The study of Apple flour formulation for functional cookies

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Abstract. The purpose of this study was to examine apple flour as a source of functional flour in various cookie formulas. Apple flour is applied as a substitute for flour in making cookies. The design used was a nested design [Nested Analisys], with two groups of apple varieties and three levels of formula adding apple flour which was nested in each variety, and repeated four times. Grouping is based on varieties, namely A = Anna and M = Manalagi, and the formula for adding apple flour to cookies is F0: 0%; F20: 20%, F25: 75%, and F30: 30%. In the formula of cookies, an analysis of chemical characteristics (water, ash, protein, fat, carbohydrates, dietary fiber, and antioxidants), physical characteristics and sensory characteristics is carried out. This study proves that apple flour can be substituted into formula cookies. In general, apple flour cookies have more brown color, distinctive flavor and aroma of apples, and lower crispness than cookies in general. The substitution level that produces the best quality and can be accepted by the panelists is 25% and 30% Manalagi apple flour. The use of higher flour levels has more fiber content, so it can reduce the crispness of cookies. Substitution of apple flour decreases protein and fat content, on the contrary, increases water content, ash content, dietary fiber content, carbohydrate levels and antioxidant activity of cookies. The most preferred product by panelists is the level of substitution of Manalagi apple flour 25% and 30%.

1. Introduction

Functional food lately has become a trending topic of the world, both of study and the food industry. Functional food is food that contains active components, in addition to the nutrients contained therein, which provide health benefits. Functions of functional food according to literature [1] include: (a) strengthening the body's defenses; (b) prevent certain diseases; (c) help restore body condition after illness; (d) maintain physical and mental health; and (e) slow down the aging process. The addition of raw materials that have chemical content in the form of bioactive compounds, into the processing of functional products, can improve product quality. The chemical content is expected to be physiologically beneficial for the body, which can indirectly meet the sensory, nutritional and physiological requirements of functional food. One ingredient that can be used in this case is apples.

Apples have high flavonoid compounds, anthocyanin, phenolic acids, and dihydrochalcone [2][3] which act as natural antioxidants, although not superior antioxidants. The ability as an antioxidant is a collaboration between vitamin A, vitamin E, copper (Cu), anthocyanin (cyanidin and malvidin), as well as a number of phytochemicals consisting of quercetin, rutin, D-glutaric acid, epicatechin, and myricetin. The compounds that most acts as antioxidants are myricetin and quercetin. According to Macheix et al. [4] myricetin is a single oxygen antioxidant that can get rid of free radicals, while
quercetin is an antioxidant that has the ability as an anti-inflammatory, including inflammation caused by free radicals. Quercetin is a compound that is found in many parts of apple skin [5][6]. Its antioxidant is 4.7 times superior to the standard antioxidant vitamin E. If vitamin C has antioxidant activity 1, then quercetin has an antioxidant activity of 4.7, or in other words, its antioxidant is equivalent to 1500 mg of vitamin C from medium-sized fresh apple extract [5]. Besides antioxidants, apples have a high pectin content of 24% [7]. Apples also have carbohydrates (14.9 g), fat (0.4 g), protein (0.3 g), calcium (6.0 mg), phosphorus (10 mg), iron (0.3 mg), calories (58.00 cal), and some vitamins A, B1, and C [7]. Therefore, apples can be categorized as antioxidant food as well as anti-aging.

Apple flour is a preserved product that can be used as an alternative to extend shelf life, facilitate storage and transportation, expand marketing reach and easily be processed into other food products. One of the popular processed products is cookies. Cookies have a high level of convenience and can meet the criteria of low energy and high food fiber needed by the human body [8]. Many formula cookies do not provide enough food fiber, so it is necessary to improve the quality of cookies by adding fiber sources that are easily available, namely dietary fiber from apples. The purpose of this study was to formulate cookies products using the ingredients of apple flour, and study the chemical characteristics, physics and assess the sensory quality of apple flour cookies.

2. Method
This research was conducted at the Laboratory of Food Science and Technology, Faculty of Agriculture and Animal Husbandry, University of Muhammadiyah Malang. The tools used in this study include cabinet dryer, microwave, freezer, texture analyzer 60-80 mesh sieve, spectrophotometry, vacuum pump, Buchler funnel, color reader, furnace, Kjedahl pumpkin, fume hood, distillation, water batch, back cooling, and oven capacity 19L C0-9919.

