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Encapsulated aromatic citronella extract *(Cymbopogon nardus)* and its responses to protein content, solubility, and water holding capacity of catfish bone powder

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ABSTRACT

Aromatic citronella contains highly bioactive components that are easily degraded during processing and storage. Their stability decreases due to heat, light, and oxygen exposure. Encapsulation is one method to maintain the stability of bioactive components. This study aims to determine the content of protein, solubility, and water holding capacity (WHC) of aromatic citronella extracted and encapsulated by various maltodextrin concentrations and foam mat drying temperatures of catfish bone powder. The experimental design in this study used a completely randomized design (CRD) with two factors. Temperature variations in this study were 70°C and 80°C, and maltodextrin concentrations were 10% and 15%. Statistical analysis was performed with two-way ANOVA and continued with the DMRT (Duncan's Multiple Range Test) test at the significance level $\alpha = 5\%$. Total protein of encapsulated aromatic citronella extract on catfish bone powder ranged from 17.24-27.34%, solubility ranged from 34.53-55.64%, and WHC ranged from 4.49 – 43.03%. Maltodextrin concentration significantly affected protein content and WHC. Drying temperatures significantly affected the solubility of catfish bone powder with the addition of encapsulated aromatic citronella.

Keywords: Catfish, Citronella, Foam mat drying temperature, Maltodextrin concentration

INTRODUCTION

Indonesia has both water and land, with almost 70% of its territory consisting of water. Aquatic products contain high protein content and low fat, making it used as a nutritious food. One variety of fish that is often used as a meal by the Indonesian population is catfish. Due to the high demand for catfish, the supply is abundant. However, the mass production of catfish in the home industry increases the amount of waste, such as fish bones (Widiastri et al., 2016).

Fish bones are rich in mineral content, such as calcium, that can be utilized in the food industry. Catfish bones that have been made into powder contain 13.48% calcium. Fortifying fish bone powder with highly bioactive compound herbs tends to increase functional food's nutritional level shelf life and storage ability (Literate, S., 2020). Citronella is used as a solution to reduce the unpleasant odors of catfish bone powder. Citronella contains essential oils with phenolic compounds and flavonoids in antioxidants (Dmitriy et al., 2023). The nature of essential oils is volatile, as they have a low boiling point and natural ingredients that are effective as antibacterials (Puspawati et al., 2016).

Maltodextrin has a strong binding ability to the encapsulated compound of food. Capsule layers contain maltodextrin to protect sensitive ingredients such as antioxidants, proteins, amino acids,

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flavorings, vitamins, colorants, and other nutritional ingredients (Madene et al., 2006). Maltodextrin is an additive used as a filling agent (Sansone et al., 2011). Maltodextrin can reduce sweetness in foods or beverages and acts as a sugar substitute, stabilizer, thickener, and coagulating agent in foods. Maltodextrin is commonly used as an additional component in spray drying processes and as a carrier for non-caloric sweeteners, spices, vitamins, or minerals in powder form (Tiefenbacher, 2017).

Encapsulation techniques produce very small particles or droplets called microcapsules or microspheres. The difference between a microcapsule and a microsphere lies in its internal structure and morphology. Microparticles have morphological differences depending on the nature of the core, encapsulation material, and microencapsulation technique (Pinheiro et al., 2019), affecting the rheological properties of food. Solubility measurements are performed to calculate the solubility rate of the instant powder obtained. WHC is the ability of a dry powder to absorb water. WHC analysis has been carried out to determine the characteristics of powder during storage in the open air and whether the powder easily absorbs the surrounding water. If the powder easily absorbs water, food powder will become moist easily, leading to chemical changes due to mold growth, bacteria, and enzymes (Ramadhani, 2015).

In order to maximize the utilization of catfish bones and overcome the inability of citronella extract to overcome temperature exposure, further research is needed to analyze optimum conditions to produce functional food additives with higher selling value and longer storage periods. Based on the above explanation, the authors are interested in further researching the aromatic citronella extract encapsulation process using various maltodextrin concentrations and temperatures to produce catfish bone powder.

RESEARCH METHOD

Materials

Materials that have been used in this study were citronella extract, catfish bone powder, maltodextrin, garlic, shallot, salt, pepper, white egg, aqua dest, Whatman filter paper no.42, Whatman filter paper no.41, H_2SO_4, H_2O_2, boric acid (H_3BO_3) 4% and HCl 0.2 N.

