

Effect of Catfish Puree and Kidney Bean Flour Formulation on The Acceptability and Chemical Quality of Sticks Lekara

Susan Ariyanti^{1*}, Zulfiana Dewi¹, Meilla Dwi Andrestian¹

¹ Department of Nutrition, Polytechnic of Health Ministry of Health, South Kalimantan, Indonesia

*Correspondence : susanaryanti1212@gmail.com

ABSTRACT

Background: Chronic Energy Deficiency (CED) and anemia remain major nutritional problems among pregnant women. In South Kalimantan, the prevalence of CED reached 15,9% and anemia 20,01% in 2023. Adequate protein and iron intake are essential to prevent these conditions and reduce pregnancy complications. Catfish and red kidney beans are potential sources of protein and iron. Sticks are dry snack foods that are practical, have a long shelf life, and can be recommended as supplementary snacks for pregnant women.

Objective: The study aims to develop a “Lekara” sticks through the substitution of catfish puree and red kidney bean flour to produce a high-protein and iron-rich snack for pregnant women.

Materials and Methods: This study consisted of four treatment comparisons: P0 (100:0:0), P1 (60:10:30), P2 (60:15:25), and P3 (60:20:20). The research used a true experimental design with a Posttest-Only Control Group Design. The analyses included organoleptic tests and chemical quality tests (proximate composition and iron content).

Results: The results showed that the best treatment for “Lekara” sticks was P1. The chemical composition of P1 included moisture content of 2.57%, ash 0.98%, protein 10.05%, fat 40.93%, carbohydrates 24.71%, and iron 182,93 mg/kg, while the control had moisture content of 1.76%, ash 0.52%, protein 8.46%, fat 31.19%, carbohydrates 42.71%, and iron 173.79 mg/kg.

Conclusion: P1 ‘Lekara’ sticks are claimed to be high in protein and iron to help address chronic energy deficiency (CED) and anemia in pregnant women.

Keywords: catfish; kidney beans; stick; proximate composition; iron

BACKGROUND

Pregnancy is a critical period encompassed within the first 1000 days of life (1000 HPK), during which nutritional status is an essential determinant of maternal and foetal health. Chronic Energy Deficiency (CED) is a prolonged imbalance between energy and protein intake, diagnosed by a mid-upper arm circumference (MUAC) below 23,5 cm.¹ Pregnant women with CED carry a 39% higher risk of developing anaemia compared with well-nourished counterparts.² National surveillance data indicate that the prevalence of CED among pregnant women in South Kalimantan Province increased to 15,9% in 2023, while the anaemia prevalence rose again to 20,01% after a temporary decline in 2022.³ Inadequate dietary intake of protein and iron during pregnancy is one of the primary drivers of both conditions.⁴

Catfish (*Clarias batrachus*) is an affordable freshwater protein source widely farmed in South Kalimantan. It provides 17.57 g protein per 100 g⁵, along with heme iron, omega-3 fatty acids important for foetal brain development⁶, and essential amino acids (lysine and leucine).⁷ Red kidney bean (*Phaseolus vulgaris* L.) is a functional plant food rich in non-heme iron (10,3 mg/100 g) and protein (22,1 g/100 g).⁸ Its flavonoid compounds can help increase haemoglobin levels in anaemic individuals.⁹ Pregnancy associated nausea and vomiting, driven by rising oestrogen, progesterone, and human chorionic gonadotropin (hCG) levels, cause loss of sodium and electrolytes, leading pregnant women to prefer savoury, dry foods such as crackers and sticks.¹⁰ Sticks are a dry, crispy snack made from wheat

flour, tapioca, fat, eggs, and water. They have a long shelf life and are tolerated well during morning sickness.¹¹

An earlier study demonstrated that combining catfish and red kidney beans in nugget formulation effectively raised protein content to 14,5 g/100 g (from 11,5 g/100 g in the control) and was well accepted as a high-protein infant snack.¹² Building on that evidence, this study aimed to develop "Lekara" (Lele dan Kacang Merah) sticks a catfish-puree and kidney bean flour stick snack and to evaluate their acceptability and proximate and iron composition as a functional food for pregnant women with CED.

MATERIALS AND METHODS

Research Design, Time, and Place

This study used a *posttest-only control group design* with a completely randomised design (CRD) and three replications per treatment. The study was conducted from January to March 2026 at the Food Technology Laboratory, Nutrition Department, Banjarmasin Health Polytechnic, and at the Standardisation and Industrial Services Centre (BSPJI), Banjarbaru. Ethical approval was obtained prior to data collection.