The materials used in this study were Manalagi’s apple and Anna’s apple flour, refined sugar, butter, choco chip, margarine, eggs, cornmeal, and low protein flour, wattman filter paper no. 42, boric acid, HCl, anti-foaming, Petroleum Benzene, Catalysts (Na2SO4 & HgO), H2SO4, NaOH, Ethanol, and DPPH pro analysis were obtained from Sigma.

The design used was a nested design [Nested Analisisys], with two groups of apple and wheat flour as controls, and three levels of formula for adding apple flour which was nested in each variety, and repeated three times. Grouping is based on varieties, namely VA = Anna, VM = Manalagi and VT = Flour, and the formula for adding apple flour to cookies is F0: 0%, F20: 20%, F25: 75%, and F30: 30%. The formulation for making cookies is presented in Table 1.

| Material     | Unit | Type of formula/ 132g flour total |
|--------------|------|----------------------------------|
|              |      | 20% (20:80)%                     |
|              |      | 25% (25:75)%                     |
|              |      | 30% (30:70)%                     |
| Apel flour   | g    | 32                               |
| Wheat flour  | g    | 100                              |
| Maizena flour| g    | 25                               |
| Margarine    | g    | 50                               |
| Eggs         | g    | 13                               |
| Choco chip   | g    | 20                               |
| Butter       | g    | 50                               |
| Total        | g    | 328                              |

The variables analyzed were chemical characteristics consisting of: 1. moisture content 2. ash content, 3. protein levels, 4. fat levels, 5. carbohydrate levels with the AOAC method [9], 6. Analysis of Food Fiber Content [10], 7. analysis of antioxidant activity [11], physical characteristics: 1. Texture [Bite and Chew], 2. Color [Brightness (L), Redness (a +), Yellowish (b +)], Sensory characteristics:
Sensory testing is carried out in the form of a hedonic test to determine the most preferred form of apple cookies [12]. Sensory characteristics performed include taste, aroma, and liking, with a 5-level assessment score, namely 5 = very like, 4 = like, 3 = neutral, 2 = dislike, 1 = very dislike. The assessment was carried out by 30 untrained panelists aged 21-23 years.

3. Results and discussion

3.1. Chemical Characteristics

The results of the analysis of the chemical characteristics of cookies due to the influence of apple types indicate that substitution of apple flour tends to reduce protein levels and fat content of cookies. On the contrary, the substitution increases water content, ash content, dietary fiber content, carbohydrate content, and antioxidant activity. The average characteristics due to the influence of substitution of apple flour in cookies are presented in Table 2 and the mean effect of the substitution formulation of apple flour in cookies is presented in Table 3.

Table 2. Effect of apple flour types on chemical characteristics of apple cookies

| Variable                  | Wheat      | Anna       | Manalagi   |
|---------------------------|------------|------------|------------|
| Moisture (%wb)            | 2.84a      | 3.36b      | 4.49a      |
| Ash content (%wb)         | 0.50b      | 0.59a      | 0.57a      |
| Protein levels (%wb)      | 31.24a     | 26.17b     | 27.66b     |
| Fat levels (%wb)          | 28.45a     | 22.27b     | 21.66b     |
| Fiber (%wb)               | 2.76c      | 3.45b      | 4.43a      |
| Carbohydrate levels (%wb) | 39.04a     | 39.09b     | 41.19a     |
| Antioxidant activity (%)  | 81.20c     | 85.93b     | 92.10a     |

Description: The numbers followed by the same letter on the same line show unreal differences according to Duncan’s test a-5%

Table 3. Effect of apple flour formulation on chemical characteristics of apple cookies

| Variable                  | Wheat       | Anna’s apple | Manalagi’s apple |
|---------------------------|-------------|--------------|------------------|
|                           | TF0 (100)   | AF20 (80:20) | AF25 (75:25)     |
|                           | AF30 (70:30)| MF20 (80:20)| MF25 (75:25)     |
|                           | AF30 (70:30)| MF20 (80:20)| MF25 (75:25)     |
| Moisture (%wb)            | 2.84d       | 3.51c       | 3.51c            |
| Ash content (%wb)         | 0.50b       | 0.53b       | 0.59a            |
| Protein levels (%wb)      | 31.11a      | 27.29c      | 27.25c           |
| Fat levels (%wb)          | 28.69a      | 22.63c      | 22.15c           |
| Fiber (%wb)               | 2.76d       | 3.60c       | 3.72c            |
| Carbohydrate levels (%wb) | 34.05c      | 41.37ab     | 39.58b           |
| Antioxidant activity (%)  | 80.20d      | 85.60c      | 85.92c           |

