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Formulations of tapioca, tofu dregs flour, pumpkin flour as cereal type-2 diabetic

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ABSTRAK

Latar belakang: *Indonesia menduduki peringkat ke-7 dunia dengan penderita Diabetes Mellitus (DM) sebanyak 10,3 juta jiwa (IDF, 2017). Tepung ampas tahu dan tepung labu kuning dipilih sebagai bahan pengembangan susu sereal karena mengandung tinggi serat dan antioksidan.*
Tujuan: *Menganalisis pengaruh formulasi tepung tapioka, tepung ampas tahu dan tepung labu kuning terhadap nilai energi, mutu kimia (protein, lemak, karbohidrat, kadar air, dan kadar abu), mutu fungsional (kadar serat dan aktivitas antioksidan), dan mutu organoleptik susu sereal pengembangan bagi penderita diabetes mellitus tipe 2.*
Metode: *Jenis penelitian adalah eksperimental dengan desain Rancangan Acak Lengkap (RAL). Taraf perlakuan adalah perbandingan tepung tapioaka, tepung ampas tahu dan tepung labu kuning yaitu P_1 (60 : 15 : 25), P_2 (45 : 20 : 35), P_3 (35 : 25 : 40).*
Hasil*: taraf perlakuan P_1 (60 : 15 : 25) merupakan taraf perlakuan terbaik karena kadar karbohidrat 64% total asupan energi, nilai energi 431 Kkal, kadar serat kasar 2,02%,kadar protein 14,7% total asupan energi, kadar lemak 24% total asupan energi, kadar abu 2,9%, tetapi kadar air melebihi standar yaitu 3,40% dan aktivitas antioksidan dalam kategori sangat lemah 176.490 µg/ml. Tingkat kesukaan panelis terhadap atribut warna, aroma, mouthfeel dan rasa susu sereal pengembangan pada taraf perlakuan 1 (P_1) memperoleh skala 3.*
Kesimpulan*: Mutu kimia (Kadar air, kadar abu, protein, lemak, karbohidrat) memenuhi standar SNI 01-4270-1996 dan PERKENI kecuali kadar air.*

KATA KUNCI: *diabetes mellitus tipe 2; susu sereal pengembangan; mutu kimia; tepung ampas tahu; tepung labu kuning*

ABSTRACT

Background*: Indonesia was ranked 7th in the world with 10.3 million diabetic based on The International Diabetes Federation (IDF) in 2017. Tofu dregs and pumpkin flour were chosen as ingredients for the development of cereal milk because they are high in fiber and antioxidants.*
Objective: *To analyze the effect of tapioca flour, tofu dregs flour and pumpkin flour on energy value, chemical quality (protein, fat, carbohydrate, water content, and ash content), functional quality (fiber content and antioxidant activity), and organoleptic quality developmental cereal milk for type 2 diabetic.*
Methods: *This type of research is experimental with a completely randomized design (CRD). The level of treatment is the ratio of tapioca flour, tofu dregs and yellow pumpkin flour, namely P1 (60: 15: 25), P2 (45: 20: 35), P3 (35: 25: 40).*
Results*: P1 (60: 15: 25) is the best treatment level because carbohydrate content is 64% of total energy intake, energy value is 431 Kcal, fiber content is 2.02%, protein content is 14.7%, content fat 24% ash content of 2.9%, but water content exceeds the standard of 3.40% and antioxidant activity in the very weak category 176,490 µg / ml. The level of preference of panelists on the attributes of color, aroma, mouthfeel and taste of cereal milk at treatment level 1 (P1) obtained a scale of 3.*
Conclusions*: Chemical quality SNI 01-4270- 1996 and PERKENI standard except water content.*

KEYWORDS: *chemical quality; milk cereal development*

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INTRODUCTION

Indonesia was the 7th in the world with diabetic as many as 10.3 million people and estimated in 2045 to be 16.7 million people (1). Diabetes mellitus sufferers experience oxidative stress caused by imbalance between the formation of free radicals with the ability of natural antioxidants in the body that can increase the risk of complications of DM (2).

