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# CHARACTERISTICS OF TILAPIA (*OREOCHROMIS NILOTICUS*) BEKASAM WITH THE ADDITION OF DIFFERENT SUCROSE CONCENTRATIONS

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## ABSTRACT

Bekasam is a traditional fermented fish product that relies on carbohydrates as an energy source for microorganisms during fermentation. Palm sugar is a conventional carbohydrate additive used in bekasam production, capable of generating a distinctive aroma; however, its relatively high market price necessitates the exploration of alternative carbohydrate sources. Sucrose represents a viable substitute, serving as an energy source for lactic acid bacteria (LAB) during fermentation. The present study aimed to determine the physicochemical characteristics and hedonic properties of tilapia bekasam prepared with different sucrose concentrations, and to identify the optimal formulation. The manufacturing procedure commenced with salting of cleaned and transversely cut tilapia fillets at a salt concentration of 10% for 15 minutes, followed by the addition of 40% cooked rice and sucrose at varying concentrations into glass jars. Fermentation was conducted at room temperature for 7 days. A completely randomized design (CRD) was employed, comprising treatments of 5% palm sugar (control), 1% sucrose, 3% sucrose, and 5% sucrose. The results indicated that increasing sucrose concentration significantly affected water activity, moisture content, total plate count (TPC), pH, and hedonic scores. Higher sucrose concentrations elevated TPC values and hedonic scores for appearance and taste, while reducing water activity, moisture content, pH, and total volatile base nitrogen (TVBN). The optimal treatment was identified as bekasam with 5% sucrose, exhibiting the following values: appearance 6.06 ± 0.90, aroma 6.63 ± 0.73, taste 6.31 ± 0.68, texture 6.66 ± 0.80, water activity 0.80 ± 0.001, moisture content 60.02 ± 0.29%, TPC 9.44 ± 0.03 cfu/g, pH 5.85 ± 0.03, and TVBN 19.33 ± 0.68 mgN/100g.

**KEYWORDS:** tilapia bekasam; palm sugar; bekasam characteristics; sucrose.

## 1. INTRODUCTION

Tilapia (Oreochromis niloticus) is one of the most economically important demersal fish species in Indonesia, owing to its tender texture, savory flavor, and wide environmental tolerance that facilitates aquaculture. Tilapia constitutes a high-quality protein source; its protein content is reported to be higher than that of several other commercially important fish species, reaching approximately 20.08 per 100 grams of edible flesh [1].

Fermentation is among the most effective methods for extending the shelf life of fish. During this process, complex compounds are broken down into new products through enzymatic activity derived from raw materials or microorganisms. Bekasam is a traditional Indonesian fermented fish product characterized by a distinctively sour and salty taste with a specific aroma [2]. As a salted fermented fish product, bekasam is produced through lactic acid fermentation under anaerobic conditions.

The production of bekasam requires carbohydrates as an energy substrate for microorganisms throughout the fermentation process. Cooked rice is commonly used as the primary carbohydrate source; however, the incorporation of supplementary carbohydrates may enhance the quality characteristics of the final product. Palm sugar has traditionally been used as an additional carbohydrate in bekasam; nevertheless, its increasing demand and consequently elevated market price relative to refined sugar have prompted interest in alternative sources. Sucrose, an accessible and cost-effective disaccharide, constitutes an important factor in fermentation processes [3]. Sucrose is hydrolyzed by microbial enzymes into fructose and glucose, which are subsequently metabolized by LAB as primary energy substrates [4].

The use of varying sucrose concentrations in tilapia bekasam production is hypothesized to influence the physical and chemical characteristics of the product. The objective of this study was therefore to investigate the effect of different sucrose concentrations on the characteristics of tilapia bekasam and to determine the optimal formulation.

## 2. MATERIALS AND METHODS

### 2.1. Product Preparation

Tilapia bekasam was prepared by mixing cleaned and transversely cut fish fillets with cooked rice, salt, and sucrose in glass jars. Jars were sealed airtight to exclude atmospheric oxygen and incubated at room temperature for 7 days.