Description: The numbers followed by the same letter on the same line indicate unreal differences according to Duncan’s test a-5%

In Tables 2 and 3, it is seen that the substitution of apple flour results in a decrease in protein content and fat content in cookies, much lower than control (flour). Protein content in cookies from Anna apple flour is 26.17% and Manalagi apple flour 27.66%, comes from flour and eggs. Although the levels are lower than the controls, the protein in apple cookies is still in accordance with the requirements of SNI, which is a minimum of 9%. Protein is a macro biomolecule that is the main constituent of all living things. Its functions include: 1) Formation and repair of deer cells and body tissues, 2) Synthesizing hormones that help cells send messages and coordinate body activities, 3) Make antibodies to our
immune system, 4) Make enzymes that facilitate biochemical reactions such as binding to hemoglobin, transporting oxygen through the blood. 4) As a reserve and energy source for the body, and others.

Percentage of fat content in apple Anna cookies 22.27% and Manalagi apple 21.66%. The fat content of these cookies is in accordance with the levels required by SNI, which is at least 18%. Fat serves as a source of taste and provides a soft texture to the product. In addition, fat is also a source of energy that can provide greater energy value than carbohydrates and proteins.

The percentage of water content in Manalagi apple cookies is 4.49%, the highest compared to Anna's flour apples cookies 3.36% and 2.84 percent control. The moisture content of manalagi apple cookies is still in accordance with the requirements of SNI which is a maximum of 5 percent. The high percentage of water content in both apple cookies is caused by high sugar content and dietary fiber so that it is hygroscopic. High reducing sugar content causes easy color changes during roasting because of caramel so the color is less attractive. High water content makes cookies less crunchy so it is less preferred. Moisture content in cookies is a critical characteristic because it determines texture (crispness). Moisture content in foods ranging from 3-7 percent will achieve optimum stability, so microbial growth and chemical reactions that damage materials such as browning, hydrolysis or fat oxidation can be reduced [13]. The high water content is also caused by low protein values resulting in higher water content. Protein content in food is related to water content, the higher the protein content of a food, the lower the water content, besides the water content also has a value inversely proportional to the total sugar [14].

The ash content percentage of Anna and Manalagi apple cookies, which is 0.59% and 0.57% respectively, is higher than the control. Ash content in apple cookies is still within the limits required by SNI, which is a maximum of 1.5 percent. This higher ash content is caused by the high mineral content in apples because the amount of ash is associated with the mineral content contained in an ingredient. Ash is an inorganic substance left over from the combustion of an organic material. The ash content and composition depends on the type of material and how it is treated. Ash content has something to do with mineral substances. Ash is an inorganic mineral that has a fairly high resistance to cooking temperature so that its presence in foodstuffs tends to remain constant.

The results of the analysis of the fiber content of cookies, Manalagi apples, showed a higher fiber content compared to Anna's apple cookies and controls. wheat flour which only contains 0.3% crude fiber [15]. The percentage of fiber content of food in Manalagi apple cookies is 4.43 percent, higher than Anna's apple cookies, which is 3.45 percent. Food can be claimed as a source of dietary fiber if the content is 3-6g/100g. Adequacy of dietary fiber for adults 20-35 grams per day or 10-13 grams per 1000 kcal. USFDA also recommends that the total fiber of food consumed by adults every day is 25 g per 2000 kcal or 30 g per 2500 kcal. Food fiber is very important for the body because it can provide the body's defense against the emergence of various diseases, such as colon cancer (large intestine), diverticular disease, cardiovascular disease, diabetes mellitus, and obesity [16]. Increased consumption of food fiber, especially soluble food fiber can reduce plasma cholesterol, and increase glycemic control [17]. According to literature [18] that the content of fresh apple fruit fiber per 100 grams of material is 2.3 grams.