Diabetes mellitus can be controlled with appropriate treatment aimed to prevent complications that can be done with medical nutrition therapy (3). Medical nutrition therapy interventions reduce 20% of HbA1c levels, bringing the average level to <8% compared to subjects without medical nutrition therapy intervention who experienced a 2% decrease in HbA1c levels, with an average level remaining > 8% (4).

One of foodstuffs which the utilization is not yet maximum is tofu dregs. According to Sadzali there are 84 thousand units of tofu industry in Indonesia with production capacity of 2.56 million tons per year, tofu formed is around 60% in one production and the remaining portion is used for cattle feed (5). Tofu dregs flour has a high content of food fiber and protein, and contains β-carotene. Total food fiber of 19.44 g / 100g and β-carotene of 245.54 µg / 100g (6).

Pumpkin *(Cucurbita moschata)* contains soluble fiber, protein, peptides, polysaccharides, sterols, and paraaminobenzoic acid (7). The yellow pumpkin showed total carotenoid content levels of 2120 µg/100 g and β-carotene 1180 µg/100 g in an evaluation study of these micronutrients in vegetables, spices and condiments (8).

Formula development for diabetes mellitus has been widely on the market, one of the most famous is diabetasol cereal. However, people with diabetes mellitus are among the middle to lower economic. This development cereal milk uses local food and ingredients that are underutilized so it does not require expensive costs to produce it.

Cereal is one type of processed food made from grain flour processed into flakes, strips, extrudates, and ready to eat for breakfast and snack. Indonesia is the largest importer of cereals in Asia and predicts cereal consumption per capita of 153 kg / year (9).

Based on this background, research studies are needed on the formulations of cereal milk modified with tofu dregs and pumpkin flour as an additional food for diabetics.

MATERIALS AND METHODS

This type of research is experimental with a completely randomized design (CRD) using 3 levels of treatment namely Tapioca Flour: Tofu Dregs Flour: Yellow Pumpkin Flour, P1 (60: 15: 25), P2 (45: 20: 35), P3 (35: 25: 40) and 3 replications were made. The treatment level is based on SNI of cereal milk, namely SNI 01-4270-1996 where the maximum water content is 3 g / 100 g, the maximum ash content is 5 g / 100 g, and Perkeni diet standard are protein 10-20% of total energy intake, fat 20-25% of total energy intake, carbohydrates 45-65% of total energy intake, and fiber 20-35 grams per day.

This research was conducted in February - April 2019 with research locations: Food Technology Laboratory (ITP) Department of Nutrition Health Polytechnic of Health Ministry Malang, Organoleptic laboratory, Central Science and Technology Center laboratory, and Quality and Safety Testing laboratory of Agricultural Product Technology Department of Brawijaya University. Independent variables are the proportion of tapioca flour, tofu dregs, pumpkin flour. Dependent variables are (1) chemical quality: protein content, fat content, carbohydrate content, water content, and ash content, (2) energy value, (3) functional quality: fiber content and antioxidant activity, (4) organoleptic quality: color, aroma, mouthfeel, taste.

The tools used for the processing of cereal milk development are triple beam scales, small

basins, spoons, and shredded molding tools. While the ingredients are tapioca flour, tofu dregs, pumpkin flour, chicken eggs, skim milk, full cream milk, and coconut oil.

The process of making sereal modifies from Agustina (2011) All ingredients are mixed, adds water until thick liquid, molded by using cake molds for 2 minutes until the flakes turn to brownish yellow then crushed and mixed with steeping milk consisting of skim milk and full cream milk (10).

The analytical method used are the analysis of water content and ash content by gravimetry, protein content by the Kjehdahl method, fat content by the Soxhlet method (11). Carbohydrate content by the difference method, energy values by the atwater factor method (12). Content of food fiber by gravimetric method (SNI 01- 2891-1992), sensory test with hedonic test, on a hedonic scale of 4: really like, 3: like, 2: dislike 1: really dislike

Data processing of energy value and chemical quality, functional quality and organoleptic quality with SPSS software are analyzed statistically with One Way Anova at 95% of confidence level and continued Duncan Multiple Range Test (DMRT).

Observation sheets and formats regarding to the analysis of water content and ash content by gravimetric, protein content using the Kjehdahl method, fat content using the Soxhlet method (11). Carbohydrate content using the difference method, energy value using the water factor method (12). Content food fiber using the gravimetric method (SNI 01-2891-1992), sensory test using the hedonic test.

