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The Effect of Pumpkin Flour and Chicken Liver Flour Substitution and Egg Concentration on the Physicochemical and Organoleptic Characteristics of *Fettuccine* Pasta

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A B S T R A C T

Indonesia continues to face health problems caused by micronutrient deficiencies, which can trigger stunting. One effort to address this issue is nutritional intervention through the substitution of staple food ingredients with more nutrient-dense sources, such as fettuccini pasta made from wheat flour substituted with pumpkin flour and chicken liver. Pumpkin contains essential minerals such as calcium (Ca) and iron (Fe), while chicken liver is rich in iron (Fe) and magnesium (Mg). This study aimed to produce fettuccini pasta with pumpkin flour and chicken liver substitution that meets good physicochemical and organoleptic quality. The research was conducted experimentally using a Completely Randomized Design with a factorial pattern consisting of two factors: flour proportion and egg concentration. The first factor included three levels of wheat flour, tapioca, pumpkin flour, and chicken liver flour proportions (80%:10%:5%:5%, 70%:10%:10%:10%, and 60%:10%:15%:15%), while the second factor was egg concentration (10%, 15%, and 20%), each with two replications. The parameters analyzed were moisture, ash, protein, fat, carbohydrate, amylose, starch, tensile strength, water absorption, and organoleptic properties. The results showed that the best product was obtained from the treatment with a flour proportion of 80%:10%:5%:5% and an egg concentration of 15%. This product contained 13.02% moisture, 0.99% ash, 12.13% protein, 2.25% fat, 71.62% carbohydrate, 13.94% amylose, 51.27% starch, 0.56 N/mm² tensile strength, and 48.58% water absorption. Organoleptic tests indicated scores of 3.38 for color, 3.19 for aroma, 3.03 for taste, and 3.76 for texture (all in the "slightly like" category). The best treatment also contained Fe 5.24 mg, Mg 14.4 mg, Zn 3.57 mg, and Ca 10.5 mg per 100 g.

Contribution to Sustainable Development Goals (SDGs):
SDG 2: Zero Hunger
SDG 3: Good Health and Well-being
SDG 9: Industry, Innovation, and Infrastructure
SDG 12: Responsible Consumption and Production

1. INTRODUCTION

1.1. Research Background

According to the Ministry of Health of the Republic of Indonesia (2015), the Indonesian people tend to consume large amounts of carbohydrates, approximately 280 grams/person/day. This creates opportunities for variations of staple foods beyond rice. Noodles and pasta, which are very popular in Indonesia, offer alternative staple foods. The average consumption of noodles and pasta is 921.52 g per capita per month, with a frequency of four times/month for noodles and once/month for pasta [1]. Pasta is one of the most common and popular staple foods due to its sensory and nutritional value, ease of processing, and versatility [2]. This simplicity facilitates modifications in pasta formulations. Most research has focused on pasta formulation, including the substitution of flour to enhance the nutritional profile of pasta according to specific dietary needs. Overall, the quality of enriched pasta is generally comparable to that of traditional pasta for enrichment levels of ≤ 10% [3]. One such enrichment approach is substituting wheat flour with other ingredients, such as pumpkin flour and chicken liver flour in fettuccini pasta.

Pumpkin (Cucurbita moschata Durch) is an easily digestible agricultural commodity. Its nutritional content per 100 g includes: energy 32 kcal; carbohydrates 6.6 g; protein 1.1 g; fat 0.1 g; fiber 0.5 g; calcium 45 mg; phosphorus 64 mg; iron 2.4 mg; potassium 356.2 mg; carotene 180 mcg; vitamin C 52 mg; water 91 g; and 77% edible portion [4]. In flour form, pumpkin contains carbohydrates 682.02 g; protein 5.06 g; fat 1.16 g; fiber 9.51 g; and carotene 2147.2 mcg. Its advantage lies in producing very fine flour that can serve as an alternative to wheat flour [5].

Chicken liver is a widely available animal-based food, being a primary organ that functions as a storage site for iron. It is reddish-brown, soft, and fragile, but hardens when heated. Chickens obtain iron from their feed, which is then stored in the liver, making chicken liver an affordable iron source [6]. Chicken liver can also be processed into liver flour, a dry solid product produced by removing water and part or all of the fat. Chicken liver flour contains 45.7 mg of iron per 100 g.

The utilisation of pumpkin flour and chicken liver flour is expected to enhance the potential of local food resources and reduce dependence on wheat flour. Furthermore, their substitution in pasta fettuccini is expected to produce a product rich in animal protein, iron, and other essential minerals for growth. This study aims to determine the best proportion of substitution and egg concentration for fettuccini pasta in terms of physicochemical and organoleptic properties.