Carbohydrates are nutrients that are composed of elements of Carbon (C), Hydrogen (H), and oxygen (O). The role of carbohydrates in the body is 1) the main energy source of the body, 2) energy reserves in the muscles and liver, 3) facilitate digestion, and others. Carbohydrates play a role in the formation of food product characteristics. The energy that can be utilized in the body and the ability to increase blood glucose levels is not always in line with starch or carbohydrate levels of food. This is strongly influenced by the digestibility of starch and resistant starch [19].

Antioxidant activity in apple cookies is relatively higher than control. Antioxidants are molecules that can slow down or prevent the oxidation process of other molecules. Oxidation is a chemical reaction that can produce free radicals, which triggers a chain reaction that can damage healthy cells. Antioxidants are substances that can fight the harmful effects of free radicals that are formed as a result of oxidative metabolism, which is the result of chemical reactions and metabolic processes that occur in the body. For this reason, a compound that can protect body cells from the harmful effects of free radicals is needed. One of the compounds that have this role is antioxidant flavonoids which play a role in
neutralizing free radicals by giving one electron to free radicals so that it becomes non-radical. One source of antioxidants is flavonoids which are secondary metabolites of plants [20].

It has been reported that a series of human diseases such as cancer, atherosclerosis, cardiovascular and diabetes, immune system disorders, neurodegenerative such as Parkinson's and Alzheimer's, and arthritis, as well as early detection of the body, can be linked to destructive actions of highly reactive free radicals. Many phenolics, such as flavonoids, have a much stronger antioxidant capacity than C and E vitamins. Flavonols and flavones are important parts of flavonoids because they have antioxidant activity and free radical scavengers derived from food [21].

3.2. Physical Characteristics

The results of the physical characteristics analysis of cookies due to the influence of apple types indicate that substitution of apple flour tends to reduce bite texture, but increases the reddish color (a+) and yellowish (b+) in cookies. In the analysis of apple flour formulation tends to reduce the texture of the bite, brightness (L) and redness (b+) but increases the yellowish color (a+) in Manalagi cookies. The average physical characteristics due to the influence of substitution of apple flour in cookies are presented in Table 4 and the mean effect of the substitution formulation of apple flour in cookies is presented in Table 5.

### Table 4. Effect of apple flour types on physical characteristics of apple cookies

| Variable      | Type of flour | Wheat       | Anna        | Manalagi    |
|---------------|---------------|-------------|-------------|-------------|
| Texture       |               |             |             |             |
| Bite (N/mm²)  |               | 22.23 a     | 16.17 b     | 17.82 b     |
| Chew (N/mm²)  |               | 50.17       | 40.24       | 48.62       |
| Color         |               |             |             |             |
| Brightness (L) |               | 53.60 a     | 49.78 b     | 45.79 c     |
| Redness (a+)  |               | 3.67 c      | 4.66 b      | 6.14 a      |
| Yellowish (b+) |               | 13.47 b     | 14.78 a     | 14.28 a     |

Description: The numbers followed by the same letter on the same row show unreal differences according to Duncan's test α-5 percent.

In Tables 4 and 5, it can be seen that the bite texture in cookies is higher in control than apple cookies. This result is caused by the addition of apple flour will increase the crispness of cookies due to the increased fiber content of food cookies from apple flour. The texture is one of the parameters used as an assessment in determining the decision to choose a product. The texture is influenced by differences in starch content and food fiber in flour. Apple flour does not contain gluten, like wheat. Non-gluten substitution products will produce a dense texture (not hollow) and not too inflated so that after the roasting process will produce a product, which has a more easily broken texture.

Manalagi apple cookies have a harder texture made possible because of their high fiber content. According to literature [22], wheat flour contains a total of 20 percent water-soluble protein consisting of albumin and globulin and small amounts of glycoproteins. But this type of protein has no contribution to dough formation. While about 30 percent of the amino acids in gluten are hydrophobic and can gather through hydrophobic interactions, and can bind fat and other nonpolar substances.

Control variable of color cookies (flour) show high brightness values compared to apple flour Anna and Manalagi. The reddish color (a+), 20% Manalagi apple flour showed a high value even though it was not significantly different from 25% and 30% Manalagi apple flour. Yellowish color (b+), Anna apple flour 20% showed a high value, although not significantly different from Anna apple flour 20% and 25%, and 20% Manalagi flour.

