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Research Article
Effect of Modified Cassava Flour Lentil Date Biscuits on the Blood Glucose Level of Type 2 Diabetics

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Abstract

Background: Type 2 diabetes mellitus can be managed through pharmacological and non-pharmacological therapies. One non-pharmacological approach is consumption of foods with low glycemic index value to maintain normal blood glucose level. **Objective:** The objective of the current study was to assess the effect of consuming biscuits made with modified cassava flour, lentils and dates on the blood glucose status of diabetic patients. **Materials and Methods:** A randomized controlled trial, pre-post test design was completed with 141 subjects with type 2 diabetes which were divided into four groups fed biscuits made of modified cassava flour, lentils and dates (Caromma), modified cassava flour, tempeh and dates (Catemma), tempeh and dates (Temma), or dates only (Bisma) over a 4 weeks period. Anthropometric collected data included the intake of energy, protein, carbohydrates and fat and then blood glucose was examined before and 2 h after eating biscuits at the beginning, in the middle and at the end of the study. **Results:** Caromma biscuits were found to contain slightly higher levels of carbohydrates, zinc and vitamin A than the other three types and produced a low glycemic index value (<50). Increased post-prandial blood glucose was found 2 h after consumption of biscuits was the lowest in the Caromma group (6.4 points) compared with another three control group Caromma at the end of the study; blood glucose levels were also significantly different for the Caromma group before and after the study. **Conclusion:** Thus, it can be concluded that Caromma biscuits are safe for diabetic patients.

Key words: Diabetes, mocaf, lentils, dates, biscuits, glycemic index, blood glucose

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Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The prevalence of Diabetes Mellitus (DM) is increasing yearly in Indonesia. Of the total number of Indonesian citizens estimated in urban areas (24,417 people), 5.7% of DM cases occur in those over the age of 15. By 2030, the International Diabetes Foundation and World Health Organization (WHO) estimate the prevalence of DM in Indonesia will reach 21.3 million[1,2]. In fact, DM has become the second leading cause of death among Indonesian elderly[3]. Obesity, smoking habits, lower consumption of fruits and vegetables, increased consumption of sugary foods and beverages as well as lack of physical activity are main risk factors for development of type 2 DM[4]. Because the symptoms of type 2 DM are not always apparent, patients are unaware of how long they have been affected by the disease. Type 2 DM occurs in many developing countries, especially in individuals over the age of 45 who do not depend on insulin. An important dietary modification for DM patients includes consuming recommended ratios of calories, carbohydrates, fats and proteins. In particular, DM patients are suggested to use the Glycemic Index (GI) to help select the appropriate amount and type of carbohydrates to eat; high GI foods increase Blood Glucose Levels (BGL) faster after consumption[5]. Foods which are high in gluten, such as wheat flour should also be avoided by diabetics because they can raise BG[6]. Biscuits made from lentils, dates and modified cassava flour represent a nutritious alternative. Modified cassava flour is gluten-free and can also reduce absorption of cholesterol and increase the production of short chain fatty acids[7]. Modified cassava flour also has a prebiotic effect that helps the growth of microbes in the digestive tract. Lentils can also lower BGL and are higher in protein and antioxidants than soybeans[8] and although dates are naturally sweet, they have a low GI value and can be safely consumed by diabetics[9]. The objective of the current study was to assess the effect of consuming biscuits made from modified cassava flour, lentils and dates on BGL of Indonesian DM subjects as these ingredients have been shown to lower BGL in diabetics.

MATERIALS AND METHODS

The current study used a randomized controlled trial, pre-post test design and included 172 patients with type 2 DM living in 1 of 7 selected villages in the West Java Province of Indonesia (Rangkapan Jaya Baru, Mekarjaya, Beji, Kukusan, Pangkalan Jati and Cimanggis at Depok City). Ethical clearance was obtained from the Research Ethics Committee of the Board of Health Research and Development at the Ministry of Health of the Republic of Indonesia. Male and female subjects included were between 35-75 years old, diagnosed by a physician as suffering from type 2 DM for at least 12 months (fasting BGL >200 mg dL^{-1}, BGL 2 h after eating >126 mg dL^{-1} and signs of polyphagia, polydipsia, polyuria and/or rapid weight loss), not suffering from other chronic diseases, such as cancer, coronary heart disease or stroke taking oral diabetic medications prescribed by physician and not herbal supplements (e.g., sousop leaves, crown god, rosella tea and other foods that can lower BGL). Subjects were randomly distributed into four equal groups (n = 43 patients per group) fed 1 of 4 biscuit types: Caromma, Catemma, Temma and Bisma for 4 weeks. Compliance with biscuit consumption (number of biscuits distributed and eaten) and daily food intake were recorded through home visits made every 2 days. In addition, measurements of fasting, random and post-prandial (2 h after consuming biscuits) BGL was conducted at the beginning, in the middle and at the end of the study. Baseline data collection was done at the beginning of the study and included characteristics of the subjects, history of DM, health status of the subjects 2 weeks before the interview and the last full day of food intake (24 h food recall). Data analysis was performed using SPSS version 13 software. Anthropometric data included body weight, height, waist circumference, pelvic circumference, blood pressure and percentage of body fat measured by trained nutritionists.