1.2. Literature Review

1.2.1. Pumpkin Flour

Pumpkin (Cucurbita moschata) is a type of climbing vegetable plant from the Cucurbitaceae family. It is classified as an annual plant that dies after fruiting. Pumpkin has been widely cultivated in Africa, the Americas, India, and China, and it can grow in both lowland and highland areas [7].

Processing pumpkins to utilise their nutritional content as part of food preservation efforts is necessary. One method is to convert pumpkin into a semi-finished product, namely pumpkin flour, through drying or partial water removal. This process produces more diverse products that are easier to use and store [8].

Pumpkin is rich in nutrients beneficial to the human body, including energy, protein, vitamins, minerals, fiber, and beta-carotene. The nutritional composition of pumpkin per 100 g is: energy 32 kcal; carbohydrate 6.6 g; protein 1.1 g; lipid 0.1 g; fiber 0.5 g; calcium 45 mg; phosphorus 64 mg; iron 2.4 mg; potassium 356.2 mg; carotene 180 mcg; vitamin C 52 mg; water 91 g; and 77% edible portion [2]. In flour form, pumpkin contains 682.02 g of carbohydrates, 5.06 g of protein, 1.16 g of lipids, 9.51 g of fibre, and 2147.2 mcg of carotene. The main advantage of pumpkin is that it can be processed into a very fine-textured flour, which serves as an alternative to wheat flour [4].

1.2.2. Chicken Liver Flour

Chicken liver is generally recognized as a type of offal product that is widely consumed and commonly utilized as a food source, often processed as a side dish [9]. It is a major internal organ that also serves as the primary storage site for iron. Chickens obtain iron from their feed, which is then stored in the liver in significant amounts; therefore, chicken liver is considered an affordable source of iron [5]. In addition to iron, chicken liver contains protein, lipids, vitamins, and minerals. It is an animal-based food rich in heme iron [9]. Heme iron from chicken liver can be absorbed intact in the intestine without the influence of enhancers or inhibitors. It is released from the porphyrin ring by the enzyme heme oxygenase, then transferred to plasma or ferritin, and subsequently transported to the bone marrow for the formation of haemoglobin. In contrast, non-heme iron is more difficult to absorb due to the presence of inhibitors such as high calcium intake, phosvitin in egg yolk, and phytates, polyphenols, tannins, and oxalates found in plant products, legumes, tea, coffee, and chocolate [10]. Furthermore, the protein content in chicken liver also plays a role in hematopoiesis, specifically in the formation of red blood cells that contain haemoglobin.

1.3. Research Objective

This study aims to determine the effect of varying proportions of pumpkin flour and chicken liver flour, as well as the addition of egg, on the physicochemical and organoleptic properties of fettuccini pasta, and to identify the optimal treatment based on physicochemical characteristics and panellists' organoleptic preferences.

2. MATERIALS AND METHODS

2.1 Materials and Tools

The raw materials used in the production of fettuccini pasta included wheat flour, pumpkin flour, chicken liver flour, tapioca flour, eggs, water, olive oil, and salt. The chemical reagents used for analysis were concentrated sulfuric acid, potassium sulfide, sodium hydroxide, hydrochloric acid, 3% boric acid, a mixed indicator of blue and red metal (1:2) in 95% ethanol, and hexane solvent.

The equipment used for fettuccini pasta production included a balance, bowl, scraper, pasta machine, grinder, cookie cutter, tray, and measuring cylinder. The instruments used for analysis were a desiccator, oven, baking tray, weighing bottle, beaker, crucible tongs, balance, spatula, mortar and pestle, Kjeldahl flask, watch glass, electric stove, distillation apparatus (heating mantle, condenser, pump, hose, bucket), analytical balance, graduated cylinder, dropper pipette, fume hood, UV-Vis spectrophotometer, hot plate, furnace, Erlenmeyer flask, funnel, burette, desiccator, filter paper, and Soxhlet extractor (tube and flask).

Table 1 shows the combination treatments used in producing fettuccine pasta. The treatments were formulated by varying the proportions of wheat flour, pumpkin flour, and chicken liver to determine their effects on the nutritional value and quality of the final product.