### 2.2. Research Design

The study employed an experimental laboratory method using a completely randomized design (CRD). Sucrose concentrations of 1%, 3%, and 5% (w/w) were applied as treatments, with 5% palm sugar serving as the control, as adapted from Wahyuni et al. [5] with modifications. The preparation procedure consisted of 100 g of transversely cut tilapia fillet, salted with 20 g of salt and allowed to rest for 30 minutes. Subsequently, 30 g of cooked rice was added and homogenized. Sucrose was incorporated at the respective concentrations, the mixture was homogenized, jars were sealed, and fermentation was conducted for 7 days.

### 2.3. Analytical Methods

#### 2.3.1. Water Activity (Aw)

Water activity was determined using a calibrated Aw meter. Prior to measurement, the instrument was calibrated with BaCl2·2H2O solution until a reading of 0.9 was achieved. Each sample was placed in the measurement chamber, the probe was positioned in contact with the sample, and the reading was recorded after a 3-minute equilibration period [6].

#### 2.3.2. Moisture Content

Moisture content was determined gravimetrically following SNI 2354.2:2015 [7]. Samples were homogenized using a blender. Empty crucibles were pre-dried in a non-vacuum oven at 105°C for a minimum of 2 hours, cooled in a desiccator for 30 minutes, and weighed (value A). Approximately 2 g of sample was weighed into each crucible (value B), placed in the oven at 105°C for 16–24 hours, cooled in a desiccator for 30 minutes, and reweighed (value C). Moisture content was calculated as follows:

$$\text{Moisture content (\%)} = [(B - C) / (B - A)] \times 100\%$$

#### 2.3.3. Total Plate Count (TPC)

Total plate count was determined in accordance with SNI 2332.3:2015 [7]. A 25 g sample was homogenized with 225 mL of buffered peptone water (BPW) for 2 minutes to yield a $10^{-1}$ dilution. Serial dilutions were prepared to $10^{-3}$. Plate count agar (PCA) was poured onto sterile petri dishes; 1 mL aliquots from each dilution were inoculated and overlaid with 15 mL of Thioglycolate Agar. Plates were incubated in an inverted position at 35 ± 1°C for 48 hours. Colony counts were calculated using:

$$N = \Sigma C / [(1 \times n_1) + (0.1 \times n_2)] \times d$$

### 2.3.4. pH Measurement

The pH of each sample was measured using a calibrated pH meter. The electrode was rinsed with distilled water, immersed in the sample, and the reading was recorded upon stabilization [7].

### 2.3.5. Total Volatile Base Nitrogen (TVBN)

TVBN was determined following SNI 01-2354.8:2009 [8] through extraction, distillation, and titration. A 0.1 g sample was extracted with 90 mL of 6% perchloric acid (PCA) and filtered through coarse filter paper. Fifty milliliters of the extract was subjected to steam distillation in the presence of phenolphthalein indicator and NaOH (20%). The distillate was collected in a receiver containing 100 mL of 3% boric acid ($H_3BO_3$) and 3–5 drops of Tashiro indicator. Titration was performed with 0.02 N HCl until a purple endpoint was reached. Blank correction was applied. TVBN was calculated as:

$$TVBN\ (mgN/100g) = [(Vc - Vb) \times N \times 14.007 \times 2 \times 100] / W$$

### 2.3.6. Hedonic Evaluation

Sensory evaluation was conducted using a hedonic (preference) scale by 35 untrained panelists, assessing four attributes: appearance, aroma, taste, and texture, following the procedure of Yusfiani et al. [9].

## 2.4. Statistical Analysis

Data were analyzed using one-way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT) at a significance level of 5% ($\alpha = 0.05$). Results are expressed as mean ± standard deviation. Different superscript letters indicate statistically significant differences among treatments.

# 3. RESULTS AND DISCUSSION

## 3.1. Hedonic Evaluation

Hedonic evaluation was performed by 35 panelists on four sensory attributes: appearance, aroma, taste, and texture. The highest overall hedonic score ($6.288 < \mu < 6.540$) was recorded for the 5% sucrose treatment, whereas the lowest score ($5.952 < \mu < 6.262$) was observed for the 1% sucrose treatment, indicating that higher sucrose concentrations positively influenced panelist acceptance of tilapia bekasam.

