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Physical and Chemical Properties of Corn-Almond Cookies Affected by Mung Bean Supplementation and Source of Fat

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ABSTRACT
Cookies generally contain gluten because they are made from wheat flour obtained from wheat, while there are groups that are intolerant of gluten. Patients with gluten intolerance also tend not to be able to consume casein and lactose intolerance. So, one of the innovations that can be done to make cookies gluten, casein, and lactose-free is to replace wheat flour with corn and almond flour. Corn-almond cookies produced still have a low nutritional value of protein so that supplementation is done with mung bean flour. This research aimed to find out: 1) the effect of mung bean flour supplementation on the quality of corn-almond cookies; 2) the effect of fat types on the quality of corn-almond cookies; 3) the right treatment combination between supplementation of mung bean flour and the type of fat that produces the best quality of corn-almond-based cookies. The design used in this study was Randomized Group Design (RGD). Factors studied included supplementation of mung bean flour (level of 10, 20, and 30%) and sources of fat (margarine, Virgin Coconut Oil (VCO), and combination of margarine and VCO). Based on these factors, nine treatment combinations were obtained, which were repeated three times. Data were analyzed using variance analysis with a level of 5% and further tests of Duncan's Multiple Range Test with a 5% level. The best treatment was chosen by using the effectiveness index test. The results showed that supplementation of mung bean flour increased water content and reduced fat content. While the type of fat increases fat content and dissolved protein levels, and decreases the development volume. The best combination of treatments is cookies with mung bean supplementation of 10% with 100% VCO fat. Physicochemical characteristics of corn-almond cookies produced from the best treatment's combination are having a value of dissolved protein content of 2.35%, fat content of 28.10%, reducing sugar content of 0.21%, moisture content of 2%, ash content of 0.27%, and volume development of 73.23%.

Keywords: Corn, Cookies, Mung bean, Virgin coconut oil

1. INTRODUCTION

Cookies are generally made from wheat flour, which contains 80% gluten of the total wheat protein [1][2] . The gluten intolerant group cannot consume cookies from wheat flour, so they need raw materials other than wheat flour, such as corn flour. Corn flour has advantages because of the presence of functional food components such as dietary fiber, Fe, and beta-carotene [3][4]. Corn is also a source of carbohydrates that have a fairly low glycemic index so that when consumed it will not raise blood sugar. However, corn flour which is applied to the manufacture of cookies, produces a less favourable sensory aroma of cookies. To improve the sensory characteristics while increasing the nutritional value, almond flour was added.

Almond flour can be used to improve the sensory aroma of corn cookies while increasing their nutritional value [5]. Generally, gluten intolerant patients also cannot consume products containing casein, a protein in milk because it can cause allergies [6]. In addition, there is a group of sufferers who are lactose intolerant in milk. Thus, the use of almond flour can be used as an alternative to powdered milk (containing casein and lactose) in cookie processing [7]. However, almond flour is expensive, so its addition to cookies is limited.

To increase the nutritional value of cookies, especially the protein content, mung bean flour can be added in the manufacture of cookies. Mung beans contain high protein by 24%db and important mineral sources, including calcium and phosphorus [8]. Thus, the addition

of mung bean also aims to supplement the low protein of corn-almond cookies.

In making cookies, it is necessary to add fat/oil to form a crunchy texture and increase flavour [9]. The type of fat that is usually used is margarine which has a solid texture, bright yellow colour, and does not melt easily. Many types of fat other than margarine can be added in making cookies. Virgin Coconut Oil (VCO) is a type of oil that has a high lauric acid content compared to other vegetable oils.   VCO contains 50% lauric acid and 7% caprylic acid [10].

This study aims to: 1) determine the effect of mung bean flour supplementation on the physicochemical properties of corn-almond flour-based cookies; 2) determine the effect of fat type on the physicochemical properties of corn-almond flour-based cookies; 3) determine the right combination of treatment between mung bean flour supplementation and the type of fat that produces corn-almond flour-based cookies with the best physicochemical properties.