Apple flour contains carbohydrates, especially simple sugars. Carbohydrates have a role in forming cookies during the roasting stage. Increasing the temperature to a certain point in the customer process can result in carbohydrate dispersal making simple sugars increase and then forming compounds that give brown color [23].
Table 5. Effect of apple flour formulations on physical characteristics of apple cookies

| Variable          | Wheat    | Anna’s apple | Manalagi’s apple |
|-------------------|----------|--------------|------------------|
|                   | TF0  | AF20 | AF25 | AF30 | MF20 | MF25 | MF30 |
| Texture           | %    | %    | %    | %    | %    | %    | %    |
| Bite (N/mm²)      | 22.23ab| 20.61ab| 17.87bc| 10.03c| 27.08a| 20.46ab| 14.93bc|
| Chew N/mm²        | 50.17 | 42.65 | 40.99 | 37.08 | 53.29 | 48.05 | 44.53 |
| Color             |        |        |       |       |       |       |       |
| Brightness (L)    | 53.60a | 50.00b | 50.30b| 49.03bc| 46.13cd| 46.03cd| 45.20d |
| Redness (a+)      | 3.67d  | 4.50cd | 5.00bc| 4.47cd| 6.43a | 5.77ab | 5.76ab |
| Yellowish (b+)    | 13.47d | 15.27a | 15.07ab| 14.00abcd| 14.90abc| 14.07bcd| 13.87cde|

Description: The numbers followed by the same letter on the same line show unreal differences according to Duncan’s test α=5%

The brown color change in cookies due to the brown color of apple pulp flour does not have a significant effect. This is due to the typical color of the cookie product is already brown, where the color comes from the chocolate ingredients used. The color difference that does not mean only detected between the standard formula and the substituted one, not between substituted products with flour addition level apple pulp. The substitution level does not have an impact on the final product color change (Table 1). Because color is the main attribute for consumers [24], designer products do not need to consider the effect of apple pulp browning on cookies. The same case also happened to the aroma attribute.

The requirements for the color quality of cookies in SNI 01-2973-1992 are normal, there is no specific provision for color on the quality of cookies. Based on the analysis of variance in cookies with treatment differences in varieties have a very significant effect on the quality of the color of apple cookies, while the treatment of the difference in the proportion of apple flour is not significantly different.

Color analysis of cookies was carried out by measuring using a color reader and using a hedonic test as a comparative data for evaluating the color of apple cookies. Based on the results of the color test of apple cookies in Table 4 shows the average color of apple cookies is significantly different due to differences in the types of apple flour varieties. A is 49.65 higher than the M value of 45.87. This is because the total sugar content in Manalagi apple flour is higher than Anna's apple flour.

Warming can cause decomposition and changes in pigment structure resulting in bleaching and decreased color stability [25]. The apples that are patted will have a pale red color due to changes in the composition of the compound due to high heating in the microwave and cabinet dryer. The increase in brown color is characterized by an increase in the color of redness and a decrease in yellowish color [26].

Increasing the addition of apple flour tends to reduce the brightness of the color of cookies. The color of the control cookies is brighter because, without the addition of apple flour, the color of apple flour is brownish yellow. The lower color of Manalagi apple cookies (dark) is possible because of the difference in the total sugar content in the raw material. Manalagi apple flour has a high total sugar content of 10.44 percent, while Anna's apple flour is 9.32 percent. Temperature rise up to a certain point can increase heat energy so that it speeds up the process of hydrolysis of carbohydrates in apples into a simple form of confectionery [23]. Apples that have a high total sugar content will easily experience browning, this is due to the caramelization process.

3.3. Sensory Characteristics

The type of apple flour used for the formulation of making cookies produces organoleptic changes. Manalagi apple flour is preferred from the control and subsequent to Anna apple flour (Table 6). The
results of the analysis of apple flour formulation on the sensory characteristics of cookies showed that the substitution of Manalagi apple flour with a composition of 25-30 percent showed a high value for taste, aroma, and preference (Table 7).

