flour; C = 20% common carp flour.

Moisture content of the cookies ranged from 3.35% to 5.13%, indicating that common carp flour addition affected this parameter. Replacing part of the wheat flour with increasing amounts of carp flour reduced moisture content. Damayanti et al. (2020) reported that increasing the wheat-flour proportion while decreasing rice-bran and red-bean flour increased cookie moisture. The original study cites Indonesian National Standard SNI 2973:2022 as specifying a maximum cookie moisture content of 5%. On that basis, treatments A, B, and C met the cited limit, whereas control K did not.

Ash content ranged from 1.07% to 1.49% and increased with common carp flour substitution. Ash content is commonly used as an indicator of total mineral residue in food (Ramadhan et al., 2019). The source manuscript states that SNI 2973:2022 sets a maximum ash content of 0.1% and interprets all treatments as exceeding that threshold, possibly because of the relatively high fish-flour inclusion. This reported standard interpretation should be verified against the original SNI before submission.

Protein content ranged from 7.76% to 14.57%, increasing with the proportion of common carp flour. The source manuscript cites a 4.5% protein criterion under SNI 2973:2022 and states that all treatments met it; its wording describing the minimum as a 'maximum' is internally inconsistent and requires checking against the standard. Similarly, Ramadhan et al. (2019) found increased protein content when a larger proportion of anchovy flour was substituted into cookies.

Fat content ranged from 1.75% to 2.43%, increasing with fish-flour addition. The increase may reflect the contributions of ingredients rich in fat, including butter, eggs, and carp flour. Nurfaidah et al. (2024) reported that flour made from carp flesh contained 7.26% fat. Lipids contribute to the flavour, texture, and tenderness of cookies.

Carbohydrate content ranged from 78.15% to 84.30% and decreased as the concentration of common carp flour increased, reflecting the corresponding reduction in wheat flour. Pulungan et al. (2020) explained that cookie dough normally contains wheat flour, an important source of carbohydrates and dietary energy.

3.3 Hardness and Colour

Table 4. Hardness and colour of cookies containing common carp flour.

Sample	Hardness (gf)	L	a*	b*
K	2141,22 ± 69,61^{a}	35,89 ± 0,45^{c}	2,36 ± 0,23^{a}	30,92 ± 0,36^{c}
A	2345,91 ± 25,88^{b}	33,78 ± 0,37^{b}	3,33 ± 0,28^{b}	29,51 ± 0,17^{b}
B	2439,05 ± 61,24^{b}	32,74 ± 0,20^{b}	3,64 ± 0,30^{b}	28,62 ± 0,26^{b}
C	2691,50 ± 51,47^{c}	31,69 ± 0,52^{a}	4,55 ± 0,23^{c}	28,15 ± 0,09^{a}

Note: Different lowercase superscript letters indicate significant differences at the 5% level. K = control; A = 10% common carp flour; B = 15% common carp flour; C = 20% common carp flour.

Cookies containing common carp flour tended to have a denser and firmer texture, attributed in the original study to higher protein and fat levels, whereas the control cookies were crisp but less compact. Pratama et al. (2014) reported that increasing fish-bone flour addition to biscuits increased product hardness. Flour composition strongly affects the texture, hardness, and shape of baked products.

The L* value decreased with increasing common carp flour concentration, indicating a darker, browner appearance. L* ranges from 0 (black) to 100 (white). Higher incorporation therefore reduced lightness. Cicilia et al. (2021) related browning during cookie baking to Maillard reactions between reducing sugars and compounds with amino groups, including proteins, amino acids, and peptides.

The a* coordinate represents redness (positive values), which increased when fish-flour addition rose from 0% to 20%. Jeyakumari et al. (2016) explained that brown pigments develop during advanced browning reactions and can be assessed through instrumental colour measurements. Higher positive a* values indicate increased redness and contribute to the darker appearance of the biscuits.

The b* coordinate indicates yellowness (positive) versus blueness (negative). Increasing fish-flour concentration lowered the yellow component of the cookies. Wijaya et al. (2022) similarly reported that increasing flour substitution may decrease cookie lightness and yellowness. The added flour may partially mask the yellow tones produced during Maillard browning.

4. CONCLUSIONS

The addition of common carp flour influenced cookie characteristics. Increasing the incorporation level increased product hardness, darkened the colour, and increased ash, protein, and fat contents. Among the concentrations investigated, 20% common carp flour was identified as the preferred treatment and remained acceptable to panellists. This formulation produced yellowish-brown cookies with a denser, firmer texture, a sweet aroma, and a savoury flavour with characteristic fish notes.

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