RESULTS AND DISCUSSIONS

Chemical Quality, Energy Value, and Functional Quality

Analysis of chemical quality, energy value, and functional quality are presented in **Table 1**.

This water level does not complete the requirements for cereal milk content according to SNI 01-4270-1996, which the maximum is 3 g/100 g. The higher proportion of tofu dregs and pumpkin flour, the higher the water content of the development of cereal milk was. But the results of statistical analysis showed that the proportion of tapioca flour, tofu dregs and yellow pumpkin flour had a non-significant effect (p=0.055) of water content.

Ash content completes the requirements for cereal milk content according to SNI 01-4270-1996, which the maximum is 5 g/100 g. The higher proportion of tofu dregs and pumpkin flour, the higher the cereal milk ash content of the development was. But the results of statistical analysis showed that the proportion of tapioca flour, tofu dregs and pumpkin flour had no significant effect (p=0.111) of ash content.

Protein content of cereal milk 15.3 – is about 18.3 g/100 g of ingredients. The higher the proportion of tofu dregs flour, the higher the protein content was. But the results of statistical analysis showed that the proportion of tapioca flour, tofu dregs and yellow pumpkin flour had a non-significant effect (p=0.103) on milk protein content development cereal.

Table 1. Results of analysis of chemical quality, energy value, and functional quality

Parameter	P_1	P_2	P_3
Water level (g/100g)	3.40 ± 0.04^{a}	3.59 ± 0.16^{a}	3.72 ± 0.13^{a}
Ash level (g/100g)	2.90 ± 0,34^{a}	3.31 ± 0.14^{a}	3.30 ± 0,02^{a}
Protein level (g/100g)	15.3 ± 0.73^{a}	16.9 ± 1.26^{a}	18.3 ± 1.89^{a}
Fat level (g/100g)	11.2 ± 0.45^{a}	11.8 ± 0.27^{a}	12 ± 0.51^{a}
Carbohydrate level (g/100g)	67.3 ± 1.45^{a}	64.4 ± 1.65^{a}	62.7 ± 2.28^{a}
Energy value (kkal/100g)	431 ± 1.11^{a}	431 ± 1.06^{a}	432 ± 1.83^{a}
Rough fiber (g/100g)	2.02 ± 0/13^{a}	2.63 ± 1.37^{ab}	3.13 ± 0.41^{b}
Antioxidant Activity (µg/ml)	176.490 ± 31.29^{a}	159.600 ± 42.76^{a}	105.680 ± 59.14^{a}

Note: Notations a b and ab is a symbol that shows the result of statistical tests, different notations in one line show significant differences (α = 0.05)
a-a : insignificant, a-ab : insignificant, b-ab : insignificant, a-b : significant

Fatty levels of cereal milk development range from 11.2-12 g / 100 g ingredients. The higher proportion of tofu dregs and pumpkin flour, the higher the fat content. But the results of statistical analysis showed that the proportion of tapioca flour, tofu dregs and pumpkin flour had a non-significant effect (p=0.116) on the development of cereal milk fat content. Increased levels of development cereal milk fat are influenced by the increasing proportion of tofu dregs and yellow pumpkin flour.

Carbohydrate levels of developing cereal milk range from 67.3 to 62.7 g / 100 g of the ingredient. The higher proportion of tofu dregs and pumpkin flour, the carbohydrate content decreased. But the results of statistical analysis showed that the proportion of tapioca flour, tofu dregs and pumpkin flour had no significant effect (p = 0.056) on carbohydrate levels of cereal milk development.

The energy value of developing cereal milk ranged from 431 to 432 Kcal /100 g. The results of statistical analysis showed that the proportion of tapioca flour, tofu dregs flour and yellow pumpkin flour had no significant effect (p=0.808) on the energy value of milk cereals.

The increase of proportion of tofu dregs and pumpkin flour tended to increase the levels of crude fiber development of cereal milk. Supported by the results of statistical analysis showing that the proportion of tapioca flour, tofu dregs and yellow pumpkin flour had a significant effect (p = 0.019) against the levels of crude fiber cereal milk. Furthermore, the Duncan Multiple Range Test (DMRT) statistical analysis shows that the treatment levels of P1 and P3 show significant differences. The levels of crude fiber of tofu dregs are 7.59 g/ 100 g.

