Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.5327/fst.099122

Nanomineral fortification on traditional Saddah Gohoge grits

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Abstract

Saddah Gohoge grits is a traditional food in Gorontalo Province, Indonesia, especially the elderly and when children are growing. The study aimed to obtain the physical, chemical, and organoleptic characteristics of the Saddah Gohoge grits fortification of nanomineral fish bones from the family *Lutjanus* sp. The materials used were Saddah Gohoge corn, bone nanominerals of the family *Lutjanus* sp. The nanomineral using *precipitation* method. The proximate, viscosity, and colour using Association of Official Analytical Chemists Procedure, and organoleptic using non-parametric. Data analysis using analysis of variance, descriptive and *kruskal wallis*. Proximate levels increased along with the increase in the concentration of fortified nanomineral fish bones of the *Lutjanus* sp. in Saddah Gohoge grits, but the water content decreased due to the use of the same volume of water and the composition of Saddah Gohoge. Hedonic quality organoleptic appearance is not dull, the texture is slightly smooth and slightly thick, the color is slightly yellowish, the flavour is slightly pungent, flavour of corn, the taste is corn. The results of the hedonic organoleptic test of the panelists gave a favorable response for all criteria of appearance, texture, color, aroma, and taste.

Keywords: *Lutjanus sp*.; characteristics; food; fish bone.

Practical Application: The practical implication of this article is that the addition of nanomineral fish bones from the family Lutjanus sp. to Saddah Gohoge grits can improve its nutritional content without significantly altering its sensory characteristics. This study provides evidence that the use of nanominerals as a fortificant is a promising approach to enhance the nutritional value of traditional foods without compromising their taste and texture. The findings of this study can be useful for food manufacturers and policymakers in developing countries who are interested in improving the nutritional status of their population through the fortification of traditional foods. Additionally, the use of nanominerals can be a more cost-effective and sustainable approach to fortification, as it requires less fortificant material and does not alter the taste and texture of the food.

1 Introduction

Porridge is a food in the weaning period in infancy and breakfast food (Om et al., 2019). The characteristics of slurry porridge are high flour content, flour and water ratio is 5-15% w/v, and thick and little nutritional composition porridge is a traditional food, especially for very low-income families (Neupane et al., 2022).

The traditional Rowe Luwa porridge in Southwest Sumba, Indonesia is a green porridge made from cassava leaves, and tubers pounded together with rice which is made in an instant dry form to extend the shelf life of the porridge (Iwansyah et al., 2022). Cornmeal-based porridge in Nigeria is "Ugali" or "Ogi", in Italy "Polenta" in Brazil "Angu" and in Romania "Mamaliga". In this study, the traditional Gorontalo grits in Indonesia called "Saddah" or "Gohoge" is made from corn flour.

Maize (Zea mays L) is the second most important cereal crop in the world in terms of production and consumption (Bustillos-Rodríguez et al., 2019). Further, Maize food processing products are indispensable in daily life, thus maize is widely cultivated in other countries (Zhu et al., 2022). In Brazil, maize production was 54.5 million tonnes in 2015, with significant quantities produced by maize farmers in central and southern Brazil (Kelte et al., 2018). Maize is composed of two glucose homopolysaccharides, amylose and amylopectin, and has a linear and branched structure (Liu et al., 2002). The starch content in corn as a functional food is widely applied to food and non-food because it can modify physicochemical, thermal, and rheological properties (Bello-Pérez et al., 1999; Waterschoot et al., 2015; Bustillos-Rodríguez et al., 2019). Corn mainly supplies starch, and its flour is used in home cooking as a food source and processed food products (Neupane et al., 2022; Barretti et al., 2022).

Saddah Gohoge grits is a local name for food from the Gorontalo province in Indonesia, which is generally popular, especially for the elderly and growing children, because it has a soft texture and corn flavor. These grits contains high carbohydrates, namely 95.43% and fiber content of 3.8%. However, it is still very low in mineral nutrient content. Mineral nutrient intake is needed, especially during the growth period of children and the elderly. For the elderly aged >60 years, the calcium needed by the body ranges from 800-1000 mg/day, calcium intake in Indonesia has only reached 237 mg/day (Indonesia, 2019). Research in Rwanda revealed that grits marketed locally still lacks nutrients that is protein, fat and vitamins A and E. (Grosshagauer et al., 2020).