Table 1. Combination Treatments of Fettuccine Pasta

Wheat Flour : Tapioca : Pumpkin Flour : Chicken Liver Flour (%)	Egg (%)		
	B1	B2	B3
A1	A1B1	A1B2	A1B3
A2	A2B1	A2B2	A2B3
A3	A3B1	A3B2	A3B3

Description:

A1B1 = Proportion of flour (Wheat : Tapioca : Pumpkin : Chicken Liver = 80% : 10% : 5% : 5%) and Egg (10%)
A1B2 = Proportion of flour (Wheat : Tapioca : Pumpkin : Chicken Liver = 80% : 10% : 5% : 5%) and Egg (15%)
A1B3 = Proportion of flour (Wheat : Tapioca : Pumpkin : Chicken Liver = 80% : 10% : 5% : 5%) and Egg (20%)
A2B1 = Proportion of flour (Wheat : Tapioca : Pumpkin : Chicken Liver = 70% : 10% : 10% : 10%) and Egg (10%)
A2B2 = Proportion of flour (Wheat : Tapioca : Pumpkin : Chicken Liver = 70% : 10% : 10% : 10%) and Egg (15%)
A2B3 = Proportion of flour (Wheat : Tapioca : Pumpkin : Chicken Liver = 70% : 10% : 10% : 10%) and Egg (20%)
A3B1 = Proportion of flour (Wheat : Tapioca : Pumpkin : Chicken Liver = 60% : 10% : 15% : 15%) and Egg (10%)
A3B2 = Proportion of flour (Wheat : Tapioca : Pumpkin : Chicken Liver = 60% : 10% : 15% : 15%) and Egg (15%)
A3B3 = Proportion of flour (Wheat : Tapioca : Pumpkin : Chicken Liver = 60% : 10% : 15% : 15%) and Egg (20%)

The data obtained were processed using Analysis of Variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT) to determine differences among treatments. The results of all tests were further analysed using the De Garmo method to identify the product with the most favourable treatment outcome.

2.2 *Procedure of Making Fettuccine Pasta*

The preparation of fettuccine pasta began with the processing of raw materials, namely pumpkin flour and chicken liver flour. Pumpkin was washed, thinly sliced, and dried for 12 hours at 60°C. The chicken liver was cleaned, soaked in lime juice for 2 minutes to reduce unpleasant odours, steamed for 30 minutes, ground, and then dried for 12 hours at 60°C. Both dried pumpkin and chicken liver were subsequently ground and sieved using an 80-mesh sieve to obtain pumpkin flour and chicken liver flour. The process of fettuccine pasta making in this study was modified from a previous study [11]. First, all the ingredients were weighed, followed by mixing the main ingredients (pumpkin flour, chicken liver flour, and eggs) with the supporting ingredients, including wheat flour, tapioca, olive oil, water, and salt. The mixture was kneaded until smooth and allowed to rest for approximately 1 hour. The dough was then flattened into thin sheets, approximately 1 mm thick, and cut into ribbon-shaped strips. Finally, the fettuccine pasta was dried for 24 hours at 60°C.

2.3 *Research Analysis*

2.3.1 Raw Material Analysis

The raw materials analyzed were pumpkin flour and chicken liver flour. The analyses included moisture content, ash content, protein content, lipid content, starch content, and amylose content.

2.3.2 Physicochemical Analysis of Fettuccine Pasta

The evaluated parameters included moisture content, ash content, protein content, fat content, carbohydrate content, amylose content, starch content, tensile strength, and rehydration capacity. For the best treatment, analyses of iron, calcium, magnesium, and zinc contents were conducted.

2.3.3 Sensory Analysis of Fettuccine Pasta

The sensory characteristics selected to evaluate the quality of fettuccine pasta included color, aroma, taste, and texture. A total of 26 semi-trained panelists were assigned to assess product acceptability using a 5-point scale ranging from 'strongly liked' to 'strongly disliked'. Data analysis was carried out using the Friedman test.

3. RESULT AND DISCUSSION

Raw Material Analysis

The raw material analysis in this study was carried out on pumpkin flour and chicken liver flour. The results of the raw material analysis are presented in **Table 2.**

Table 2. Raw Material Analysis

Analysis	Raw Materials	
	Pumpkin Flour	Chicken Liver Flour
Moisture Content (%)	14.46	15.31
Ash Content (%)	4.75	0.98
Protein Content (%)	9.36	15.73
Fat Content (%)	0.42	13.26
Amylose (%)	5.34	-
Starch Content (%)	27.64	

Based on **Table 2.** The water content of pumpkin flour is higher, at 14.46%, compared to the reference value of 10.96% [12]. The lipid content of pumpkin flour is 0.42%, which is lower than the value reported in Ref. [12], 0.80%. This is due to the difference in the method of making pumpkin flour described in Ref. [12], which involves a 24-hour drying time. Temperature and drying time have a significant effect on the lipid content of flour. The higher the temperature and drying time, the greater the lipid content in the flour tends to be, as more water evaporates, decreasing the water content in the flour and increasing the relative lipid content.