2. MATERIALS AND METHOD

The main ingredients used for making cookies are yellow corn flour from Purbalingga Regency, "Khas Jaya Nusantara" almond flour from Tangerang Banten, "Healthy" mung bean flour from Sukamanunggal Surabaya, margarine, VCO "Mutia", refined sugar "Gulaku", baking powder, eggs and salt.

The ingredients for making cookies include corn flour (67%), almond flour (33%), mung bean flour (according to the percentage of supplementation), fat (45% of total flour), eggs (20% of total flour), sugar (40% of total flour), baking powder (1% of total flour) and salt (0.5% of total flour). The method of making cookies refers to the method of [11] with modification of ingredients. Making cookies begins with mixing sugar and fat for 3 minutes to form a cream. Then add eggs and mix until homogeneous, then add corn flour, almond flour, mung bean flour, salt, and baking powder. Mixing is done until all the ingredients are homogeneous, followed by moulding. The next stage is roasting for 20 minutes at 170°C. Cookies that have been cooked are then cooled to room temperature and packaged using plastic until analysed. Analysis was conducted on the volume expansion [12], moisture content using gravimetric method [13], fat content using extraction method[13], soluble protein content, ash content was using thermogravimetric [13], and reducing sugar using ICUMSA method [14].

This research is an experimental study with a factorial randomized block design. The factors studied were the percentage of mung bean flour supplementation consisting of 3 levels (10, 20 and 30%) and the type of

fat consisting of 3 rates (margarine, VCO, combination of margarine and VCO (1:1)). These factors were then arranged in a factorial manner so that 9 treatment combinations were obtained, and were repeated 3 times.

The data obtained were analyzed using analysis of variance (F test) at the 5% level. If the results of the analysis have a significant effect, then proceed with Duncan's Multiple Range Test (DMRT) with a level of 5%. Based on the results of physicochemical analysis, the determination of the product with the best cookie formulation was analyzed using an effectiveness index.

3. RESULTS AND DISCUSSION

Table 1 shows that mung bean supplementation has a very significant effect on water content, significantly affects fat content, and has no significant effect on ash content, reducing sugar content, protein content, and expansion volume. Meanwhile, different types of fat had a significant effect on fat content, protein content, and volume of expansion and had no significant effect on water content, ash content, and reducing sugar content. The combination of mung bean supplementation and the type of fat showed no significant effect on all variables.

Table 1. The effect of mung bean flour substitution and the type of fat on the characteristics of cookies

No	Variable	Type of fat	Mung bean supplementation	Interaction
1.	Moisture content	**	ns	ns
2.	Ash content	ns	ns	ns
3.	Fat content	*	*	ns
4.	Reducing sugar content	ns	ns	ns
5.	Soluble protein content	ns	*	ns
6.	Expansion volume	ns	*	ns

Exp: * = very significant effect at the level of 1%
     ** = significant effect at the level of 5%
     ns = non-significant effect

3.1. Moisture Content

Mung bean flour moisture content is 6.25% [7] and its supplementation had a significant effect on the moisture content of cookies, while the type of fat and the combination of them did not have a significant effect. Supplementation with 30% mung bean flour resulted in cookies with the highest moisture content of 2.98%, but it was not significantly different from 20%

supplementation which resulted in 2.93% moisture content in cookies. The lowest water content was found in 10% mung bean flour supplementation, which was 2.16%. The moisture content of cookies increases with the increase in the amount of mung bean flour (Fig 1).
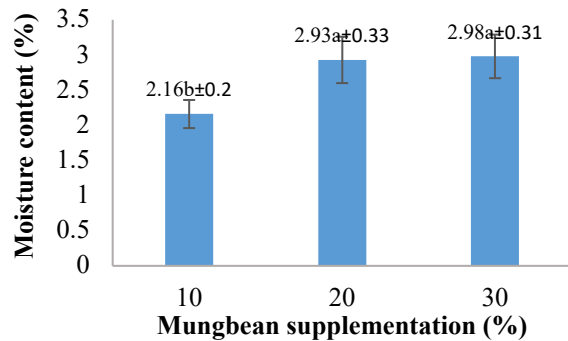

Figure 1. Effect of mung bean supplementation to moisture content of cookies

The result in this study was in compliance to Widjajaseputra et al. (2019), showing that moisture content increased following the increase of mung bean flour content [8]. The increase in moisture content was due to an increase in the amount of protein due to an increase in the amount of mung bean flour. The roasting process results in protein denaturation, where large protein molecules exposed to heat will form a compact network in the form of a matrix [9]. The matrix causes water to be trapped in these protein molecules and cannot escape.

