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Anti-diabetic action of probiotic fermented legumes on type 2 diabetic patients

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Abstract

This study aimed to investigate the effect of receiving fermented legumes on type 2 diabetec patients. Three common legumes (Fababean,Chickpea andSoybean) were fermented using yogurt starter culture (Lactobacillus delbrueckiibulgaricus and Streptococcus salivarius subsp.

Thermophilus)orprobioticbacteriamixedculture(Lactobacillu sacidophilus,Bifidobacteriumsp.andS.thermophilus).

Fermented leguminous purees were sensory and chemically evaluated.Antidiabetic effect was investigatedon type 2 diabetes patients. Results revealed thatthe most acceptable odor, mouth feeling and overall acceptability scores were observed for Y Chick pea puree (8.2 ± 0.2), Y Soy bean puree (8.4 ± 0.2) and Y Fababean.Uric acid value as it increased from 8.00 to 9.00 after receiving fermented legumes puree. Y soy bean and P chickpea recorded the highest increase in urea level (11.00 and 12.00,

respectively).Significant decreases in Fasting Blood Glucose, Post Blood Glucose and HbA1c for all groups either in treatment groups comparing to positive control or in treated groups after experiment comparing to levels before receiving fermented legumes. The decrease after experiment in total cholesterol and triglycerides levels were significant for all treated groups.

Introduction

Diabetes mellitus is the most prevalent metabolic disorder. It is characterized by hyperglycemia that attributed to an prorated or absolute insulin deficiency and is associated with long-term complications affect the secretion of insulin, heart, kidneys, eyes and nerves ***(Gispen and Biessels, 2000).***Functional foods are defined as 'the foods contain health support components beyond the traditionally food nutrients'.Functional foods are also referred to as therapeutic foods, designer foods, medifoods,nutraceuticals, medicinal foods,superfoodsandfoodiceuticals ***(Shah et al., 2001)*** Fermented foods are food substances that are overgrown by edible microorganisms whose enzyme, especiallyproteases, lipase, amylases hydrolyze the protein, lipids and polysaccharides to nontoxic products with pleasant aromas,textures and flavors that make it attractive to the human consumer***(Stinkraus, 1996).***Probiotics are viable non-pathogenic microorganisms which, when ingested,exhibits a positive effects on health or physiology of the host ***(Marteau et al., 2001).***

Fermentation improves pulse texture, flavor, shelf-life, appearance, nutritional quality and nutrient digestibility.

Furthermore, this process decreases nonnutritional compounds in legume seeds such as oligosaccharides, proteas inhibitors, lectins and phytate ***(Desphande et al., 2000).***It is indicated that probiotic treatments of diabetic rats increase gliclazide bioavailability and lowers blood glucose levels by insulin-independent mechanisms.

It is suggested that the probiotics administration may be beneficial as adjunct therapy in the diabetes treatment. ***Lactobacillus casei*and *Lactobacillus acidophilus*** significantly delayed the onset of glucose intolerance, dyslipidemia hyperglycemiaandhyperinsulinemia ***(Yadav and Sinha 2007).***

Fasting blood glucose and insulin levels significantly reduced after consumptionof up to half a cup of legumes per day for more than fourweeks as reported by a meta-analysis of 11 trials ***(Sievenpiper et al., 2009).***

When legumes were consumed as part of a low-GI (glycaemic index) diet, they also significantlylowered HbA1c or fructosamine for up to 52 weeks in both diabetic and non-diabetic individuals.Lactic acid bacteriashowed an essential role in pulse foods fermented products. Their combination with pulse content of nonstarch polysaccharides results in symbiotic potential benefitsinclude formation of many acidic compounds, likelactate, acetate, propionate, and butyrate (formation of short-chain). Acids with further decrease of pH of fermented foods are associated with favorable changes in the gastrointestinal microecology***(Parvez et al., 2006).***Results show preliminary evidence on the effect of fermented pulses on diabetes human clinical studies are encouraged to validate the results observed in preclinical studies ***(Frias et al., 2017).***In this context, the objective of this study was to prepare acceptable functional food product manufactured by fermentation of legumes (faba bean, chickpea and soy bean) by yogurt bacteria or mixed culture of probiotic bacteria and investigate their synergistic effect on type 2 diabetes patients.