Mineral content can be obtained from fish bone waste from processed fish residue. Utilization of processed fish to produce new products can be done effectively and increase income and contribute to environmental conservation. Processed fish waste is

Received 23 Sept., 2022
Accepted 06 Nov., 2022
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divided into two groups, namely used to increase animal or plant production and the development of value-added by-products for human consumption, namely stomach contents, scales, bones including skull bones to be used as flour, oil, silage and compost for use in animal feed or fertilizer in plants (Kumar et al., 2022). Fish bones have a fairly high mineral content but are still in the form of macrominerals and have not been completely absorbed by the body. The main constituents of fish bones as an important source of minerals are calcium, sodium (5.63 g/kg), phosphorus (2.38 g/kg), and carbonates. In addition, fish bones contain inorganic salt minerals, namely calcium phosphate, creatine phosphate and hydroxyapatite [Ca10(OH)(PO4)6] in the form of crystals attached to fibrillar collagen (Malde et al., 2010; Suptijah et al., 2012).

One of the processed fishery waste is fish bones from the *Lutjanus* sp. This family of fish is found in Indonesian waters, including in the waters of the Gorontalo area. Types of fish family *Lutjanus* sp. There are 33 species in Indonesian waters. Types of fish belonging to the family *Lutjanus* sp. Most live around coral reef areas (Oktaviyani, 2018).

The particle size of minerals as feed additives in nanoparticle form is claimed to be smaller than 100 nanometer, it can pass through the stomach wall and into body cells more quickly than ordinary minerals with larger particle size (Singh & Pankaj, 2016).

The fulfillment of protein and fat nutrients as well as vitamins A and E in Saddah Gohoge corn grits can be served with fish sauce and boiled vegetables. Fish bones can be used as an inexpensive natural material that contains calcium phosphate. Previous research produced calcium phosphate in micro and nanoparticle sizes from fish bones. Fish bone waste originating from household consumers, processed fish fillet industries into the aquatic environment can have an unfavorable effect. Utilization of fish bone waste can be used as a product that provides beneficial value, especially in the growth and maintenance of healthy bones and teeth. Fish bones derived from processed fish fillet waste can be processed into nanominerals (nm) and can be fortified in food. Through nanotechnology for application to food, one of them is increasing the bioavailability of nutrients (Greiner, 2009; Lekahena et al., 2014). One of the additions of nutrients to the Saddah Gohoge corn grits is by fortifying nanominerals derived from fish bone waste from the *Lutjanus* sp. This study carried out fortification of nanomineral waste from fish bone *Lutjanus* sp. and perform physical, chemical and organoleptic characteristics based on the response of the panelists to the Saddah Gohoge grits.

2 Materials and methods

This research was conducted in April 2022-September 2022 at the Laboratory of the Faculty of Mathematics and Natural Sciences, the Laboratory of Biotechnology and Characteristics of Fishery Products, Faculty of Fisheries and Marine Sciences, State University of Gorontalo, Laboratory of Quality Testing of Fishery Products of Gorontalo Province and the Gorontalo Polytechnic Laboratory.

2.1 Materials and tools

Saddah Gohoge corn flour and salt are purchased at the Gorontalo traditional market. Fish bone waste of the family Lutjanus sp. Taken from the rest of the processed fillets in the fishery processing industry of PT.99 Tinakin Laut, Banggai Laut Regency, Central Sulawesi Province. NaOH, HCl, H2SO4, Na2CO3, KIO3, CuSO4.5H2O, (NH4) 2HPO4, 1% phenolphthalein, LuffSchoorl solution were purchased from an analytical chemical agent in Jakarta.