Protein has two types of, that is both hydrophobic and hydrophilic [15]. Protein on mung bean flour, which can be as 22.05%, has more hydrophilic bonds, which has a high-water binding power, so that if the water content of protein in the high mung beans, then allow these cookies water content is also high[16]. The higher the hydrophilic proteins in a food will cause an increase in solubility in liquids because the more hydrophilic group (e.g., lysine, tryptophan, asparagine, glutamine, and histidine) that causes increased water binding capacity [17]

The moisture content of cookies is also influenced by the content of amylose and amylopectin in mung bean flour. The amylose content of mung bean flour is 33%, and amylopectin is 67% [18]. Amylose is easy to absorb and release water. Meanwhile, amylopectin has the property of being difficult to absorb water but the water will be retained when it is absorbed [19][20]. So, the more the amount of mung bean flour added, the higher the moisture content value.

The moisture content of cookies can be affected by the interaction between starch and protein. The decrease in water content can occur due to the bond between starch and protein which causes water to not be bound to the maximum. Hydrogen bonds formed between molecules

of starch and water will be reduced by the interaction between starch and protein [20],[21]. According to SNI (01-2973-2011), the water content of the cookies maximum of 5%, so these cookies already fulfil the quality requirements of cookies by the Indonesian National Standard.

3.2. Ash Content

Ash content is a value that indicates the amount or total minerals contained in a product. Mung bean supplementation and different types of fat had no significant effect on the ash content of cookies. The ash content of corn-almond cookies is 0.27-1.17%, as seen in Fig 2. Supplementation of mung beans 10% and the use of margarine resulted in cookies with the lowest ash content of 0.27%.
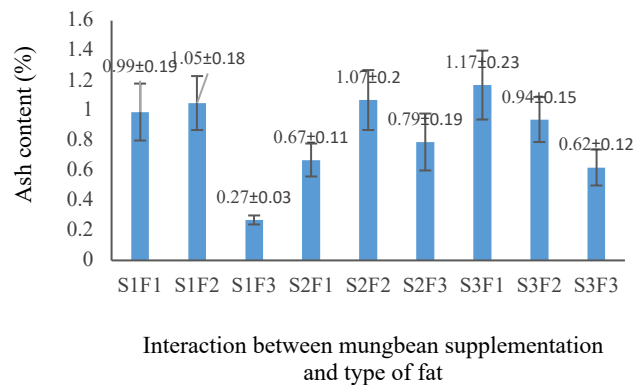

Interaction between mungbean supplementation and type of fat

Figure 2. Ash content of corn-almond cookies with soy flour supplementation and types of fat

The higher the supplementation of mung bean flour, the higher the ash content of the product [22]. The increase was because beans had a high ash content of 3.07% compared to) corn flour (0.13%). Mung beans are a source of minerals calcium, phosphorus and iron as 223, 319 and 7.5 mg every 100g. The low ash content of corn flour is due to the separation of the germ in its manufacture, where the germ contains 75% of minerals in corn.

According to the Indonesian National Standard (SNI) (01-2973-2011) the maximum ash content for cookies is 1.5%. Therefore, the ash content of these cookies has met the requirements of the Indonesian National Standard.

3.3. Fat Content

Mung bean supplementation and differences in fat sources had a significant effect on the resulting cookies, but the combination of the two had no significant effect. The highest fat content of 26.2% was produced in 10% mung bean flour supplementation, while the lowest at 23% was found in 30% supplementation (Figure 3).