The antioxidant activity of developing cereal milk ranges from 105,680 - 176,490 µg / ml ingredients with an average of 147,250 ± 51.02 µg / ml. The increase of the proportion of pumpkin flour tended to increase the antioxidant activity of cereal milk development. However the results of statistical analysis showed that the proportion of tapioca flour, tofu dregs and yellow pumpkin flour had no significant effect (p = 0.222) on the antioxidant activity of milk development cereal.

The average protein, fat, and carbohydrate levels of cereal milk development from fiber requirements for snacks at each treatment level is presented in **Table 2**.

Table 2. Average protein, fat, and carbohydrate levels of cereal milk development of fiber requirements for snack at each treatment level (% total energy intake)

Parameter	P_1	P_2	P_3
Protein level	14.7	16.2	17.3
Fat level	24	25.2	25.7
Carbohydrate level	64	61.3	59.6

Protein levels of developing cereal milk range from 14.7 to 17.3% of the total daily energy intake of snacks which is 420 Kcal which means that has completed the protein requirements for diabetics according to PERKENI which is 10-20% of total energy intake.

The fat content of cereal milk development ranges from 24 - 25.7% of the total daily energy intake of snacks which is 420 Kcal, as presented in table 2, which means it has not completed the fat requirements for diabetics according to PERKENI which is 20-25% of total intake energy for treatment levels 2 and 3 (P2 and P3).

The development of carbohydrate cereal milk content ranges from 59.6 - 64% of the total daily energy intake of snacks which is 420 Kcal, as presented in Table 2, which means that it has completed the carbohydrate requirements for diabetics according to PERKENI , which is 45-65% of total intake energy.

Organoleptic Quality

The average level of panelists' preference for color, aroma, mouthfeel, and taste is presented in **Table 3**.

The higher proportion of tofu dregs and pumpkin flour, the panelists' preference for color will decrease. This is supported by the results of statistical analysis showing that the proportion of tapioca flour, tofu dregs flour and pumpkin flour has a significant effect (p = 0.014). Furthermore, the statistical analysis of the Duncan Multiple Range

Table 3. Average score of preference for color, aroma, mouthfeel, and taste of developmental cereals milk

Parameter	P_1	P_2	P_3
Color	3.25^{a}	3.0^{ab}	2.65^{b}
Aroma	3.15^{a}	3.05^{a}	2.85^{a}
Mouthfeel	3.15^{a}	2.9^{a}	2.9^{a}
Taste	3.3^{a}	2.95^{b}	2.5^{c}

Note : Notations a b and ab is a symbol that shows the result of statistical tests, different notations in one line show significant differences (α = 0.05)

a-a : insignificant, a-ab : insignificant, b-ab : insignificant, a-b : significant

Test (DMRT) shows that the treatment levels of P1 and P3 show a significant difference.

The higher proportion of tofu dregs and pumpkin flour, the level of panelists' preference for aroma decreases. However, statistical analysis showed that the proportion of tapioca flour, tofu dregs and pumpkin flour had no significant effect (p = 0.172) on the aroma of cereal milk development.

The higher proportion of tofu dregs and pumpkin flour, the level of panelists' preference for mouthfeel decreases. However, statistical analysis showed that the proportion of tapioca flour, tofu dregs and pumpkin flour had no significant effect (p = 0.349) on the mouthfeel of cereal milk development.

The higher the proportion of tofu dregs and pumpkin flour, the panelists' level of preference for taste decreases. This is supported by the results of statistical analysis showing that the proportion of tapioca flour, tofu dregs flour and pumpkin flour has a significant effect (p = 0,000) on the color of cereal milk development. Furthermore, the statistical analysis of the Duncan Multiple Range Test (DMRT) shows that the treatment levels P1 and P3, P1 and P2, P2 and P3, are significant in the taste of cereal milk

DISCUSSIONS

Water Level

The higher the proportion of pumpkin flour, the higher the cereal milk content. This is in line with the results of research Cahyaningtyas et al. (2014) the higher the concentration of pumpkin flour, the higher the eggroll water content, where the characteristics of pumpkin flour clumped, less to expand, and hygroscopic properties (easy to absorb water) due to high levels of sugar pumpkin flour (13).