This study used Oven Memmert UN 55/UN 30, Blender Philips HR 2115, Cabinet Dryer 50°, Gas Stove (Rinai), Mixer Philips HR 1559, 40 mesh sieve, Digital Scales (Heles HL4350), Ohaus Scales PA323, Glass Funnel (Iwaki) 60 mm, 30 x 50 Weighing Bottle, Thermoscientific Vortex, protein set tools.

Methods

Citronella is extracted by the decocta method (Badan Pengawas Obat dan Makanan Republik Indonesia, 2010), and catfish bone powder is extracted by foam mat drying (Syah, 2018). This study used experimental research with a completely randomized design (CRD) research design with factorial consisting of two factors, namely the use of maltodextrin and drying temperature. Maltodextrin concentration consists of 2 levels, 10 % and 15%. Drying temperature consists of 2 levels, 70°C and 80 °C. The following steps are an analysis of protein total (Novianti, 2021), solubility (Adhayanti & Ahmad, 2020), and WHC (Wijayanti *et al*., 2015). The research design of this study is shown in Table 1.

Table 1. Research Design

Variasi suhu	**Variasi Maltodekstrin**	
	M_1 10%	**M_2 15%**
	A_1	A_2
A_1 70°C	M_1A_1	M_2A_1
A_2 80°C	M_1A_2	M_2A_2

Note: A_1 = 0% Maltodekstrin + 70°C; A_2 = 0% Maltodekstrin + 80°C; M_1A_1 = 10% Maltodekstrin + 70°C; M_1A_2 = 10% Maltodekstrin + 80°C; M_2A_1 = 15% Maltodekstrin + 70°C; M_2A_2 = 15% Maltodekstrin + 80°C.

Data Analysis

Data obtained in this research was analyzed statistically using a two-way ANOVA (Analysis of Variance) test. ANOVA test was used to identify significant differences in each treatment. Further tests have been carried out using the DMRT (Duncan's Multiple Range Test) with a significance level of p= 5%.

RESULT AND DISCUSSION

Foam mat drying uses foam formation and developer additives to dry materials that are liquid and temperature-sensitive. The drying process in the form of foam can accelerate the process of water evaporation and occurs at low temperatures (Asiah et al., 2012). The benefit of the foam drying method is that the process is simple and economical. The drying process takes place at 50°C to 80°C, which preserves the color, flavor, vitamins, and other nutrients (Mulyani et al., 2014). The foam-making process is the first to consider in the foam mat drying method. Foam stabilizer maintains the composition of the foam so that drying is fast and the material is not damaged when heated. The composition of the foam stabilizer has an important effect on the quality and stability of the foam formed (Asiah et al., 2012).

The foam mat drying method requires a foam-forming agent that is useful for driving foam formation, as well as the addition of fillers that accelerate the drying process, increase the amount of solids, prevent nutrient damage due to drying heat, can encapsulate flavor components, and increase volume (Mulyani et al., 2014). The foam mat drying method requires foam-forming agents such as tween 80 and egg white. Apart from this, adding fillers such as maltodextrin, xanthan gum, Arabic gum, and cyclodextrin is also required in this method (Olaoye & Obajemihi, 2017). A filler is an agent that can reduce surface tension and facilitate foaming. This study used egg white as a developer with varying concentrations of 10%, 15%, and 20%. Including albumen will increase the slurry's size, leading to increased thermal energy transfer and an accelerated drying process (Abidin et al., 2019).

Adding maltodextrin and egg white albumin can produce foam trapped by maltodextrin, increase surface area, and accelerate drying. At the same time, the addition of protein in the foam mat drying method increases the surface area, reduces the surface tension, enlarges the cavity, accelerates the evaporation of water, and protects the quality of materials such as color, taste, and nutrient content (Haryanto, 2020).

A complete randomized design was used in this study because several conditions meet the requirements of a complete randomized design. CRD produces precise data analysis if the experimental material is homogeneous or relatively homogeneous in the number of treatments. CRD research is used when all experimental media are in a homogeneous environment (Christina et al., 2016). This study allowed the placement of treatments into experimental units and was carried out completely randomized, which means all experimental units were seen as one unit.

Protein Total

The purpose of protein analysis is to determine the quantity of protein contained in flavoring powder made from fish meat because, during processing, fish meat and spices undergo protein denaturation, resulting in the loss of a certain amount of protein (Tahir, 2014). Protein intake is beneficial for the health of the body; in addition to acting as a source of energy, protein is also useful as a building material and control in the body. Based on the analysis of the total protein content in the flavor powder of citronella extract and catfish bones, it can be found in Table 2.