The amylose content of the pumpkin flour obtained was 5.34%, which is lower than the value reported in Ref. [13] of 9.86%. This is due to the difference in the stages of making pumpkin flour used. In Ref. [13], pumpkin flour was manufactured by drying at a temperature of 50°C for 6 hours. In contrast, this study employed a temperature of 60°C and a drying time of 12 hours. The higher the temperature and the longer the heating time, the lower the amylose content in flour [14]. In addition, the difference in results is attributed to variations in

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harvest age and the types of raw materials used. Differences in varieties, harvest age, soil, and climate where the plants grow, as well as post-harvest handling, can cause variations in the analysis results [15].

The ash, lipid, and protein content of the chicken liver flour obtained was lower, specifically 0.98%, 13.26%, and 15.73%, compared to the literature on chicken liver flour, which reported values of 1.60%, 16.10%, and 27.40%. This is due to the process of soaking chicken liver in lime juice during the manufacture of chicken liver flour, which is done to reduce unwanted odours. Lime affects lipid content because citric acid in lime can bind lipid and dissolve lipid in water [16]. Additionally, it also affects ash content, as noted in Ref. [17]. Lime water solution can reduce ash content because lime juice contains reactive acids, such as citric acid, which can bind more acid-soluble ash. Meanwhile, the decrease in protein content is caused by protein denaturation resulting from the heating process [18]. In making chicken liver flour, heating is carried out twice: first, in the steaming process for 30 minutes, and then in the oven drying process at a temperature of 60°C for 12 hours.

3.1. Physicochemical Analysis of Fettuccine Pasta

Physicochemical analysis of fettuccine pasta includes the determination of moisture content (%), ash content (%), protein content (%), lipid content (%), amylose content (%), tensile strength (N/mm²), and water absorption capacity (%) (Table 1).

3.1.1 Moisture Content

The results of the ANOVA showed a significant interaction ($p \leq 0.05$) between the substitution treatments of pumpkin flour and chicken liver, as well as the addition of eggs, on the moisture content of fettuccine pasta products. Each treatment had a significant effect. **Figure 1** shows that the higher substitution by pumpkin flour and chicken liver flour would decrease the moisture content. On the contrary, the higher the addition of egg, the higher the moisture content increases.

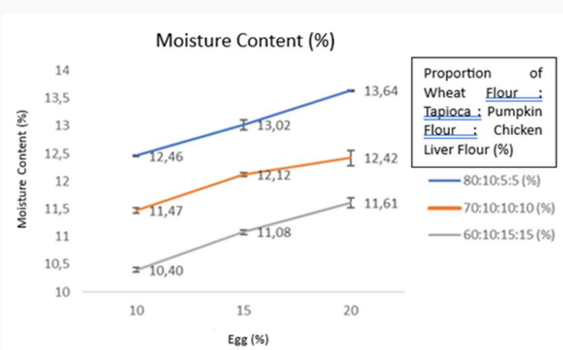

Figure 1. The interaction effect between the treatment of wheat flour, tapioca, pumpkin flour, chicken liver flour proportions, with egg addition on the moisture content of *fettuccine* pasta

The more substitutions are made, the smaller the proportion of wheat flour used. This is influenced by the ability of wheat flour to bind water. Wheat flour has a high starch content that allows it to bind water effectively. In addition, wheat flour also contains gluten which has the property of binding water [19]. The high gluten content of fettuccine results in a high water-binding capacity, as gluten forms during the mixing process when wheat flour is combined with water. Additionally, the addition of egg concentration also affects the water content of the product. Eggs have a high protein content and are easy to release water.

.1.2 Ash Content

The results of the ANOVA showed no significant interaction ($p \geq 0.05$) between the substitution treatments of pumpkin flour and chicken liver and egg concentration on the ash content of fettuccine pasta. However, each treatment had a significant effect ($p \leq 0.05$) on the ash content of fettuccine pasta products. The ash content values in **Table 3**. Show that the average ash content of fettuccine pasta ranged from 0.94% to 1.86%. The higher the substitution by pumpkin flour and chicken liver flour are made, the higher the ash content would be. This is because pumpkin flour and chicken flour have a higher ash content than wheat flour, as shown in **Table 2.** The ash content of pumpkin flour 4.7%, chicken liver flour 0.98%, while wheat flour is only 0.60% [20].