Increased mung bean supplementation resulted in a decrease in the fat content of cookies. These results are in compliance with Agung et al. (2018) , which showed that the substitution of mung bean flour could reduce the fat content of bagea [23]. This is because mung bean flour has a low fat content. According to Widjajaseputra et al. (2019), the fat content in mung beans is 1.2% [8]. Corn flour has a higher fat content than mung beans, which is 3.80% [3]. Therefore, the greater the added mung bean flour, the lower the fat content.
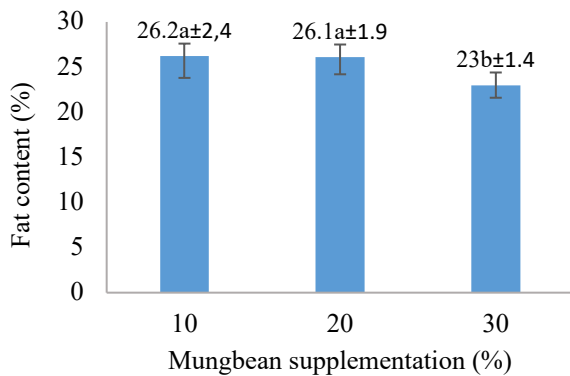

Figure 3. Effect of mung bean supplementation to fat content of cookies

The highest fat content is found in cookies that use VCO, which is 26.8%, while the lowest fat content (23.8%) is produced by using margarine. The higher the proportion of VCO in the manufacture of cookies, the higher the fat content of cookies. This is due to the difference in the amount of fat in margarine and VCO. VCO contains 98% fat, while margarine contains 80% fat. This resulted in the addition of more VCO in the manufacture of cookies, the fat content increased as can be seen in Figure 4.
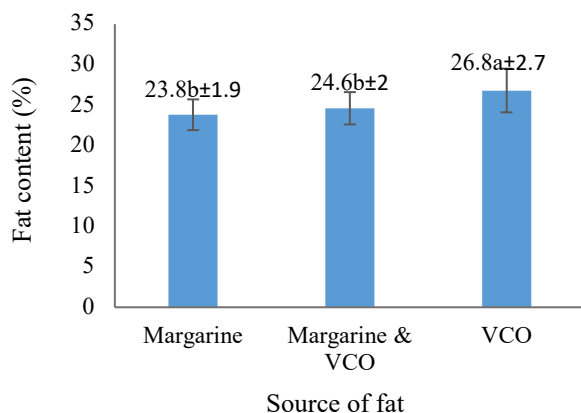

Figure 4. Fat content of cookies was affected by fat source

The fat content of cookies is quite high, but the fat contained in margarine is free of trans fat, while VCO is classified as a healthy oil because almost 50% of its fatty acids are medium chain, so it is easily absorbed. According to Lee et al. (2018), medium chain fatty acids

have an advantage over long chain fatty acids is that they are easier to digest and absorb [24]. Medium chain fatty acids can be directly digested in the intestine without hydrolysis and enzymatic processes. So, in this study, although the fat content of cookies has a higher proportion of VCO, it is more easily absorbed and digested by the body.

One of the factors that can affect the fat content of cookies is the type of flour, because each flour has a different oil absorption capacity. Oil absorption is related to protein structure, where the minor components of gluten (lipids and polysaccharides), the proportion of different gluten protein groups and the balance of hydrophilic gluten properties cause differences in oil absorption capacity [25][26]. According to Fairouz et al. (2018), the high absorption of oil is due to the protein content and fat content [27]. The greater the fat or protein content, the greater the oil absorption capacity.

According to El Waseif and Badr (2018), oil absorption is also influenced by amylose content because it has the ability to form complexes with oil (lipids) in the form of amylose-lipids [28]. The higher the amylose content, the higher the oil absorption capacity. The high fat content of cookies affects the resulting texture, especially the crunchiness [29][30]. However, high fat content can also cause the shelf life of cookies to be shorter due to fat oxidation so that cookie packaging needs to be considered to prevent fat oxidation.