Based on the analysis of total protein content, the average level of total protein obtained in citronella extract flavor powder and catfish bones ranged from 17.24-27.34%. The highest total protein content value was shown in the A_1 treatment, which amounted to 27.34%. The lowest value was shown in the M_2A_2 treatment, which amounted to 17.24%. Powder-flavored citronella extract and catfish bones meet the quality requirements of protein in powdered broth flavoring following SNI 01-4273: 1996 with a minimum requirement of 7% protein content. The average value of protein obtained in this study is following the study's results Harni (2014). The citronella waste has an average total protein content of 11.2%.

Table 2. Total protein content values

Treatment	Protein Total (%)
A_1	27.34 ± 0.10^{a1}
A_2	25.03 ± 0.02^{b1}
M_1A_1	20.10 ± 0.04^{c1}
M_1A_2	20.78 ± 0.11^{d1}
M_2A_1	19.84 ± 0.04^{e1}
M_2A_2	17.24 ± 0.18^{e1}

Note: Values followed by different notations in each column indicate significant differences at $p < 5\%$; A_1 = 0% Maltodekstrin + 70°C; A_2 = 0% Maltodekstrin + 80°C; M_1A_1 = 10% Maltodekstrin + 70°C; M_1A_2 = 10% Maltodekstrin + 80°C; M_2A_1 = 15% Maltodekstrin + 70°C; and M_2A_2 = 15% Maltodekstrin + 80°C.

Statistical tests that have been carried out show significant differences between each treatment; this is influenced by the temperature when drying the flavor powder and the addition of maltodextrin in the flavor powder of citronella extract and catfish bones. In this study, maltodextrin variations were used at 10-15%; the addition of maltodextrin concentration significantly affected the protein content of citronella and catfish bone extract flavor powder. The use of maltodextrin in this study has the highest value in the use of maltodextrin by 10%, while the use of maltodextrin by 15% decreased the total protein content. In the use of maltodextrin concentration, the higher the addition of maltodextrin concentration, the lower the protein content contained in citronella extract flavor powder and catfish bones. This research follows research conducted by Hindom et al. (2013), which states that the more maltodextrin added, the lower the protein content and the fewer raw materials because the composition of the ingredients used is the total amount of all ingredients after the addition of maltodextrin by 100%.

Factors that influence the increase in protein content are the drying process length and the low moisture level in the foodstuff. In this study, two different temperatures of 70°C and 80°C for 10 hours were applied for the drying process. The duration of drying time affects the total protein content because the longer and higher the drying temperature, the more the protein concentration in the powder will increase. By reducing the moisture content, food ingredients will contain higher concentrations of compounds such as proteins, carbohydrates, fats, and minerals, but vitamins and dyes tend to decrease. This follows (Riansyah, 2013), which states that the increase in protein content value continues with the longer time used during the drying process, up to 24 hours.

This study shows that each citronella extracts flavor powder and catfish bone treatment has a total protein content that meets SNI. The more the addition of maltodextrin, the lower the protein content contained in the fragrant lemongrass extract flavor powder and catfish bones. In addition, different temperatures in each treatment can provide different total protein content in citronella extract flavor powder and catfish bones. The overall influencing factor in this study is the use of temperature. The use of higher temperatures in the drying temperature of the flavor powder will cause the protein concentration in the powder to increase so that the total protein content of citronella and catfish bone extract flavor powder will be high.

Solubility

Solubility is the maximum limit of a substance that can dissolve in a certain amount of solvent or solution at a specified temperature. Based on the solubility test results of flavor powder made from citronella extract and catfish bones made using the Foam mat drying method. The solubility analysis test on this flavored powder had an average value of 34.53-55.64%. The average solubility results of catfish bone flavor powder with citronella extract can be seen in Table 3.

The highest solubility was obtained in the M_2A_2 treatment at 55.64%, with maltodextrin utilization of 15% and using a drying temperature of 80ºC. This result was lower than that of tuna flavor powder with maltodextrin filler in Kanpairo et al. (2012), which had a 60.87% -70.12% solubility level. With citronella extract flavoring powder and catfish bones having a low solubility level.

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Table 3. Solubility Value

Treatments	Solubility (%)
A_1	35.80 ± 0.32^{a1}
A_2	50.82 ± 0.03^{b1}
M_1A_1	38.02 ± 2.94^{a1}
M_1A_2	51.80 ± 2.76^{b1}
M_2A_1	34.53 ± 2.72^{a1}
M_2A_2	55.64 ± 2.26^{c1}

Note: Values followed by different notations in each column indicate significant differences at p < 5%; A_1 = 0% Maltodekstrin + 70°C; A_2 = 0% Maltodekstrin + 80°C; M_1A_1 = 10% Maltodekstrin + 70°C; M_1A_2 = 10% Maltodekstrin + 80°C; M_2A_1 = 15% Maltodekstrin + 70°C; and M_2A_2 = 15% Maltodekstrin + 80°C.