The tools used are Atomic Absorption Spectrophotometry (AAS) (Perkin Elmer Analysis 100 flame emission type), High Performance Liquid Chromatography (HPLC) (Shimadzu Prominance) Scanning Electron Microscope (SEM) Phenom ProX G5. Field Emission Scanning Electron Microscopy (FE-SEM) and Electron Diffraction X-ray, crystallinity morphology analysis with XRD tool (Venkatesan & Kim, 2010). Rapid Visco Analyzer (RVA-Techmaster, Macquarie Park, Australia) (Iwansyah et al., 2022).

2.2 Sample preparation

Fish bone preparation

Fishbone preparation methods is washing stage, boiling the bone at a temperature of ± 130 °C or 250 °F, drying, reducing and screening of fish bone powder modification (Harmain et al., 2018). The first stage was carried out to produce fishbone powder with several stages of the process, that is washing, boiling, drying and size reduction. The second stage of fish bone powder was divided into 3 treatment methods is milling, HCl and NaOH. (Prinaldi et al., 2018). Nanocalcium using the *precipitation* method with prawn shell soaking time for 48 hours (Suptijah et al., 2012).

Saddah Gohoge corn preparation

Corn flour was washed from dirt and dust using clean water, allowed to stand for a while and the filtrate was removed slowly, until the flour that had settled was clean. Then the corn flour is dried using an oven at 100-120 °C for 1-3 hours to dry or using a drum dryer at 120 °C at 8Hz speed. The process of making corn flour when using corn shells follows corn flour production by Houssou & Ayemor (2012) and Om et al., (2019) modification (Figure 1).

Formulation of composites of Saddah Gohoge corn with cooking water based on *trial and error* of 1:5 w/w. Fish bone nanomineral fortification formulation fish bone of family *Lutjanus* sp. are 10%, 15% and 20%. For Saddah Gohoge were formulated to produce composite grits while the control sampel used was 100% Saddah Gohoge. As many as 200 g Saddah Gohoge corn flour was mixed and homogenized with fortification of fish bone nanominerals from the family Lutjanus sp. and then cooked with 1000 mL (1:5) cooking water at a temperature of 100 °C for ± 45 minutes..

2.3 Procedure of analyses

Organoleptic test

Samples of Saddah Gohoge grits fortification of fish bone nanominerals Lutjanus sp. with concentrations of 0%, 10%, 15% and 20% presented together with a hedonic and hedonic

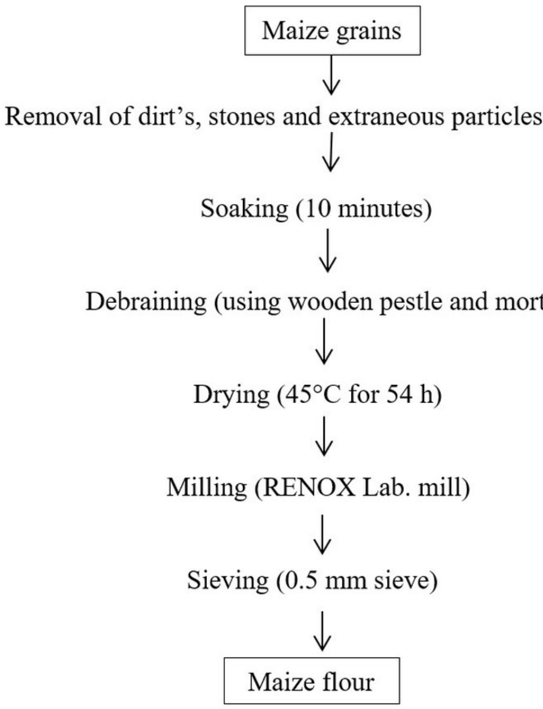

Figure 1. Process flow for the production of maize flour.

quality organoleptic assessment score sheet, the panelists used were untrained panelists and came from consumers who used to consume Saddah grits as many as 30 people with a scale of 1 – 5 based on the parameters of appearance, texture, color, aroma and taste through an assessment in the score sheet provided. Organoleptic testing uses panelists who are divided into trained, semi-trained and untrained panelists with a certain scale range based on an assessment of organoleptic parameters (Lawless & Heymann, 2010).