The addition of eggs used also affects the increase in the ash content of fettuccine pasta. This is due to the presence of mineral components in eggs. Eggs contain minerals such as iron, potassium, phosphorus and calcium which can increase the ash content in the product [21]. This is also supported by the statement that eggs have an ash content of 1.00% [22]. Food products derived from animals contain a high ash content due to the presence of several minerals, such as phosphorus, iron, and calcium [23].

3.1.3 Protein content

The results of the ANOVA showed there is a significant interaction ($p \leq 0.05$) between the substitution treatment of pumpkin flour and chicken liver and egg concentration on the protein content of fettuccine pasta. And each treatment has a significant effect. Figure 2 shows that the higher the substitution by pumpkin flour and chicken liver flour, along with the higher concentration of egg added, the higher the protein content would be.

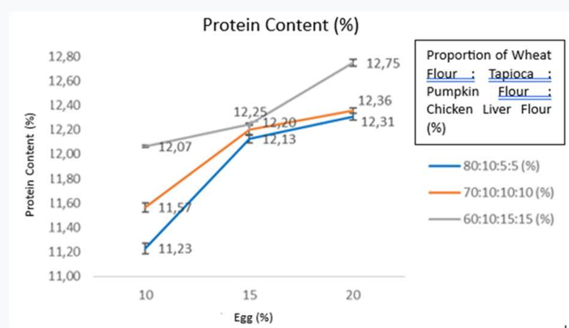

Figure 2. The interaction effect between the treatment of wheat flour, tapioca, pumpkin flour, chicken liver flour proportions, with egg addition on the ash content of *fettuccine* pasta

This is because the raw material, namely chicken liver flour, based on protein analysis, has a higher protein content of 15.73% compared to wheat flour, which ranges from 10% to 12% [20]. By decreasing the wheat flour and increasing the substitution of pumpkin flour and chicken liver flour, the protein content of the pasta product increases. Chicken liver flour contains a higher protein content, at 27.40% [24]. In addition, the addition of egg concentration used also affects the protein content of fettuccine pasta. This is because eggs contain quite high protein levels. The protein content in chicken eggs is 12.4 grams per 89 grams [25].

The amount of water present can also influence the high or low protein content. Protein content and water content have an inverse relationship; the higher the protein content, the lower the water content tends to be, and vice versa. The water content produced can affect the protein content; the lower the water content, the higher the protein content.

3.1.4 Lipid content

The results of the ANOVA showed there is a significant interaction ($p \leq 0.05$) between the substitution treatment of pumpkin flour and chicken liver, as well as the addition of eggs on the lipid content of the fettuccine pasta product. Based on **Figure 3, it is evident that the higher the substitution by pumpkin flour and chicken liver flour, along with the higher concentration of egg added, the higher the lipid content will** be.

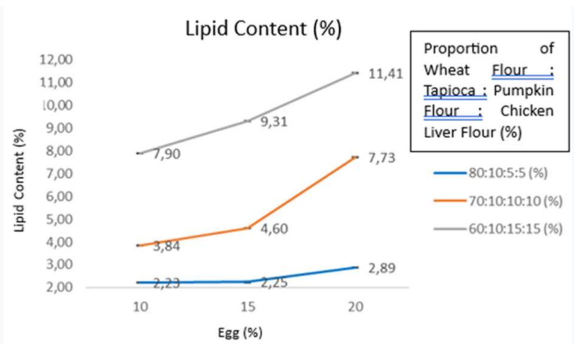

Figure 3. The interaction effect between the treatment of wheat flour, tapioca, pumpkin flour, chicken liver flour proportions with egg addition on the lipid content of *fettuccine* pasta

the higher the substitution of pumpkin flour and chicken liver and the concentration of eggs added increases the lipid content in fettuccine pasta products. Differences in lipid content can occur due to variations in the lipid content of raw materials [26]. The lipid content of chicken liver flour is higher than wheat flour. Chicken liver itself contains 16.1% lipid [24].

In addition to being caused by flour substitution, the lipid content of pasta products increases when the concentration of eggs used is greater. Eggs contain 12.9% lipid [27].

3.1.5 Carbohydrate content

The results of the ANOVA showed significant differences ($p \leq 0.05$) in the interaction between the substitution treatments of pumpkin flour and chicken liver, as well as the addition of eggs, on the carbohydrate content of fettuccine pasta products. Figure 4 shows that the higher the substitution by pumpkin flour and chicken liver flour, along with the higher concentration of egg added, the lower the carbohydrate content of fettuccine pasta.