The increase of tofu dregs influences the water content of cereal milk development. Because tofu dregs have the ability to bind water strongly, in line with the results of Ayunir et al. (2017) the higher the substitution of tofu dregs, the water content of sweet bread produced is increasing, where the crude fiber of tofu dregs has the ability to bind water, the water which is firmly bound in food fiber is difficult to evaporate again (14).

Ash Level

The increase of ash content is related to ash content of initial raw materials. The ash content of the tofu dregs flour was 3.59 g / 100 g while the pumpkin flour was 4.93 g / 100 g. Tofu dregs contains minerals such as Fe 0.20-0.50 mg which are not lost during the processing, magnesium 0.030-100 mg, Cu 0.005-0.0015 mg and zinc > 0.05 mg (15).

Yellow pumpkin flour also influences the increase in ash levels of developing cereal milk, which contains the mineral phosphorus 0.03 g, calcium 0.5 g, sodium 0.65 g, potassium 1.9 g (16). The results of Wati's research (2018) showed that the higher the proportion of pumpkin flour, the higher the ash content of flakes was 2.45 g / 100 g with 67% of the proportion of pumpkin flour (17).

Protein Level

Contributions that influence the increase of protein content in cereal milk development come from tofu dregs flour. This is due to the protein content of tofu dregs 29.15 g / 100 g ingredients. Protein levels of tofu dregs are still lower when compared to 34.4 g / 100 g soybean flour and 46 g / 100 g fermented soybean flour. This is in line with the results of Chandra's research (2010), the higher the percentage of tofu dregs flour addition, the higher the snackbar protein content of 11.03 g / 100 g with 20 % of the proportion of tofu dregs flour (18).

The amino acid score of this cereal milk development is quite high, net protein utilization (NPU) is 92 - 93. According to Sinaga and Wirawanni

(2012) protein is metabolized to be a source of energy replacing carbohydrates in the process of gluconeogenesis and has several types of amino acids that are good in the intervention of DM sufferers (19).

Fat Level

Tofu flour as the source of protein also the source of fat. Tofu dregs contains 22.23 g / 100 g. Chandra's research results (2010) the higher percentage of tofu dregs, the higher fat content. That is because soy contains a lot of unsaturated fatty acids, in addition to the pressing process of tofu dregs, the fat component does not dissolve and is generally still left in tofu dregs (18).

The regulation of dietary fat in diabetics is to limit consumption of saturated fatty acids, trans fatty acids, and cholesterol intake thereby reducing the risk of cardiovascular disease because all three are dietary components that are determinants of plasma LDL cholesterol levels (20).

Carbohydrate Level

Carbohydrate content is calculated by difference, so carbohydrate content is influenced by other nutritional components. The increase of carbohydrate content is influenced by water content, ash content, protein, and cereal milk fat. The higher value of all or one of the water content, ash content, protein, and fat, then the carbohydrates will be lower.

Type 2 Diabetes Mellitus sufferers must regulate the amount of carbohydrates, in the form of total calories, the type of carbohydrate that is the main strategy in achieving glycemic control (20).

Energy Value

According to Almatsier (2009) the value of energy is determined by the content of carbohydrates, proteins, food fats. The decrease of average levels of carbohydrates, protein, and fat can cause a decrease in the energy value of cereal milk development. Protein and fat content of cereal milk tends to increase along with the increasing proportion of tofu dregs flour and pumpkin flour so that at the level of treatment 3 (P3) has the highest energy value (12).

Fiber Level

The level of tofu dregs flour fiber is higher than soybean flour 3.2 g / 100 g and tempe flour 2.5 g / 100 g. The results of research by Manurung et al. (2016) which states that the higher proportion of tofu dregs flour, the higher the crude fiber content of cookies is 12.13 g with the proportion of tofu dregs flour 80% (21). Levels of crude fiber of pumpkin flour are 8.7 g / 100 g. This is higher than the fiber content of sweet potato flour which is 1.95 g / 100 g.

The results of Dhiyas and Rustanti's research (2016) was the higher the pumpkin flour, the higher the KUMO flakes fiber content was 8.35 g / 100 g with 50 % of the proportion of pumpkin flour (22).