Proximate analysis

Proximate analysis of Saddah Gohoge grits consisting of water content, ash content, protein content, fat content, crude fiber content and carbohydrate content can be carried out based on the Association of Official Analytical Chemists (2005) method. The Association of Official Analytical Chemists (2005) and Iwansyah et al. (2022) method for determining water content and ash content can be determined using the gravimetric method. Determination of protein content used equipment Buchi-Dumaster, fat content using the Weibull method (Association of Official Analytical Chemists (2005; Iwansyah et al., 2022), carbohydrate content can be calculated by difference, fiber content can be determined using the method of Association of Official Analytical Chemists (2005).

Viscosity measurement

Measurement of slurry viscosity using a Rapid Visco Analyzer (RVA-Techmaster, Macquarie Park, Australia) connected to a computer (Amagloh et al., 2013). The slurry sample was weighed 3 g and then mixed with 25 mL of distilled water in an aluminum container. The sample was then put into the Rapid Visco Analyzer with a rotation speed of 100 rpm at 25 °C for 2 minutes. The sample was then heated to 95 °C for 5 minutes, then held at 95 °C for 3 minutes. After that, the sample was cooled again to 50 °C in 4 minutes and then held at 50 °C for 2 minutes (Iwansyah et al., 2022).

Coloring analysis

The staining of the slurry samples used an NH 310 colorimeter (Indriati et al., 2020) based on the analytical method, namely CIE (Commission Internationale de L'Eclairage) L* a* b* and hue coordinates. The L* coordinates describe where L = 0 is black, and L* = 100 is colorless. The coordinates of a* represent red and green shadows, where a* > 0 indicates red and a* < 0 indicates green. The b* coordinates represent the blue and yellow tones, where b* > 0 indicates the intensity of the yellow color and b* < 0 indicates the blue color. Hue (h*) is a color characteristic, namely red, yellow, green, and blue (Iwansyah et al., 2022).

Determination of mineral grade

Nanomineral analysis of fish bone meal of the family Lutjanus sp. can be done based on several methods of ashing (ash content). According to Ciobanu et al. (2013), a sample of 20-30 g was dried in an oven at 105 °C followed by calcination at 450 °C, then 5 mL of HNO3 was added, and stored in a desiccator at 150 °C to dissolve the ash. the remaining. Tejera et al. (2013) digested a sample of 10 g of wheat flour with 2 mL of concentrated HNO3 and then the sample was calcined at a temperature of 450 °C for 48 hours. Pourhossein & Shalaei (2016) determined Fe in flour samples after being calcined in a furnace at 600 °C for 10 hours, adding 10 mL of HCl (1 M) and neutralized by adding 10 mL of NaOH until the volume became 100 mL.

2.4 Statistical analysis

The research design used a completely randomized design with 1 treatment and 6 levels, namely the concentration of fish bone nanominerals Lutjanus sp. namely 0%, 10%, 15% and 20%. The results organoleptic, physical and proximate test were subjected to statistical analysis to determine possible differences among samples by LSD's multiple range test using the *SPSS* programme Significant differences were expressed at $p < 0.05$. Data were presented as mean ± standard deviation (sd) (n = 4). Normality test was carried out on the data, and Analysis of Variance (ANOVA) was used to determine the significantly differences between treatments (Statistical Package for Social Sciences, 2022; Rao, 2009).

3 Results and discussion

3.1 Organoleptic analysis of the Saddah gohoge grits

The sample of Saddah Gohoge corn grits fortification of fish bone nanominerals from the family Lutjanus sp. What has been prepared is hedonic and hedonic quality organoleptic testing along with the score sheet provided (Figure 2).

Hedonic quality analysis

The results of organoleptic tests include quality hedonic and hedonic tests based on appearance, texture, color, aroma and taste criteria (Table 1, Table 2).

Based on the results of hedonic quality organoleptic testing, it was found that the highest value fortification of the fortification concentration of fish bones of the Lutjanus sp. 10% with a score of 3.40 the assessment criteria are rather bright. The texture of the highest value at 20% concentration fortification scores a score of 3.48 with the assessment criteria being slightly smooth and slightly thick. Texture is the nature of the product that can be felt through the touch of the skin or tasting and affects the quality of the product which ultimately affects consumer acceptance of the product (Ahmad et al., 2018).