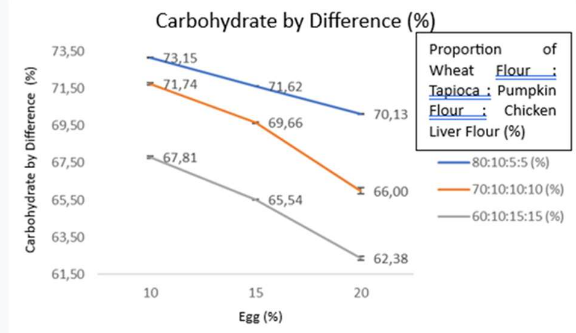

Figure 4. The interaction effect between the treatment of wheat flour, tapioca, pumpkin flour, chicken liver flour proportions with egg addition on the carbohydrate of *fettuccine* pasta

The higher the substitution of pumpkin flour and chicken liver, the lower the carbohydrates. This is due to the increasing content of macronutrients, such as protein and lipids, as well as being influenced by water content and ash content. The calculation of carbohydrates used is based on the difference method, which involves subtracting the percentages of water content, ash content, protein content, and lipid content from 100%.

3.1.6 Amylose content

The results of the ANOVA showed that there was no significant interaction ($p \geq 0.05$) between the substitution treatment of pumpkin flour and chicken liver and the concentration of eggs. The substitution treatment of pumpkin flour and chicken liver had a significant effect, but the addition of egg concentration did not affect the amylose content of the resulting fettuccine pasta product. The amylose content values in **Table 3**. Show that the average amylose content of fettuccine pasta ranged from 13.40% to 13.96%.

The higher the substitution of pumpkin flour and chicken liver flour is, the lower the amylose content in fettuccine pasta products. This is because wheat flour has a higher amylose content than pumpkin flour and chicken liver. According to data from the results of raw material analysis, wheat flour contains 14.83% amylose, while pumpkin flour only contains 5.34% amylose. The amylose and amylopectin content of pumpkin flour is relatively smaller than wheat flour [7].

3.1.7 Starch Content

The results of the ANOVA showed that there was no significant interaction ($p \geq 0.05$) between the substitution treatment of pumpkin flour and chicken liver and the concentration of eggs. The substitution treatment of pumpkin flour and chicken liver, along with the addition of eggs, had a significant impact on the starch content of the resulting *fettuccine* pasta product. The starch content values in **Table 3.** Show that the average starch content of *fettuccine* pasta ranged from 51.47% to 40.87%.

The higher the substitution of pumpkin flour and chicken liver flour, the lower the starch content in the fettuccine pasta product. This is because wheat flour contains a higher starch level compared to pumpkin flour, while chicken liver flour contains no starch at all. According to the raw material analysis data in **Table 2.**, pumpkin flour contains 27.64% starch. This starch level is lower compared to wheat flour, which contains 78.36% starch [28].

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3.1.8 Tensile Strength

The results of the ANOVA showed that significant differences ($p \leq 0.05$) were obtained in the interaction between the substitution treatments of pumpkin flour and chicken liver, as well as the addition of eggs on the tensile strength of fettuccine pasta products. Additionally, each treatment had a significant effect on the tensile strength of fettuccine pasta products. Based on **Figure 5, it is evident that the lower the flour substitution and the higher the egg concentration, the higher the tensile strength of fettuccine pasta products will be**.

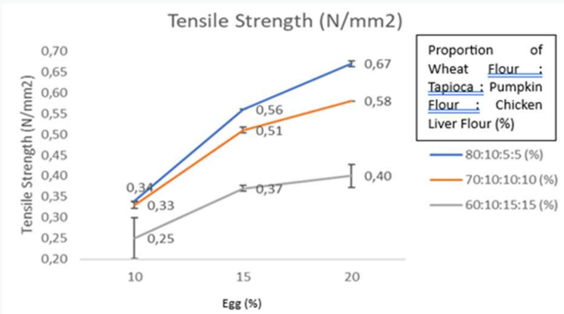

Figure 5. The interaction effect between the treatment of wheat flour, tapioca, pumpkin flour, chicken liver flour proportions with egg addition on the tensile strength of *fettuccine* pasta

Flour contains high protein in the form of gluten, while pumpkin flour and chicken liver do not contain protein in the form of gluten. Therefore, pumpkin flour and chicken liver cannot make fettuccine pasta products as elastic as those made with 100% wheat flour. The tensile strength value is closely related to the protein content in the form of gluten, namely if the peptide bond formed is short, it does not require a lot of energy to break the bond [29]. In addition, the addition of egg concentration can also affect the tensile strength value of fettuccine pasta products. Tensile strength is related to protein content where high protein content provides a high breaking strength value, because the higher the protein content means the longer the peptide bond so that more energy is needed to break the peptide bond [30]. This theory is proven by the previous research by Ref. [31] which states that the use of eggs in making noodles with the addition of other proportions of flour is intended to improve the quality and texture of the noodles to make them tough so that they do not break easily because the albumin protein content in eggs acts as a binder for the dough.