Treatment Formulations

Four treatment ratios of wheat flour : catfish puree : kidney bean flour were tested (Table 1). The proportions were guided by previous works. Catfish addition was capped at 20% to maintain workable dough and prevent excessively fishy flavour¹³, and kidney bean flour was used at up to 30% based on optimal sensory outcomes reported elsewhere.¹⁴ Four treatment proportions of wheat flour : catfish puree : kidney bean flour were evaluated: P0 (100%:0%:0%), P1 (60%:10%:30%), P2 (60%:15%:25%), and P3 (60%:20%:20%).

Table 1. Composition of lekara sticks per 100 g of dough

Ingredient	Amount (g)			
	P0 (0%)	P1 (10%)	P2 (15%)	P3 (20%)
Wheat flour (g)	100	60	60	60
Catfish puree (g)	0	10	15	20
Kidney bean flour (g)	0	30	25	20
Tapioca flour (g)	25	25	25	25
Eggs (g)	15	15	15	15
Margarine (g)	10	10	10	10
Garlic (g)	10	10	10	10
Shallot (g)	15	15	15	15
Pepper (g)	2	2	2	2
Salt (g)	5	5	5	5
Celery (g)	20	20	20	20
Water (mL)*	50	41,3	32,3	22,5
Cooking oil (g)	500	500	500	500

* The amount of water in each treatment was calculated and adjusted according to the addition of catfish puree to obtain a uniform dough consistency.

Preparation of Catfish Puree

Fresh catfish were cleaned, rinsed, marinated in lime juice for 10 min to reduce fishy odour¹⁵, and steamed at 100 °C for 15 min. The flesh was separated from skin and bones, homogenized in a food chopper with 10 mL water, and filtered to obtain smooth puree.

Preparation of Kidney Bean Flour

Kidney beans were sorted, washed, soaked in sodium bicarbonate (NaHCO₃) solution for 10 h to reduce flatulence-causing compounds and soften the seed coat¹⁶, steamed at 100 °C for 15 min, dehulled, dried in an oven at 70 °C for 6 h, ground, and sieved through an 80-mesh sieve.

Stick Production

All dry and wet ingredients were blended according to treatment formulation, kneaded until smooth, rested for 15 min, rolled to 3–4 mm thickness, cut into strips using a noodle cutter, and deep-fried at 140 °C for 3 min until golden. Sticks were cooled at room temperature before packaging.¹¹

Acceptability Evaluation

Acceptability was evaluated by 30 semi-trained panelists (active sixth-semester nutrition students who had completed the Food Technology course) using a 5-point hedonic scale (1 = dislike very much; 5 = like very much) for colour, aroma, texture, and taste. Each panelist neutralized their palate with mineral water between samples. Coded samples were presented in randomized order.

Selection of Best Treatment

The best treatment among P1, P2, and P3 was selected using the Effectiveness Index method of De Garmo et al. (1984)¹⁷, which calculates a weighted productivity score for each sensory parameter. The treatment with the highest productivity value was then compared with P0 (control).

Chemical Analysis

The best treatment (P1) and control (P0) were subjected to proximate analysis moisture (oven drying, 105 °C, 6 h), ash (dry ashing, 650 °C), protein (Kjeldahl method; conversion factor 6.35), fat (Soxhlet extraction, petroleum benzene), and carbohydrate (Luff-Schoorl method by difference) and iron determination by Atomic Absorption Spectrophotometry (AAS) at 248 nm, all in triplicate. Analyses were performed at BSPJI Banjarbaru using AOAC 2019 protocols.¹⁸

Statistical Analysis

Sensory data from the four treatments were analysed by Friedman test ($\alpha = 0.05$). Pairwise comparison between P0 and the best treatment used the Mann-Whitney U test ($\alpha = 0.05$). Chemical data were compared with the Independent Samples T-test ($\alpha = 0.05$). All analyses were performed using SPSS version 25.

RESULTS

Phase I: Acceptability Testing

Mean hedonic scores for the three treatments (P1–P3) are presented in Table 2. Friedman test results showed that the proportions of catfish puree and kidney bean flour significantly influenced colour ($p = 0.000$) and taste ($p = 0.042$), but did not significantly affect aroma ($p = 0.145$) or texture ($p = 0.099$). P1 (60% wheat flour, 10% catfish puree, 30% kidney bean flour) achieved the highest mean scores across all four sensory parameters.