The color parameter obtained the highest value of hedonic quality with an assessment score of 3.08 the assessment criteria are slightly yellowish. Saddah Gohoge grits with yellow corn as raw material because it contains carotenoids in addition to vitamin A and vitamin E (Table 1). An important indicator of the acceptance of a food product is flavor (Yang et al., 2022). The flavor of Saddah Gohoge grits fortification of fish bone nanominerals *Lutjanus* sp. 10% obtained a hedonic quality value of 4.00 which is slightly pungent with the flavor of corn criteria.

The hedonic quality score of Saddah Gohoge grits fortification of fish bone nanominerals Lutjanus sp. The highest score in a score is 3.16 on the taste parameter, the criteria are rather good, the taste of corn. Analysis of variance obtained that appearance, texture, color and flavor were not significant but on taste there were significant concentrations of fortification 15% and 20% (Table 1).

Hedonic analysis

The results of hedonic organoleptic testing for appearance parameters obtained the highest value for the concentration of fortified nanomineral fish bones of the Lutjanus sp. 0% with a

Figure 2. Serving of Saddah Gohoge grits fortification of fish bone nanomineral formulation family Lutjanus sp. (a = 0%, b = 10%, c = 15%, d = 20%).

Table 1. Hedonic quality organoleptic test results.

Concentration (%)	Appearance	Texture	Color	Flavour	Taste
F0 (100:0)	3.40 ± 1.041[a]	3.40 ± 0.913[a]	3.08 ± 0.909[a]	3.64 ± 1.075[a]	3.16 ± 1.248[a]
F1 (90: 10)	3.68 ± 0.945[a]	3.28 ± 1.021[a]	2.88 ± 0.881[a]	4.00 ± 0.866[a]	2.96 ± 1.207[a]
F2 (95:15)	3.44 ± 1.044[a]	3.36 ± 1.551[a]	3.00 ± 1.000[a]	3.96 ± 1.060[a]	2.56 ± 0.917[ab]
F3 (80:20)	3.32 ± 1.145[a]	3.48 ± 1.503[a]	2.76 ± 1.052[a]	3.96 ± 4.00[a]	2.24 ± 1.200[b]

a: no significant difference between the treatments. b, ab: there is significant difference between treatments.

Table 2. Hedonic organoleptic test results.

Concentration (%)	Appearance	Texture	Color	Flavour	Taste
F0 (100:0)	3.96 ± 0.841[a]	3.64 ± 1.114[a]	4.04 ± 0.935[a]	3.80 ± 1.041[a]	3.52 ± 1.194[a]
F1 (90: 10)	3.64 ± 0.995[a]	3.36 ± 1.319[a]	3.96 ± 0.889[a]	3.64 ± 0.907[a]	3.28 ± 1.100[ab]
F2 (95:15)	2.96 ± 0.790[b]	3.12 ± 0.927[a]	3.76 ± 0.879[a]	2.96 ± 0.935[b]	2.80 ± 0.913[bc]
F3 (80:20)	2.80 ± 1.000[b]	2.84 ± 1.143[a]	3.40 ± 1.118[a]	2.88 ± 1.013[b]	2.56 ± 1.044[c]

a: no significant difference between the treatments. b, c, ab, bc: there is significant difference between treatments.

rating score of 3.96 likes rating. The results of the analysis of significant variance in the concentration of fortified nanomineral fish bones of the Lutjanus sp. on texture and color parameters but significant on appearance, flavor and taste (Table 2). The texture parameter obtained the highest value at 0% concentration fortification with an assessment score of 3.64 the criteria were rather like. This study is in line with the results of research by Ahmad et al. (2018) which found that the panelists fortified corn grits fortified cherry leaves (Muntingia calabura L) gave a neutral to moderate response on a scale of 4.1-4.9.