The solubility of maltodextrin affected the solubility of samples because maltodextrin has a high solubility level, is soluble in water, and has a fast diffusion process. The solubility level of maltodextrin is 99% in water solvents (Ramadhani, 2016). Maltodextrin also contains reducing sugars. The more maltodextrin the total dissolved solids, the more the total dissolved solids increase (Siagian et al., 2017).

A higher solubility value indicates better product quality because the presentation process is easier (Yuliawaty, 2015). Besides, maltodextrin, a coating material, contributes to the solubility response. This is in line with Adawiyah's (2018) statement that the use of maltodextrin and sucrose significantly influences the solubility of the instant drink. Each treatment of citronella extract in catfish bone powder had increased solubility value along with the addition of maltodextrin and high drying temperatures.

WHC

WHC is the ability of dry powder to absorb water or water vapor. A water absorption test needs to be carried out to determine the characteristics of the flavor powder when stored in the open air and whether the powder easily absorbs water around it. If the flavor powder absorbs water, it will become damp easily, which can cause chemical changes due to the growth of mold, bacteria, and enzymes (Ramadhani, 2015). WHC analysis of the citronella extract flavor powder and catfish bones can be seen in Table 4.

Table 4. Water Holding Capacity

Treatments	WHC (%)
A_1	$20.34 \pm 0.04e^{1}$
A_2	$43.03 \pm 0.66f^{1}$
M_1A_1	$6.59 \pm 0.02c^{1}$
M_1A_2	$11.42 \pm 0.08d^{1}$
M_2A_1	$3.73 \pm 0.06a^{1}$
M_2A_2	4.49 ± 0.05^{b1}

Note: Values followed by different notations in each column indicate significant differences at p < 5%; A_1 = 0% Maltodekstrin + 70°C; A_2 = 0% Maltodekstrin + 80°C; M_1A_1 = 10% Maltodekstrin + 70°C; M_1A_2 = 10% Maltodekstrin + 80°C; M_2A_1 = 15% Maltodekstrin + 70°C; and M_2A_2 = 15% Maltodekstrin + 80°C.

Average WHC results in catfish bone powder with encapsulated citronella extract ranged from 3.73 – 43.03%. The highest WHC was shown in treatment A_2 (43.03%), and the lowest was M_2A_1 (3.73%). A higher WHC value indicates the gel's greater ability to bind water (Wijayanti et al., 2015). WHC value in this study follows research conducted by Djaafar et al. (2018) on kendang essence powder, which ranged from 2.98% - to 64.55%.

Statistical analysis showed a significant effect of maltodextrin concentration and temperature differences on WHC value. The highest WHC value was A2 with a temperature of 80°C without maltodextrin addition. This result is caused by the hydrophilic nature of proteins, indicating the ability of proteins to bind to water. The temperature has a significant effect on the WHC value. Higher drying temperature will cause WHC value to increase (Ekafitri et al., 2016).

The higher the maltodextrin concentration, the lower the WHC value of catfish bone powder with encapsulated citronella extract. This result was caused by the low hygroscopic properties of maltodextrin (Rodríguez-Hernández et al., 2005) and the destruction of the phenolic network structure between the phenolic groups and maltodextrin. Damage to tissue structure weakens the ability of catfish bone powder to bind water. During the drying process, some gel forms, creating a three-dimensional network that can trap water. Increasing maltodextrin concentration results in more three-dimensional networks, which reduces the ability to trap water in the resulting powder. Thus, the greater the concentration of maltodextrin, the more the WHC value of the powder decreases (Djaafar et al., 2018). Adding maltodextrin affected the WHC value more than variations in the drying temperature of catfish bone powder with encapsulated citronella extract. Thus, the greater the concentration of maltodextrin added, the lower the WHC value of the citronella extract flavor powder and catfish bones.

CONCLUSION

Maltodextrin concentration significantly affected the solubility and WHC of catfish bone powder with encapsulated citronella extract. However, drying temperature affected total protein significantly. Using 15% maltodextrin greatly decreased WHC value compared to 10% concentration. However, using 10% and 15% concentrations of maltodextrin showed almost similar trend values in protein and solubility parameters.

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