3.1.8 Water Absorption Capacity

The results of the ANOVA showed that there is a significant difference ($p \leq 0.05$) in the interaction between the substitution treatments of pumpkin flour and chicken liver, and the addition of eggs on the water absorption capacity of fettuccine pasta products. Additionally, each treatment has a significant impact on the water absorption capacity of fettuccine pasta products. The graph illustrating the relationship between the substitution of pumpkin flour and chicken liver, and the addition of eggs, and their effect on the water absorption capacity of fettuccine pasta products is shown in **Figure 6.**

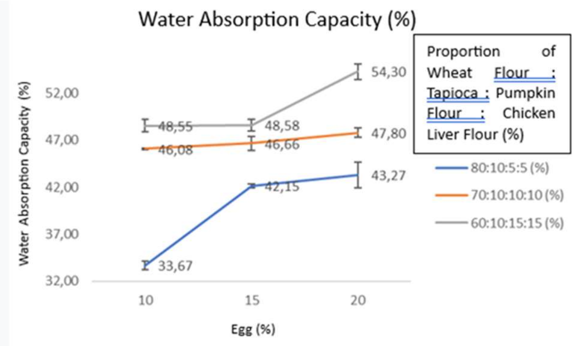

Figure 6. The interaction effect between the treatment of wheat flour, tapioca, pumpkin flour, chicken liver flour proportions with egg addition on the water absorption capacity of fettuccine pasta

The more flour substitution is done and the more egg concentration is added, the greater the water absorption of the fettuccine pasta product. Water absorption is inversely proportional to the moisture content of the product; the higher the moisture content, the lower its water absorption capacity [32]. The gluten matrix and hydrogen bonds influence water absorption in the pasta dough. The lower the gluten matrix and the weaker the hydrogen bonds, the higher the water absorption capacity. The protein content in food ingredients can affect their ability to absorb water. The formation of complex bonds between starch and protein is caused by the high protein content in the product, which in turn can influence water absorption [33].

The addition of egg concentration used also influences the water absorption capacity of pasta products. The higher the addition of eggs, the greater the water absorption capacity will be. This is due to the protein content in eggs which is hydrophilic or binds water. Ref supports this statement. [34], which states that proteins are able to bind water due to the chains that contain polar groups, such as carbonyl, hydroxyl, amino, and sulfhydryl, which can form hydrogen bonds with water.

3.2. Organoleptic Analysis of Fettuccine Pasta

3.2.1. Color

The comparative treatment of chicken liver and pumpkin flour substitution, as well as the addition of eggs, had a significant effect ($p < 0.05$) on the panellists' level of preference (hedonic) for the colour of fetuccini pasta. Based on the results of the hedonic test on the color indicator, the highest average was obtained in the A1B1 treatment with pumpkin flour and chicken liver substitution (80:10:5:5) and an egg concentration of 10% which had a slightly liked category and the lowest average value was in the A3B1 treatment with pumpkin flour and chicken liver substitution (60:10:15:15) and an egg concentration of 10% which had a disliked category.

The resulting colour comes from the ingredients in the fettuccini pasta product, namely pumpkin flour, chicken liver, and eggs. The colour of pumpkin flour tends to be yellow to bright orange due to its beta-carotene content of 1187.23 µg/g [35]. This can also be caused by eggs containing carotenoids in the yolk. However, the resulting fettuccini pasta product is rather dark or dull in color due to the presence of chicken liver flour. Chicken liver flour is brownish-yellow, so the more chicken liver flour substitutions there are, the browner the pasta produced [36].

3.2.2. Aroma

The comparative treatment of chicken liver and pumpkin flour substitution, as well as the addition of eggs, has a significant effect ($p < 0.05$) on the panellists' level of preference (hedonic) for the aroma of fetuccini pasta. Based on the results of the hedonic test on the aroma indicator in the nine treatments, the highest average for the aroma indicator was in the A1B3 treatment with a substitution of pumpkin flour and chicken liver (80:10:5:5) and an egg concentration of 20% which had a slightly liked category and the lowest average value was A3B1 with a substitution of pumpkin flour and chicken liver (60:10:15:15) and an egg concentration of 10% which had a disliked category.