The texture of Saddah Gohoge grits with different viscosities according to the given nanomineral fortification also depends on the amylopectin content which affects sensory, especially texture and taste. Types and varieties of corn have different amylopectin content. This is in line with what was stated by Singh et al. (2006); Rodriguez et al. (2018) that the physicochemical properties of corn starch can change the function of polysaccharides. Starch contributes to the textural properties of various corn products, namely as a gelling agent, thickener, adhesive, colloid stabilizer and water retention agent.

The results of hedonic organoleptic testing obtained the highest value for fortification of fish bone nanominerals from the family Lutjanus sp. 0% score 3.08 on the color parameter of the assessment criteria is rather like. This is the same as the research by Ahmad et al. (2018) on fortified corn grits of cherry leaves (Muntingia calabura L) which obtained a score of 4.3 – 5.4 with the criteria of somewhat liking.

The concentration of fortified nanomineral fish bones of the Lutjanus sp. (0%) for the parameters of flavor and taste, respectively, the highest scores were 3.80 and 3.52 with the criteria of each rating being somewhat like. The results of research by Ahmad et al. (2018) showed that the fortified corn grits of cherry leaves (Muntingia calabura L) panelists responded with a score of 4.3-4.6 on the aroma and taste parameters with the assessment criteria being somewhat like.

3.2 Physical analysis

Viscosity analysis

The results of the physical test of the thickness of the Saddah Gohoge grits fortification of fish bone nanominerals *Lutjanus* sp. showed that the higher the concentration of fortified nanominerals (Table 3).

The results of measuring the thickness of the sample of Saddah Gohoge grits fortification of fish bone nanominerals Lutjanus sp. obtained the highest value of 14069.7333 cP at a concentration of 15% (Table 3). These results are influenced by the addition of the volume of cooking water. This was because the volume of boiled water for Saddah Gohoge grits was the same at all concentrations of nanomineral fortification (1000 mL). This can be added to the volume of cooking water if want to achieve the same viscosity with nanomineral fortification. The results of statistical analysis showed that all fortification concentrations were significant ($p < 0.05$). The results of research by Iwansyah et al. (2022) show the relationship between pre-gelatinization temperature and viscosity with the correlation coefficient (r) and coefficient of determination (R2) being 0.9924 and 0.9849, respectively (Iwansyah et al., 2022).). The thickness of the instant grits that has been brewed varies from slightly thick to thick. This is because the greater the concentration of addition of white rice flour, the higher the value of instant grits viscosity (Makame et al., 2019). The pre-gelatinization process is a modification of starch, carried out through a process involving water and heat to break down all or part of the granules, then dried to produce a complete or partial pre-gelatinization of starch (Wadchararat et al., 2006; Palguna et al., 2014; Iwansyah et al. 2022). Several factors influence this pre-gelatinization process, including temperature (Iwansyah et al., 2022).

Coloring analysis

The results of the color test of Saddah gohoge grits fortification of fish bone nanominerals Lutjanus sp. showed that the staining at all concentrations of fortification ranged from 47.10-50.03 for the L component. different values for *a are -39.23-3.76 and *b values 15.96-16.50. Statistical analysis results obtained on all staining components were not significant ($p > 0.05$) (Table 4). The results of this staining analysis are the same as the results of the hedonic quality organoleptic test, which is not significant ($p > 0.05$) for the color parameter.

The results of the staining study were suspected because Saddah Gohoge flour basically has the same color, namely a yellowish color and the fortification concentration given does not exceed 20% so it does not affect the basic color of Saddah gohoge corn flour, which is yellow. The coloring component is the same as the results of the research by Iwansyah et al. (2022) in the rowe luwa grits sample which was not significant for *L and hue values ($p > 0.05$) but significant for the components of *a and *b values ($p > 0.05$). This shows that the cooking temperature of gelatinization also affects the coloring component of the slurry. The enzymatic reaction is slower with the longer pre-gelatinization time of Gayam flour (Inocarfus fagifer Forst.) (Wijanarka et al. (2017). The longer pre-gelatinization time will also increase the temperature and inactivate polyphenol oxidase (Akyıldız & Ocal, 2006).