### Table 6. Effect of apple flour types on sensory characteristics of apple cookies

| Variable          | Wheat | Anna | Manalagi |
|-------------------|-------|------|----------|
| Taste             | 2.57<sup>c</sup> | 2.87<sup>b</sup> | 3.98<sup>a</sup> |
| Aroma             | 2.71<sup>b</sup> | 3.51<sup>a</sup> | 3.54<sup>a</sup> |
| Consumer likes    | 1.62<sup>c</sup> | 2.92<sup>b</sup> | 3.62<sup>a</sup> |

Description: The numbers followed by the same letter on the same line show unreal differences according to Duncan's test a-5%

### Table 7. Effect of apple flour formulations on sensory characteristics of apple cookies

| Variable          | The ratio of wheat and apple flour |
|-------------------|-----------------------------------|
|                   | Wheat | Apel Anna | Apel Manalagi |
|                   | TF<sub>0</sub> | AF<sub>30</sub> | AF<sub>50</sub> | AF<sub>30</sub> | MF<sub>20</sub> | MF<sub>50</sub> | MF<sub>30</sub> |
| Taste             | 2.57<sup>c</sup> | 3.19<sup>d</sup> | 2.71<sup>e</sup> | 2.71<sup>e</sup> | 3.52<sup>e</sup> | 4.10<sup>b</sup> | 4.33<sup>a</sup> |
| Aroma             | 2.71<sup>c</sup> | 3.48<sup>ab</sup> | 3.52<sup>ab</sup> | 3.52<sup>ab</sup> | 3.43<sup>b</sup> | 3.57<sup>ab</sup> | 3.62<sup>a</sup> |
| Consumer likes    | 2.62<sup>c</sup> | 3.29<sup>b</sup> | 3.35<sup>b</sup> | 3.22<sup>bc</sup> | 3.24<sup>b</sup> | 3.88<sup>a</sup> | 4.14<sup>a</sup> |

Description: The numbers followed by the same letter on the same line show unreal differences according to Duncan's test a-5%

The taste of a product involves the taste senses of the tongue. The taste of food can be recognized and distinguished by the taste buds that lie in the papilla which is the orange-red stain on the tongue [13]. Each individual has a different level of acceptance. This affects the sensitivity of each individual.

Aroma is one of the important factors for consumers to choose food. Many food scents determine the delicacy of a food. The aroma received by the nose and brain is a mixture of four main odors, namely fragrant, sour, rancid and charred. The fragrance of fruits is created by various volatile esters. The aroma production will increase when the fruit approaches the climatic period [13]. Panelists prefer the taste and aroma of Manalagi apple cookies compared to Anna's apple cookies, so the level of preference for Manalagi apple cookies is higher when compared to other cookies. Flavors and aromas are actually produced from approximately 230 chemical components, including various acids such as acetic acid, formats and 20 other types of acids. These acids turn into sugar and esters, the taste of sweet fruit and a sharp aroma. Sugar comes from changes in carbohydrates which are then used to produce energy. Besides that, alcohol also ranges from 30-40 species, esters such as ethyl acetate around 100 types, carbonyls such as formaldehyde and acetaldehyde, and others.

### 4. Conclusions

This study proves that apple flour can be substituted into formula cookies. In general, apple cookies have more brown color, distinctive flavor and aroma of apples, and crispness is higher than cookies in controls. The substitution level that produces the best quality and can be accepted by panelists is Manalagi apple cookies 25% and 30%. The use of higher flour levels has more food fiber content, so it can increase the water content and is hygroscopic in cookies. The things that can be concluded from this study are as follows: (1) The substitution of apple flour still has protein content ranging from 26.17% - 28.84%, which is still within the SNI limit of at least 6.5%. While the fat content of apple flour cookies is 21.84% - 22.95%; (2) Moisture content is 4.46% and 5.00%; (3) The use of apple flour increases ash content, dietary fiber content, carbohydrate levels and antioxidant activity of cookies. Ash Content of 0.53% - 0.60%, fiber content of 3.60% - 5.76%, carbohydrate content of 36.33% - 44.37%, and antioxidant activity 85.60% PPR / gr - 92.69% PPR/gr.
In order to help provide nutritional products that are in line with the needs of a low-energy diet and high in dietary fiber, apple flour cookies, both Anna and Manalagi apples, can be considered as an alternative.

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