These cookies have almost the same fat content, compared to the 25.3% fat content of wheat flour cookies [31] but are higher than cookies from sorghum [32] . This is due to the use of corn flour that has 84% oil absorption capacity compared to 1.5% of wheat flour [25], [33]. This is due to the difference in amylose content, where corn flour has a higher amylose content (30%) compared to wheat flour (25%). According to Widjajaseputra *et al*. (2019), mung bean flour used for supplementation has an amylose content of 33% [8]. These differences, so that it can affect the amount of fat content contained in corn-almond cookies. The fat content of cookies is in accordance with the fat content of Indonesian National Standard (SNI 01-2973-2011) which is at least 5%.

3.4. Reducing Sugar

Mung bean flour supplementation, the use of types of fat, and the combination of the two did not have a significant effect on the reducing sugar content of cookies. The increasing supplementation of mung bean flour and the proportion of VCO in the processing of corn-almond cookies causes the value of reducing sugar content to tend to increase. According to Widjajaseputra *et al*. (2019), mung bean flour has reduced sugar content as much as 6.85% [8].
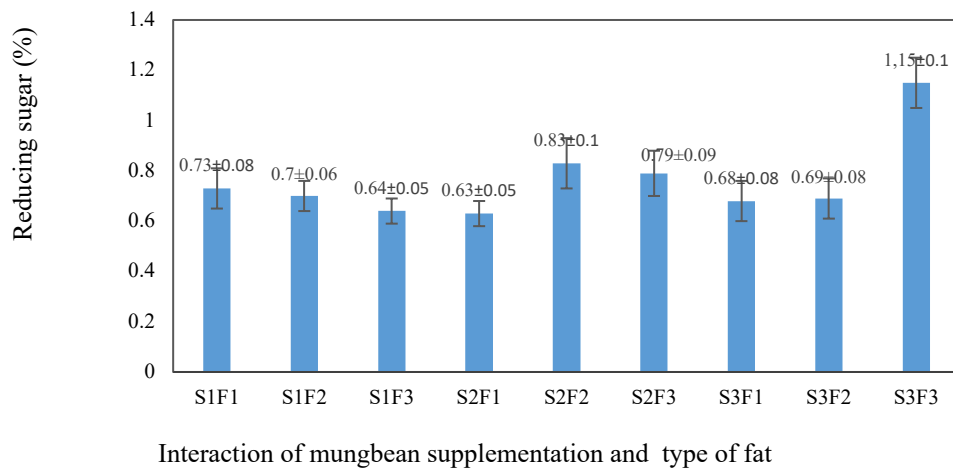
Figure 5. Reducing sugar of corn-almond cookies with soy flour supplementation and types of fat

The reducing sugar content in cookies mostly comes from sugar in the ingredients. In this study the sugar used is granulated sugar which is sucrose. The sucrose content in sugar is 99.3% or more. Heating sucrose causes sucrose to break down into glucose and fructose which is called invert sugar. The increase in reducing sugar levels was due to the inverse process of sucrose into reducing sugar and the inversion process increased in line with the increase in the sucrose content, in addition heating also encouraged hydrolysis of sucrose into reducing sugars, glucose and fructose [34]. According to Indonesia's National Agency of Drug and Food Control, a product can be said to be a low-sugar product if it contains no more than 5% sugar. Referring to these requirements, the corn-almond cookies are included in the low-sugar product.

3.5. Soluble Protein

The type of fat has a significant effect on the soluble protein content of cookies. Increasing the amount of VCO in the cookie formulation increased the soluble protein content of cookies. Cookies with the addition of VCO as a source of fat had the highest soluble protein content, which was 2.57%, as shown in Figure 6.

The increase in soluble protein content is influenced by the reaction between protein and fat in the process of making cookies. Protein will coagulate by heating so that during the roasting process, more protein will coagulate [34][35]. During the coagulation process, fat globules will be formed which can bind proteins and peptides in it so that it can increase protein levels. So that if the VCO or margarine is increased as a source of fat, it will increase the bound protein and also increase the dissolved protein content. The increase in VCO can increase the dissolved protein content because the fat content in VCO