3.3 Proximate analysis

Proximate analysis include water content, ash content, protein content, fat content, fiber content and carbohydrate content.

Table 3. Viscosity levels of Saddah g*ohoge* grits fortification of fish bone nanominerals *Lutjanus* sp.

Component	Results of the viscosity		
	F1	F2	F3
Viscosity levels (cP)	8309.4667 ± 42.46285[a]	14069.7333 ± 103.87946[b]	10264.7000 ± 123.87946[c]

a: no significant difference between the treatments. b, c: there is significant difference between treatments.

The results of the analysis of the highest water content without fortification of nanomineral fish bones of the *Lutjanus* sp. 0% as a fortification concentration increased, the water content decreased with the use of the volume of water for cooking Saddah Gohoge grits which was the same as 1000 mL for all concentrations (Table 5).

The results of the LSD further test showed that the concentration of 25% was significantly different from 0%, 15% and 20% ($p < 0.05$). This is due to the absorption of nanominerals into the corn *grits* granules. The type, polarity of the absorbate, the type of bond, the size of the absorbate, the viscosity of the mixture are factors that affect absorption.

The statistical results of the research by Ahmad et al. (2018) were significant ($p < 0.05$) for all concentrations of fortification of cherry leaves (Muntingia calabura L) in corn grits allegedly due to the absorption of cherry extract into corn grits granules. The results of the research by Iwansyah et al. (2022) found that the water content was not significant ($p > 0.05$) along with the increase in temperature of the instant rowe luwa grits with pre-gelatinization with the highest value of water content at 80°C, namely 6.78. The results of the analysis of ash content showed that it increased with each addition of the concentration of fortified nanomineral fish bones of the *Lutjanus* sp. This is because there are different nanomineral content at each concentration which affects the amount of ash content at each concentration.

The results of the further test of ash content at 15% and 20% and 25% fortification concentrations were not significantly ($p > 0.05$) but significantly different from those without nanomineral fortification ($p < 0.05$).

This is also inline with Iwansyah et al. (2022) study that obtained statistical results that the ash content was not significant ($p > 0.05$) with increasing temperature in pre-gelatinized instant Rowe Luwa grits samples.

Protein content, fat content and fiber content at each concentration of fortification increased along with the fortification of nanomineral fish bones of the *Lutjanus* sp. which are given. The results of further test of protein content showed that all fortification concentrations were significantly different.

The results of the study on the protein content of fortified Saddah Gohoge grits were the same as those of Ahmad et al. (2018), which was significant ($p < 0.05$). The protein content in this study increased along with the increased fortification concentration carried out. This is presumably because there is protein content in the fish bones of the Lutjanus sp.

Protein and carbohydrate levels in the study of Iwansyah et al. (2022) were also significant ($p < 0.05$) along with the increase in temperature in pre-gelatinated Rowe Luwa grits. The interaction between starch and protein in food can increase the gel strength which is associated with an increase in the density of the protein matrix (Couto et al., 2012; Jamilah et al., 2009; Iwansyah et al., 2022).

The fat content showed that the fortified concentration of 15% was significantly ($p < 0.05$) different with the concentration of 20% and 25% and without fortification (0%) but the concentration of fortified 20% and 25% was not significantly different ($p > 0.05$). The fat content increased along with the fortification of the bone nanomineral concentration of the fish of the Lutjanus sp. on grits Saddah Gohoge. The results of this study are the same as those of Iwansyah et al. (2022), which is not significant ($p > 0.05$) with increasing pre-gelatinization temperature of Rowe Luwa grits.

For fiber content, the concentration of fortified of 15%, 20%, and 25% not significantly different but significantly different from without fortification (0%). This is because there is a fiber content in the Saddah Gohoge corn grits.

The results of the further test of carbohydrate content showed that all fortification concentrations were significantly different.

3.4 Mineral analysis

Fish bone nanominerals family *Lutjanus* sp. To be fortified in Saddah Gohoge grits, it mainly contains minerals Ca which

Table 4. Color of Saddah Gohoge grits fortification of fish bone nanominerals *Lutjanus* sp.