**Table 1. Hedonic evaluation results of tilapia bekasam.**

| Treatment | Appearance | Aroma | Taste | Texture |
|---|---|---|---|---|
| 1% Sucrose | $5.26 \pm 1.71^{a}$ | $6.66 \pm 0.73^{a}$ | $5.94 \pm 0.90^{ab}$ | $6.57 \pm 0.81^{a}$ |
| 3% Sucrose | $5.54 \pm 0.98^{ab}$ | $6.68 \pm 0.79^{a}$ | $5.66 \pm 0.97^{a}$ | $6.66 \pm 0.76^{a}$ |
| 5% Sucrose | $6.06 \pm 0.90^{c}$ | $6.63 \pm 0.73^{a}$ | $6.31 \pm 0.68^{b}$ | $6.66 \pm 0.80^{a}$ |

*Note: Values are means ± SD (n = 35). Different superscript letters indicate significant differences ($p < 0.05$, DMRT).*

### 3.1.1. Appearance

The highest mean appearance score was recorded for the 5% sucrose treatment (6.06), whereas the lowest was observed for the 1% sucrose treatment (5.26). Bekasam prepared with 5% sucrose exhibited a bright, slightly brownish appearance. This coloration is attributable to non-enzymatic browning reactions facilitated by increasing sucrose concentrations [10]. The browning phenomenon in fermented fish products has been associated with cooking-induced Maillard reactions involving proteins and amino acids present in fish flesh [10].

### 3.1.2. Aroma

Mean hedonic scores for aroma ranged from 6.37 to 6.68 across all treatments, with the 3% sucrose treatment receiving the highest score (6.68) and the palm sugar control the lowest (6.37). The aroma profiles of all treatments were broadly similar, characterized by a typical fermentation odor resulting from microbial metabolism that produces an acidic atmosphere. The low concentrations of sucrose employed were insufficient to substantially alter the characteristic bekasam aroma. The acidic aroma is recognized as a defining sensory attribute of this product class [11].

### 3.1.3. Taste

Mean hedonic scores for taste ranged from 5.66 to 6.31, with the 5% sucrose treatment receiving the highest score. The incorporation of sucrose moderately reduced the saltiness of bekasam while contributing to a more balanced flavor profile. The sweetening function of sucrose in fermented products has been documented, as it can attenuate excessive acidity characteristic of lactic acid fermentation [12]. The dominant taste of bekasam is sour-salty, arising from lactic acid production by LAB and the concurrent increase in free amino acids from proteolytic activity [13].

#### 3.1.4. Texture

Mean hedonic scores for texture ranged from 6.57 to 6.68, with no statistically significant differences among treatments ($p > 0.05$). Bekasam exhibited a soft yet cohesive texture (following steaming). This characteristic is attributed to the proteolytic activity of lactic acid, which degrades myofibrillar proteins, resulting in textural softening. The progressive softening of fish muscle during fermentation is a well-documented consequence of protein degradation by LAB and endogenous enzymes [11].

### 3.2. Water Activity

**Table 2. Water activity (Aw) of tilapia bekasam.**

| Treatment | Water Activity (Aw) |
|---|---|
| 1% Sucrose | $0.83 \pm 0.006^{c}$ |
| 3% Sucrose | $0.82 \pm 0.006^{b}$ |
| 5% Sucrose | $0.80 \pm 0.001^{a}$ |

*Note: Values are means ± SD (n = 3). Different superscript letters indicate significant differences (p < 0.05, DMRT).*

Water activity decreased progressively with increasing sucrose concentration, from 0.83 (1% sucrose) to 0.80 (5% sucrose). This reduction is consistent with the hygroscopic nature of sucrose, which binds free water molecules, thereby lowering the proportion of water available for microbial activity [14]. Sucrose acts as a humectant by forming hydrogen bonds with water, and its addition to food systems is associated with a reduction in Aw that is proportional to concentration [15].