is higher than margarine. VCO contains 98% fat content, while margarine contains approximately 80% fat. So, the greater the fat content, the greater the amount of fat that can bind protein.
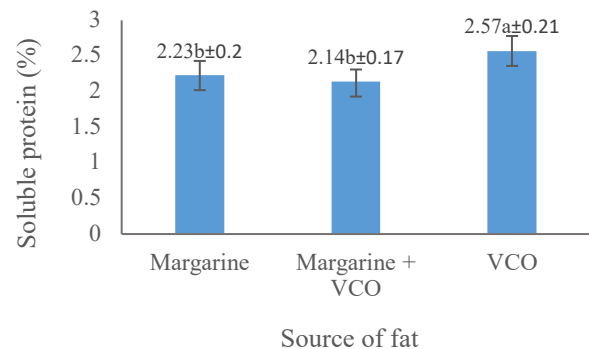

Figure 6. The effect of source fat on the soluble protein of cookies

The protein content in margarine is lower than VCO. Margarine has a protein of 0.6%, while VCO is 1%. The process of making VCO involves breaking the emulsion using enzymes to separate the oil from the coconut milk. According to Amin *et al.* (2017), the breakdown of coconut milk emulsions can occur in the presence of proteolytic enzymes that catalysed protein breakdown reactions by hydrolysing their peptide bonds into simpler compounds [10]. Proteolytic enzymes catalysed peptide bonds in proteins into simpler compounds such as dipeptides and amino acids. Protein hydrolysis that occurs can cause proteins that are initially insoluble to become soluble proteins.

3.6. Expansion Volume

The volume of cookie development is closely related to the ingredients or formulation of cookies used. Different types of fat had a significant effect on the

volume of cookie development, while supplementation with mung bean flour and the combination of the two had no significant effect. As the number of VCOs added increases, the development volume decreases as seen in Figure 7. Cookies with the addition of 100% margarine had the highest expansion volume, namely 81.2%, while cookies with the addition of 100% VCO had the lowest expansion volume, namely 63.6% (Figure 7). One of the factors that affect the volume of cookies development is moisture content.
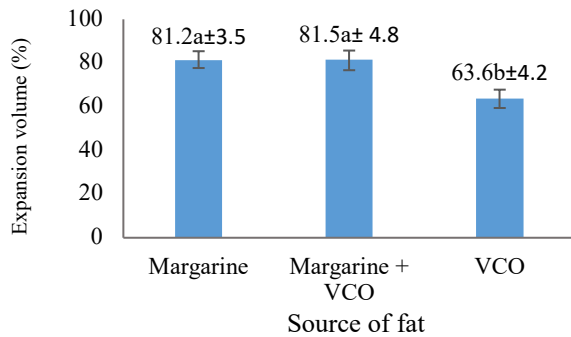

Figure 7. The effect of source fat on the soluble protein of cookies

The decreases in the volume of development can be due to the very small amount of liquid available in cookie dough [24]. This causes less interaction between water and gluten to form a gluten network that can withstand the expanding gases during the baking process. This is due to the low VCO water content as stated in the VCO composition, which is 0.1%. Margarine has a higher moisture content maximum of 16%. At the time of making cookies, the dough added with VCO turned out to be more viscous or denser and easier to shape than the dough added with margarine. According to Bolarinwa *et al.* (2019) cookie dough that has a more viscous consistency has a tendency to expand less when baked [34].

The expansion volume is influenced by protein content, amylopectin content and fat content [34], [36]. This is because the protein is denatured, causing the cookies to be difficult to expand and hard. Starch granules without protein will break easily and the amount of water that enters the starch granules will be more so that the development of starch will increase. This is in line with Mancebo *et al.* (2016) who stated that the volume of cookie development was also caused by the addition of high fat in the formula [37]. The proportion of added fat in the cookie formula affects the bond development of gluten.

Fat in cookies will change the texture, taste, and flavour of the product. The addition of fat can also cause interactions with starch granules and break hydration so that the increase in viscosity of the material becomes low. The mechanism of inhibition is that fat will form a layer

on the outside of the starch granules and at the same time inhibit the penetration of water into the granules. Less water penetration will result in high gelatinization and will form cookies that are less fluffy with a denser / compact texture. According to Bolanriwa *et al.* (2019), if too much fat is added, it can cause cookies to widen and break easily, while too little fat makes the texture of the pastry hard and less fluffy [34]. The baking process also affects the swell ability of cookies, because when roasting the water bound in the starch granules is released during oven at a certain temperature so that the water evaporates and the steam formed will push the gel network out and cookies will develop.