Component	Results of sample coloring rate		
	F1	F2	F3
L	47.10 ± 2.60^a	51.33 ± 1.01^a	50.03 ± 3.55^a
*a	3.76 ± 3.00^a	-39.23 ± 74.27^a	2.03 ± 1.74^a
*b	15.96 ± 2.45^a	16.30 ± 2.26^a	16.50 ± 2.60^a

a: no significant difference between the treatments.

Table 5. Proximate levels of Saddah Gohoge grits fortification of fish bone nanominerals *Lutjanus* sp.

Sample	Water Content	Ash Content	Protein Content	Fat Content	Fiber Content	Carbohydrate Content
0%	86.82 ± 0.411^a	0.92 ± 0.87^a	7.16 ± 0.90^a	0.47 ± 0.95^a	1.77 ± 0.54^a	95.37 ± 0.50^a
15%	85.03 ± 0.744^b	1.13 ± 0.26^{ab}	8.53 ± 0.72^b	0.74 ± 0.41^b	3.30 ± 0.49^b	95.43 ± 1.52^b
20%	80.33 ± 0.562^b	1.31 ± 0.27^{ab}	9.63 ± 0.47^c	1.21 ± 0.87^c	3.60 ± 0.37^b	92.48 ± 0.40^c
25%	79.70 ± 0.113^c	1.53 ± 0.25^b	10.51 ± 0.30^d	1.22 ± 1.36^c	3.8 ± 0.37^b	92.96 ± 0.61^d

a: no significant difference between the treatments. b, c, d, ab: there is significant difference between treatments.

Table 6. The composition of nanomineral fish bones of the Lutjanus sp.

Number	Minerals	Unit	Result
1	Nitrogen (N)	%	2.10
2	Potassium (K)	mg/100 g	36.67
3	Magnesium (Mg)	mg/100 g	555.21
4	Manganese (Mn)	mg/100 g	30.48
5	Phosphor (P)	mg/100 g	148409.80
6	Iron (Fe)	mg/100 g	27.31
7	Calcium (Ca)	mg/100 g	28556.18

is 30.89% and P 15.22%. Saddah Gohoge grits made from corn also contains various essential minerals, namely K, Na, Ca, P and Fe. The results of the overall nanomineral analysis on fish bones of the Lutjanus sp. family (Table 6).

The results of the analysis of the nanomineral composition in the fish bones of the Lutjanus sp. The highest levels were obtained in Phosphorus (P) followed by Calcium (Ca), Magnesium (Mg), Potassium (K), Manganese (Mn), Iron (Fe) and Nitrogen (N) (Table 6). The highest levels of nanominerals were found in fish bone waste. This is the same as research by Harmain et al. (2018) which obtained nanomineral levels in skipjack bones, namely phosphorus (P) 6.841%, calcium (Ca) 2.935%, Magnesium (Mg) 0.528%, Manganese (Mn) 0.014%, iron (Fe) 0.016%, Potassium (K) 0.002% and zinc (Zn) 0.0089%.

Fortification of fish bone nanominerals in one serving of *binte biluhuta* cream soup or corn cream soup as a high-calcium food product has met the calcium needs of the elderly (>50 years old) which is 51.47%. Furthermore, a product can be claimed to be high in calcium if it has met twice the calcium source material (Riyanto et al., 2020).

4 Conclusion

Foritification of fish bone nanominerals of the family Lutjanus sp. on Saddah Gohoge grits from organoleptic hedonic quality, the appearance parameters are slightly bright - bright, texture is slightly smooth, slightly thick - smooth thick, slightly yellowish - yellowish in color, slightly overpowering aroma of corn - pungent aroma of corn, slightly delicious taste of corn - slightly good taste of corn, hedonic ranges from a bit like and like. Viscosity, coloration and proximate increased with fortification of the formulation but decreased in water content.

Acknowledgements

We would like to thank the Institute for Research and Community Services (LP2M) of Universitas Negeri Gorontalo, Indonesian Endowment Fund for Education (LPDP) of Ministry of Finance, the reviewers of this article and all those who have helped carry out the research.

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