### 3.3. Moisture Content

**Table 3. Moisture content of tilapia bekasam.**

| Treatment | Moisture Content (%) |
|---|---|
| 1% Sucrose | $62.31 \pm 0.38^{c}$ |
| 3% Sucrose | $61.14 \pm 0.19^{b}$ |
| 5% Sucrose | $60.02 \pm 0.29^{a}$ |

*Note: Values are means ± SD (n = 3). Different superscript letters indicate significant differences (p < 0.05, DMRT).*

Moisture content decreased significantly with increasing sucrose concentration, ranging from 62.31% (1% sucrose) to 60.02% (5% sucrose). This reduction is attributable to the hygroscopic properties of both salt and sucrose, which bind water through hydrogen bonding, reducing the amount of free moisture in the product [16]. The capacity of sucrose to immobilize water increases with concentration, so that higher sucrose levels result in greater water binding and consequently lower moisture content [17].

### 3.4. Total Plate Count (TPC)

**Table 4. Total plate count (TPC) of tilapia bekasam.**

| Treatment | TPC (cfu/g) |
|---|---|
| 1% Sucrose | $7.94 \pm 0.04^{a}$ |
| 3% Sucrose | $8.81 \pm 0.01^{b}$ |
| 5% Sucrose | $9.44 \pm 0.03^{c}$ |

*Note: Values are means ± SD (n = 3). Different superscript letters indicate significant differences (p < 0.05, DMRT).*

TPC increased significantly with increasing sucrose concentration, from 7.94 cfu/g (1% sucrose) to 9.44 cfu/g (5% sucrose). This trend reflects the role of sucrose as a readily fermentable carbohydrate substrate that supports LAB proliferation during bekasam fermentation [18]. The higher the available carbohydrate content, the more abundant the nutrients for bacterial growth, and the greater the resulting microbial population. Sucrose is hydrolyzed into fructose and glucose by microbial enzymes, and these monosaccharides are subsequently utilized as primary carbon and energy sources by fermenting bacteria [4].

### 3.5. pH

**Table 5. pH values of tilapia bekasam.**

| Treatment | pH |
|---|---|
| 1% Sucrose | $6.15 \pm 0.05^{c}$ |
| 3% Sucrose | $5.94 \pm 0.04^{b}$ |
| 5% Sucrose | $5.85 \pm 0.03^{a}$ |

*Note: Values are means ± SD (n = 3). Different superscript letters indicate significant differences (p < 0.05, DMRT).*

pH decreased progressively with increasing sucrose concentration, from 6.15 (1% sucrose) to 5.85 (5% sucrose). The addition of supplementary carbohydrates stimulates greater metabolic activity in LAB, resulting in the production of increased quantities of organic acids, particularly lactic acid, from carbohydrate catabolism [19]. The accumulation of these organic acids reduces the pH of the fermentation medium. The presence of both cooked rice and sucrose as nutrient sources supported greater bacterial proliferation and consequently higher acid production, lowering the pH proportionally [20]. Lactic acid produced during fermentation is the primary determinant of pH decline in bekasam [20].

### 3.6. Total Volatile Base Nitrogen (TVBN)

**Table 6. TVBN values of tilapia bekasam.**

| Treatment | TVBN (mgN/100g) |
|---|---|
| 1% Sucrose | $25.12 \pm 0.74^{c}$ |
| 3% Sucrose | $23.38 \pm 0.38^{b}$ |
| 5% Sucrose | $19.33 \pm 0.68^{a}$ |

*Note: Values are means ± SD (n = 3). Different superscript letters indicate significant differences (p < 0.05, DMRT).*

TVBN values decreased significantly with increasing sucrose concentration, from 25.12 mgN/100g (1% sucrose) to 19.33 mgN/100g (5% sucrose). The reduction in TVBN is associated with the enhanced growth of LAB promoted by sucrose, which in turn reduces the pH and inhibits the growth of proteolytic spoilage bacteria and pathogens [21]. The lower pH environment created by greater LAB activity suppresses the production of volatile bases from protein degradation. The addition of sucrose therefore accelerates the fermentation process, limiting the formation of volatile nitrogenous compounds from putrefactive microorganisms [19].

## 4. CONCLUSIONS

The incorporation of sucrose at varying concentrations significantly influenced the physicochemical characteristics and hedonic properties of tilapia bekasam. Increasing sucrose concentration progressively elevated TPC values and hedonic scores for appearance and taste, while reducing water activity, moisture content, pH, and TVBN. The 5% sucrose treatment yielded the most favorable overall product characteristics and is recommended as the optimal formulation for tilapia bekasam production.

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