Table 2. Mean hedonic scores and friedman test results for lekara sticks

Parameter	P1	P2	P3	p-value
Colour	4.43	3.87	3.47	0.000*
Aroma	4.23	4.20	3.97	0.145
Texture	4.37	4.03	4.10	0.099
Taste	3.97	3.70	3.57	0.042*
Productivity Value (De Garmo)	0.91	0.40	0.14	—

* Significant ($p < 0.05$); ns Not significant. Scale: 1 = dislike very much; 5 = like very much

Based on the highest productivity value (0.91), P1 was confirmed as the best treatment and was carried forward for comparison with the control (P0). Mann-Whitney U tests between P0 and P1 showed significant differences in colour ($p = 0.04$) and texture ($p = 0.028$), but not in aroma ($p = 0.76$) or taste ($p = 0.058$).

Phase II: Chemical Quality

Proximate composition and iron content of P0 and P1 are shown in Table 3. All parameters except iron content differed significantly between treatments.

Table 3. Proximate composition and iron content of lekara sticks (mean $\pm$ SD, n = 3)

Parameter	P0 (Control)	P1 (Best)	p-value	SNI Limit*
Moisture (%)	1.76 $\pm$ 0.31	2.57 $\pm$ 0.05	0.025	Max. 5
Ash (%)	0.52 $\pm$ 0.14	0.98 $\pm$ 0.18	0.025	Max. 2
Protein (%)	8.46 $\pm$ 0.70	10.05 $\pm$ 0.43	0.028	Min. 6
Fat (%)	31.19 $\pm$ 2.04	40.93 $\pm$ 4.34	0.025	Min. 8
Carbohydrates (%)	42.71 $\pm$ 2.85	24.71 $\pm$ 9.25	0.032	Min. 10
Iron (mg/kg)	173.79 $\pm$ 185.03	182.93 $\pm$ 228.80	0.960	—

* Indonesian National Standard (SNI 01-2973-1992) for stick/cracker products. All values met the SNI specification

DISCUSSION

Colour Acceptability

Treatment P1 produced a light-brown colour that was most preferred by panelists, whereas P2 and P3 yielded increasingly darker products. The colour differences resulted from the Maillard reaction between reducing sugars and amino groups at frying temperature.¹⁹ Increasing catfish puree intensified the reaction because myoglobin the primary heme pigment in fish muscle denatures and darkens during heating.²⁰ Kidney bean flour also contributes protein and carbohydrates that promote browning; the higher the proportion, the darker the product.²¹ The Mann-Whitney comparison between P0 and P1 confirmed a significant colour difference ($p = 0.04$), with the light-brown tone of P1 perceived as indicating optimal doneness.²²

Aroma Acceptability

No significant difference in aroma was detected between P0 and P1 ($p = 0.76$). The characteristic onion/garlic aroma in P0 was stronger because organosulphur compounds (allicin and related volatiles) were not masked by other ingredients.²³ In P1, the protein matrix of catfish flesh interacted with these volatile sulphur compounds through hydrophobic and hydrogen bonding, reducing their release into the headspace.²⁴ The pre-treatment of catfish puree with lime juice (citric acid) suppressed trimethylamine (TMA) formation, the primary source of fishy off-odour.¹⁵ Deep-frying also inactivated lipoxygenase in kidney bean flour, responsible for beany notes, while Maillard reaction products generated savoury volatiles that further masked residual off-odours.²⁵

Texture Acceptability

P1 was crispier and better liked than P0 ($p = 0.028$). In P0, excess water in the gluten network produced larger air cells and a more fragile structure.²⁶ In P1, catfish protein (myosin and actin) denatures and coagulates during frying, forming a compact protein network that interacts with starch from wheat flour and kidney bean flour, creating a denser matrix.²⁷ Water evaporation during frying formed small, uniform air pockets that yielded the characteristic crunch.²⁸ Excessive kidney bean proportions (P2 and P3) hardened texture because gluten-free legume protein cannot form the elastic network required for crispness.²⁹

Taste Acceptability

P1 had a balanced savoury-fishy with mildly sweet flavour that was most preferred. The umami character arose from glutamate-rich amino acids in catfish flesh.³⁰ Kidney bean flour contributed a mild sweetness.³¹ As catfish puree proportion increased (P2, P3), the fishy flavour became dominant and reduced palatability. Conversely, higher kidney bean flour proportions introduced beany notes.³² The Mann-Whitney test showed no significant difference in taste between P0 and P1 ($p = 0.058$), indicating

that the addition of catfish and kidney bean did not negatively alter the overall taste profile perceived by panellists.