Corn flour also plays a role in the development of cookies. According to Aini *et al.* (2016), corn flour contains amylose and amylopectin, this amylopectin content can affect the volume of cookie development, where amylopectin has a structure that easily absorbs water and water will be retained in it if it is absorbed [25]. The existence of these properties will make the starch structure will be hollow when baked due to evaporation of water from the starch molecules so that the volume of cookies will be larger.

The main component in flour that affects the texture of cookies is protein [34],[38]. The protein contained in flour can form gluten when added to water. Gluten can make dough elastic and able to hold gas. If the amount of gluten in the dough is small, the dough is less able to hold gas, so the pores that form in the dough are also small. As a result, the dough does not rise properly. The flour used in this study did not contain gluten, so development was lacking. This is in line with Jan *et al.* (2018) which states that cookies do not require basic ingredients that affect the swelling power so that cookies can be made using flour containing <1% gluten [39].

Cookies have a dough that is less elastic and less stretchy [40][41]. The amount of fat and sugar in the dough gives the dough plasticity and unity with no or very little gluten network formation. Cookies do not require volume expansion like wet cakes and rolls, but must be crispy, not absorbing water quickly, not hard and not crumbling easily. These properties are in accordance with the physicochemical and functional properties of corn flour.

3.7. Selected Formula

The 10% mung bean flour supplementation and the use of VCO produced cookies with the best physicochemical properties. The combination has soluble protein of 2.35%, 28.10% fat content, 0.21% reducing sugar, 2% moisture content, 0.27% ash content, and 73.23% expansion volume. The moisture and fat content of these corn cookies were higher than those of sago cookies that used VCO, while the ash content was lower.

According to Barlina et al. (2012), sago cookies that use VCO have a water content of 0.25%, ash content of 1.35%, and fat content of 19.68% [42]. This is influenced by the use of sago flour and wheat flour, where sago flour has 14% water content, 0.2% fat and 1.4% ash content, meanwhile wheat flour has 12% water content and 1.4% fat. The water and fat content are lower than corn and almond flour, while the ash content is higher.

According to Ratnasari and Yunianta (2015), cookies added with 10% mung bean flour have a protein content of 10.52%, a fat content of 17.52%, a water content of 6.41%, and an ash content of 0.67% [43]. When compared with corn-almond cookies in this study, the fat content value is smaller but the ash content and water content are higher. Meanwhile, Yuliatmoko and Satyatama (2012) state that Lampung taro cookies supplemented with 10% mung bean flour in a previous study are shown to have a water content of 3.9%, ash content of 1.32%, fat content of 24.56%, and protein content of 8.07% [44]. When compared with almond corn cookies with mung bean supplementation as much as 10%, the water content and ash content values of corn-almond cookies were lower than those of taro Lampung cookies. Meanwhile, the fat content of corn-almond cookies was higher. This is influenced by differences in ingredients.

Agung et al. (2015) states that biscuits with the addition of 15% mung bean flour were the most preferred, which had 1.5% ash content, 7.12% water, 14.29% fat, and 3.39% protein content [23]. If seen from these results, the corn-almond cookies have a value of ash and lower water levels, but it has a higher fat content value. Based on a comparison with some cookies that are added or supplemented with mung beans and the use of VCO, it turns out that the cookies in this study have several advantages in terms of their physicochemical variables. Cookies produced in this study have also fulfilled Indonesian National Standard.

4. CONCLUSION

Increased mung bean supplementation in corn-almond cookies improves moisture content and reduces fat content. Different fat sources affect fat content, soluble protein and expansion volume, and the best is VCO. The product with the best formulation is cookies d with 10% mung bean flour supplementation and uses VCO. These cookies have a soluble protein of 2.35%, 28.10% fat, 0.21% reducing sugar, 2% water content, 0.27% ash, and 73.23% expansion volume.

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