Antioxidant Activity

The increase of antioxidant activity in cereal milk development along with the addition of pumpkin flour. In line with the results of Ramadhani's study (2012) which states that the more yellow pumpkin flour the greater β-carotene content in food cereals is 27.7% with the addition of 66% pumpkin flour (23). At all three levels of treatment cereal milk development has very weak antioxidant activity, where IC50> 200 µg / ml. Molyneux (2004) states that the smaller the IC50 value, the higher its antioxidant activity (24).

The process of developing cereal milk processing is warming at high temperatures so that products that are heating at high temperatures can reduce antioxidant activity. The carotene retention of pumpkin processed products for crackers (temperature 190^{0}C, frying a few seconds) of 79.44%, but there was the addition of Bimoli oil, then biscuits of 71.27% (temperature 190^{0}C, roasting 6 minutes) and noodles (temperature 100^{0}C, boiling 20 minutes) 64.46% in 100% ingredients (25).

Organoleptic Quality

Color

The color of the developmental milk cereal is brownish yellow. The yellow color in cereal milk development comes from the β-carotene found in pumpkin flour. Dark color which is produced due to the substitution of pumpkin flour can occur due to flour pumpkin that is yellow in color as well as the

effect of the proteins that combine with sugar in a hot setting will cause the color to darken (26)**.** According to Winarno (2004), this is caused by the maillard's reaction, which is a reaction between sugar / starch which causes the color to darken (27).

Aroma

The aroma of cereal milk is dominated by the distinctive aroma of milk from steeping, which is a mixture of skim milk and full cream milk with a ratio of 1: 3. The disliked aroma can be caused by unpleasant odor derived from tofu dregs containing lipoxygenase enzyme. According to Pramitasari (2011) the lipoxygenase enzyme will react with fat when grinding soybeans, especially if using cold water and causing unpleasant odors (28).

Mouthfeel

Mouthfeel cereal milk development is crispy before brewing and soft in the mouth after brewing with milk. This shows the tendency of the lower proportion of tapioca flour, the Mouthfeel cereal milk development will be less good. According to Supriyadi and Sugiyono (2012) tapioca flour has a high content of amylopectin which is 69.06% (db) which can provide crispness to the product (29). Meanwhile, the higher the proportion Pumpkin flour makes the flakes even more brown as this happens maillard's reaction on the starch content of pumpkin flour which causes the surface of the flakes brown faster even though it is not yet cooked so affects the crispiness of the flakes.

Taste

The taste of cereal milk development is savory and there is a sweet taste. The savory taste is influenced by fat content and protein content in the development of cereal milk, as presented in Table 1 which shows that the higher proportion of tofu dregs flour and pumpkin flour, the higher the protein content and fat content is 18.3 g / 100 g and 12 g / 100 g. Nadia's research results (2004) protein and fat content affects the formation savory taste of the product (30).

The addition of pumpkin flour gives a sweet taste to the development of cereal milk. The results of the research by Thenir, et al. (2017) are increasing adding pumpkin flour to making cupcake sponge cakes, so the thypical taste of pumpkin is getting real (sweet) (31). However, the increase of the proportion of pumpkin tends to decrease the level of panelists' preference for taste. This is closely related to Maillard's reaction to the dough flakes.

CONCLUSIONS AND RECOMMENDATIONS

Chemical quality (water content, ash content, protein, fat, carbohydrate) complete SNI 01-4270-1996 requirements except water content and standard diet requirements PERKENI. The proportions of tapioca flour, tofu dregs flour and yellow pumpkin flour have no significant effect energy value. Functional quality shows that the levels of crude fiber do not complete the requirements of SNI 01-4270-1996 and antioxidant activity in the very weak category. The proportions of tapioca flour, tofu dregs and pumpkin flour have a significant effect on color and taste, but not significantly on the aroma and mouthfeel of cereal milk development.

The proportion of tapioca flour, tofu dregs flour, and pumpkin flour at Treatment level 1 (P1) with a proportion of 60: 15: 25, however still need to improve functional quality (antioxidant activity) because it is still in the very weak category. Needing research to be done for the best processing methods, which have an impact on decreasing antioxidant activity.

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