Moisture Content

Moisture content of P1 (2.57%) was significantly higher than P0 (1.76%) ($p = 0.025$), but both satisfied the SNI 01-2973-1992 maximum of 5%. The higher moisture in P1 is attributable to the high intrinsic moisture of catfish flesh (74.9%) and residual moisture in kidney bean flour (7.17%), with the protein matrix retaining water during heat treatment.³³ Low moisture content is associated with extended shelf life by suppressing microbial growth and deleterious chemical reactions.³⁴

Ash Content

Ash content increased significantly from 0.52% (P0) to 0.98% (P1) ($p = 0.025$), remaining below the SNI maximum of 2%. This reflects the higher mineral density of catfish (potassium, sodium, magnesium, phosphorus, iron, zinc) and kidney bean flour (calcium, phosphorus, iron, magnesium), the latter having an ash content of 3.02% versus 0.52% for wheat flour.³⁵

Protein Content

Protein content of P1 (10.05%) was significantly greater than P0 (8.46%) ($p = 0.028$), and both values exceeded the SNI minimum of 6%. Catfish puree (18.79% protein) and kidney bean flour (16.42% protein) jointly elevated the protein fraction.³⁶ The combination of animal (heme) protein and plant protein provides complementary amino acid profiles, improving overall protein quality.¹² Importantly, protein from fish also facilitates iron absorption by chelating non-heme iron and keeping it in soluble, absorbable form.⁹

Fat Content

Fat content increased significantly from 31.19% (P0) to 40.93% (P1) ($p = 0.025$), exceeding the SNI minimum of 8%. The rise was driven by the natural lipid content of catfish (omega-3: 237 mg, omega-6: 337 mg per 100 g)⁶ and the native fat of kidney bean flour (6.60%). Previous studies on red-bean-flour cookies similarly reported fat values in the range 34.92–36.66%.³⁷ The fat content contributes positively to energy density, important for CED management, and acts as a flavour carrier enhancing the savoury profile.

Carbohydrate Content

Carbohydrate content decreased significantly from 42.71% (P0) to 24.71% (P1) ($p = 0.032$), yet still exceeded the SNI minimum of 10%. The reduction was attributable to catfish flesh containing negligible carbohydrate, and kidney bean flour (60.29% carbohydrate) being a lower-carbohydrate substitute than wheat flour (78.78%).³⁸ This shift in the macronutrient profile lower carbohydrate, higher protein is nutritionally advantageous for CED management.

Iron Content

Mean iron content of P1 (182.93 mg/kg or 18.3 mg/100 g) was numerically higher than P0 (173.79 mg/kg), but the difference was not statistically significant ($p = 0.960$). The large within-group standard deviation in both treatments reduced statistical power. The increase was biologically plausible: catfish contributes heme iron, which is more bioavailable than non-heme iron and acts as a meat factor promoting absorption of the non-heme iron from kidney bean flour.³⁹ Protein from catfish forms soluble chelates with ferric iron, preserving iron bioavailability during cooking.⁹ Earlier investigations reported that catfish-based products can contain up to 25.58 mg iron per 100 g⁴⁰, and kidney bean flour substitution in cookies yielded iron values of 16.96 mg/100 g.⁴¹ Consumption of one serving (30 g) of Lekara sticks P1 would contribute approximately 5.5 mg iron, covering ~30% of the additional iron requirement during the second and third trimesters of pregnancy (9 mg/day above baseline).⁴²

CONCLUSIONS

Lekara sticks formulated at P1 (60% wheat flour, 10% catfish puree, 30% kidney bean flour) achieved the best overall acceptability and the highest productivity value. Ingredient proportions significantly influenced colour and taste acceptability, and all proximate parameters, but not aroma, texture, or iron content. All proximate values met SNI 01-2973-1992 standards. The P1 formulation represents a promising high-protein, iron-enriched functional snack for pregnant women with CED. Further research is needed to evaluate its clinical efficacy in reducing CED prevalence and improving iron status in pregnant women.

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