RESULTS AND DISCUSSION

Table 1 illustrates the macro-nutrient (energy, carbohydrates, protein and fat) and micro-nutrient (Na, Zn, Fe and vitamin A) content of the four types of biscuits used in the study. Caromma biscuits contained more vitamin A than all of the other biscuits types, while its protein content was equivalent to that of Temma biscuits. Furthermore, Caromma biscuits contained the most energy and fat, while Bisma biscuits had the highest carbohydrates levels. At the beginning of the present study, 172 subjects with type 2 DM were distributed evenly among four groups each consisting of 43 patients. However, 31 subjects were excluded from the final analysis for various reasons, such as getting bored to eat biscuits and refusing to continue eating the biscuits, they left

Table 1: Glycemic Index (GI) of biscuits

Type of biscuit reference/standard	Glucose	Bread
Caromma	27.2	37.6
Catemma	27.4	37.8
Temma	17.1	23.6
Bisma	32.0	44.1

Source: Food and Nutrition Center Laboratory of Gadjah Mada University at Yogyakarta, 2015

town and were uncertain whether they would return, or they were hospitalized and unable to consume the biscuits. At the beginning of the study, majority of subjects in all groups were women, with predominantly elderly women (≥60 year old) in the Caromma group and pre-elderly (45-59 years old) women in the each other control group. Most subjects in the four groups had a low level of education and generally did not work anymore (Table 2). The highest mean weight was in the Temma group and the lowest was in the Caromma group (Table 3). Catemma group had the highest mean height compared to of all the three other groups. Nutritional status was indicated by measurement of Body Mass Index (BMI) and weight ratio with height average nutritional status of the Caromma group was within normal limits (18.5<BMI<24.9), while all of three of the other groups had overweight. Mean waist and pelvis circumferences in the Caromma group were lower than all other groups. Mean waist/hip ratio (WHR) in the four groups was considered at risk for central obesity (≥0.9). Mean body fat percentages of the Caromma and three control groups ranged from 30-34.9% (Body fat monitor, Omron). Mean systolic and diastolic blood pressure were already categorized as a risk of hypertension in the intervention and three control groups. Overall, high weight, BMI, body fat percentage, mean waist and pelvis circumferences and high blood pressure (hypertension) were found among all type 2 DM patients included in the current study. Most DM patients are classified as overweight due to high body fat percentages, especially in abdominal area. Scientific evidence actually shows that accumulation of body fat heightens BGL, which means makes it worse, not improved[10]. Therefore, larger waist circumferences and WHR signify distribution of fat in the abdomen (central obesity) and an increased BGL[11]. Moreover, hypertension is a risk factor for DM and can cause non-β-cells to become resistant to insulin[12]. More than 75% of subjects in the Caromma and all control groups said they developed type 2 DM as a result of habitually consuming food and drinks high in sugar from childhood, while the remainder of patients said it was a hereditary condition or due to low physical activity and/or obesity. Most subjects in the intervention and the three control groups have been suffering from type 2 DM for 2-3 years. Moreover, 43.3% of subjects stated they had at least one current or late family member suffering from DM. Throughout the study, 63.1% of all subjects were taking oral DM medications, such as glibenclamide, metformin and glempiride. However, some subjects consumed mahogany fruits and ginger herbs as an alternative to the oral medications. The BGL changed in all subjects while fasting and 2 h after consuming biscuits (post-prandial) as shown in Table 4. Mean difference fasting BGL at the beginning and

Table 2: Profile of socio-demography

	Type of groups							
	Caromma (n = 35)		Catemma (n = 39)		Temma (n = 27)		Bisma (n = 40)	
Variables	n	%	n	%	n	%	n	%
Sex								
Man	11	21.8	13	23.6	2	6.5	5	16.1
Woman	24	35.5	26	41.9	25	22.7	35	31.8
Ag: <60 years old	13	17.3	23	30.7	14	18.7	25	33.3
≥60 years old	22	33.3	16	24.2	13	19.7	15	22.7
Mean±SD	63.1±10.5		57.8±8.9		57.2±8.8		55.9±7.9	
Educational level								
Low (not graduated from elementary school-graduated from junior high school)	19	54.3	28	71.8	15	55.6	32	80.0
Middle (graduated from senior high school-academy/university)	16	45.7	11	28.2	12	44.4	8	20.0
Working status								
No	28	80.0	24	61.5	21	77.8	34	85.0
Yes	7	20.0	15	38.5	6	22.2	6	15.0