The addition of pumpkin flour and chicken liver influences the aroma of fettuccini pasta. Wheat flour does not produce a distinctive aroma in the product, whereas pumpkin flour produces a preferred aroma when used in small amounts [37]. In addition, chicken liver flour has a fishy and pungent aroma that arises from the oxidation of inorganic compounds, such as iron, resulting from protein denaturation that reacts with electrons from other compounds, including fatty acids [38]. The addition of sufficient eggs can provide a savory aroma to the product [32].

3.2.3. Taste

The comparative treatment of chicken liver and pumpkin flour substitution, as well as the addition of eggs, had a significant effect ($p < 0.05$) on the panellists' level of preference (hedonic) for the taste of fettuccini pasta. Based on the results of the hedonic test on the taste indicator in the nine treatments, the highest average for the aroma indicator was in the A1B1 treatment with a substitution of pumpkin flour and chicken liver (80:10:5:5) and an egg concentration of 10% which had a category of slightly liked and the lowest average value was A3B1 with a substitution of pumpkin flour and chicken liver (60:10:15:15) and an egg concentration of 10% which had a category of disliked.

The taste of fettuccini pasta products is influenced by ingredients such as pumpkin flour and chicken liver, as well as the addition of eggs. The higher the proportion of pumpkin flour and chicken liver in the product, the lower the panellists' acceptance. This is due to the bitter taste in the product resulting from the addition of pumpkin flour, which contains high total phenolics, specifically 12.8 + 4.6 mg GAE/g db [40]. In addition, according to research from Ref. [41], the highest level of preference is produced by the lowest concentration of chicken liver flour addition.

3.2.4. Texture

The comparative treatment of chicken liver and pumpkin flour substitution, as well as the addition of eggs, had a significant effect ($p < 0.05$) on the panellists' level of preference (hedonic) for the texture of fettuccini pasta. Based on the results of the hedonic test on the texture indicator in the nine treatments, the highest average for the texture indicator was in treatment A1B2 with a substitution of pumpkin flour and chicken liver (80:10:5:5) and an egg concentration of 15% which had a category of slightly liked and the lowest average value was A2B1 with a substitution of pumpkin flour and chicken liver (70:10:10:10) and an egg concentration of 10% which had a category of disliked.

The texture of pasta products can be influenced by the ingredients added. The greater the substitution made, the less wheat flour is used, which also decreases the presence of gluten in the dough and affects the texture of the resulting fettuccini pasta product. The characteristics of a good noodle texture, such as tensile strength and elasticity, are influenced by the gluten content of the flour used in the manufacturing process. Gluten can increase the density and strength of the dough, resulting in a chewy product [42]. Poor texture of fettuccini pasta products can also occur due to the process of starch retrogradation when amylose is dispersed in water. Dissolved amylose can be suppressed by using eggs so that the use of eggs can reduce the fraction of retrograded amylose. This means that the use of eggs is beneficial for improving the texture of fettuccini pasta in terms of softness, tensile strength, and elasticity. Eggs function as a binding agent for starch molecules found in wheat flour and pumpkin flour so that more eggs can help form the texture of the resulting product. Lecithin from egg yolks functions as an emulsifier, facilitating the hydration of water in flour during dough development [43].

4. CONCLUSION

The substitution of pumpkin flour and chicken liver, as well as the addition of egg concentration, significantly affects the physicochemical and organoleptic characteristics of fettuccine pasta. The more flour is substituted, the lower the water, carbohydrate, amylose, tensile strength, and water absorption content. While the ash, protein, and lipid content are getting higher. The results of the hedonic organoleptic test showed that the highest panellist acceptance was obtained with the least flour substitution in terms of colour, aroma, taste, and texture indicators. Based on the research results, the best product selected was the treatment of fettuccine pasta with flour proportions (wheat flour, tapioca, pumpkin flour, chicken liver flour) (80%:10%:5%:5%) with the addition of 15% eggs resulted in water content of 13.01%, ash content of 0.99%, protein 12.12%, lipid 2.25%, carbohydrate 71.62%, amylose 13.94%, tensile strength of 0.56 N/mm2, and water absorption of 48.58%, and organoleptic color 3.38 (quite liked), aroma 3.19 (quite liked), taste 3.03 (quite liked), and texture 3.76 (quite liked).

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