Table 3: Profile of anthropometric characteristic

	Type of groups (Mean±SD)			
Variables	Caromma (n = 35)	Catemma (n = 39)	Temma (n = 27)	Bisma (n = 40)
Weight (kg)	5.7±11.2	60.90±11.5	62.2±9.1	58.7±11.5
Height (cm)	151.5±6.5	155.50±8.6	152.6±6.9	152.1±5.9
BMI (kg m^{-2})	24.7±3.8	25.30±4.7	26.7±3.4	25.3±4.5
Waist (cm)	85.7±10.4	88.70±9.2	90.9±8.1	89.8±10.2
Hip (cm)	96.1±8.4	97.40±10.8	99.3±8.5	96.7±8.8
Waist hip ratio	0.9±1.0	0.90±1.1	0.9±1.0	0.9±1.1
Body fat (%)	33.1± 4.9	31.50±6.6	34.9±5.1	34.0±6.1
Blood tension/(Systolic/diastolic)	134.2±25.0/84.3±13.2	136.80±19.7/81.10±9.8	132.0±15.5/82.1±10.9	186.5±65.1/84.6±13.1

Table 4: Mean blood sugar at fasting and at 2 h post-prandial after eating biscuit

	Type of groups (Mean±SD)							
	Caromma (n = 35)		Catemma (n = 39)		Temma (n = 27)		Bisma (n = 40)	
Variables	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Blood sugar shortly	290.3±81.9	346.8±192.3	212.3±92.8	409.0±106.5	210.5±69.3	217.0±0.0	209.7±76.0	311.6±120.5
Fasting blood sugar	163.3±70.1	152.2±62.3	178.4±83.3	165.1±72.2	126.6±59.9	121.1±43.6	186.5±65.1	215.9±73.1
Blood sugar at post-prandial after eating biscuit	205.8±74.8	212.2±105.8	205.8±83.5	224.6±89.9	149.4±57.0	201.6±63.3	213.3±70.9	280.6±99.8

Table 5: Mean macronutrient intake of subjects

	Type of groups (Mean±SD)							
	Caromma (n = 35)		Catemma (n = 39)		Temma (n = 27)		Bisma (n = 40)	
Indicators	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Energy (cal)	1339.7±307.7	1290.5±409.8	1327.2±369.6	1260.9±435.6	1396.9±293.2	1412.9±249.1	1298.8±310.7	1252.5± 370.6
Carbohydrate (g)	174.5±50.3	185.1±52.2	173.9±57.0	164.6±54.2	202.9±54.1	193.4±53.1	179.8±45.4	168.2±46.9
Protein (g)	43.9±15.2	37.3±15.7	40.6±14.3	36.7±15.9	40.1±14.7	47.3±9.6	39.6±14.5	34.7±15.6
Lemak	54.8±15.7	45.9±22.4	54.9±23.2	53.6±27.5	49.3±19.4	52.4±20.8	48.8±20.3	50.2±23.1
Serat	10.2±4.3	8.5±3.9	9.0±3.6	9.0±3.9	8.9±4.6	9.5±3.0	8.6±3.6	8.1±3.7

end of the study was lowest for Temma group. Most of the subjects in the Caromma and Catemma groups showed a decrease in fasting BGL between the beginning and end of the study, while the Bisma group exhibited a 29.4 points increase. The lowest mean increase in post-prandial BGL 2 h after consuming biscuits at the end of the study was in the Caromma group (6.4 points), while the largest increase was in the Bisma group (67.3 points). Table 5 shows the mean macro-nutrient intake for each group, including energy, carbohydrate, protein, fat and fiber. The Caromma group and two of the control groups (Catemma and Bisma groups) had a decreased mean energy intake but the Temma group showed an increase of 16 calories by the end of the study. The mean carbohydrate intake in the Caromma group increased by 10.6 g compared to the other three groups which generally showed a decrease in carbohydrate intake. The Caromma group had the largest decrease in mean protein (6.6 g), fat (8.9 g) and fiber (1.7 g) intake compared to the other three groups. Moreover, the Caromma group showed the highest rate of biscuit consumption (850 g) over the 4 weeks study period compared to the other three group. The GI value for the four biscuit types is shown in Table 5 and generally, all date biscuits have a low GI level (<50). Herein, Temma biscuit had the lowest GI value, while Bisma biscuits had the highest GI value.

CONCLUSION

This study concluded that the nutritional status of subjects from all groups was largely poor and unbalanced, with high waist-to-hip ratios, blood pressure and body fat percentage. These four measures indicate a high risk for DM. The lowest increase in post-prandial BGL 2 h was found in the Caromma group (6.4 points) compared to the other three groups at the end of the study and this group also showed significant BGL differences before and after the 4 weeks study period. However, a longer study period and greater number of included DM subjects, as well as comparison of BMI values, body fat percentages, waist-to-hip ratios and blood pressure before and after study onset need to be assessed to validate the effects of consuming Caromma biscuit on all four indicators of nutritional status.

SIGNIFICANCE STATEMENT

Studies on nutritional interventions for diabetic patients do not always show a significant benefit due to limited quantities of healthy food choices and/or nutritious food with low glycemic index values enriched in macro-nutrient and micro-nutrient.

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