Materials and methods

Faba bean (*Viciafaba*), Chick pea (Cicerarietinum) and Soy bean (Glycine max) were purchased from Local market at Meet-Ghamr city- Dakahlia Governorate, Egypt.

Starter culture: Commercial yogurt (Lactobacillus acidophilus ,Bifidobacteriumsp.and S. *thermophilus*) and probiotic fermented milk (Lactobacillus delbrueckiibulgaricus and Streptococcus salivarius subsp. thermophilus) were used as starter culture was obtained fromMicrobiology Dept.Faculty Of Agriculture Mansoura University, Egypt,or mixed culture of probiotic bacteria and investigate their synergistic effect on type 2 diabetes patients.

Preparation and fermentation of legume puree

Faba bean, chickpea and soy bean were soaked in tap water for 8 hours,boileduntil cooked, dried at 55°C andcooled to room temperature ***(Sarah 2003 and Feng et al ., 2007).*** Finally, legumes puree was prepared by mixing of salt (2g/100g), lemon (15 g/100g) and sesame paste (Tahina) (20g/100g) in the blinder.

Legumes fermentation by yogurt bacteria or probiotic bacteria Puree of faba bean, chickpea and soy bean were fermented using yogurt bacteria (Lactobacillus delbrueckii subsp.bulgaricus and Streptococcus salivarius subsp. thermophilus) as starter by adding10% yogurt. Samples were incubated at 37°C until pH 5.2 was reached according to (***Kiriiet al., 2009)*** samples were stored at refrigerator at 5°C.Howver; samples were fermented using mixed culture of prbiotic bacteria or mixed culture of probiotic bacteria (*Lactobacillus acidophilus,**Bifidobacterium***sp.and *S. thermophilus*) as starter by adding 10%. samples were incubated at 37°C until pH 5.2 was reached according to ***(Kirii et al., 2009)***samples were stored at refrigerator at 5°C.

Products chemical analysis

Moisture,protein, fats, crude fiber and ash and crude were determined according to the methods of ***A.O.A.C. 2005).***Carbohydrates were calculated by difference as following: Carbohydrates = 100- (% moisture + % protein + % fat + % ash).

Sensory evaluation of fermented Legumes

Sensory evaluation of the fermented legumes prepared from each mixture was estimated to determine their sensory characteristics. All members 15 panel of adult invividuals including the participants in our study according to ***(Sanni et al., (1998).***Members were asked to evaluate samples the first day after manufacture for appearance, color, taste , odor and Mouth feeling, using a ten-point score system (10 excellent, 1 unacceptable).Overall acceptability was calculated as the average of sensory parameters.

Biological evaluation of fermented legumes

Subjects and experimental design

One hundred and twenty individuals characterized in Table 1 are divided into two main groups (15 are normal and the other 120 are patients with type 2 diabetes) aged between 45 to 60 years oldwere selected as shown in Table 1. After subjects' agreement, they were entered to study.Patients had not use Insulin to study the effect of consuming legumes fermented with yogurt or probiotic bacteria on type 2 diabetes mellituspatients, the groupswere divided into eight groups (fifteen subjects each) as the following:

Group 1: Represented as normal control group;
Group 2: Represented as patient group (positive control);
Group 3:Received faba bean fermented with yogurt bacteria; Group 4:Received chick pea fermented with yogurt bacteria; Group 5:Received soy bean fermented with yogurt bacteria;
Group 6:Received faba bean fermented with probiotic bacteria; Group 7:Received chick pea fermented with probiotic bacteria; Group 8: Received soy bean fermented with probiotic bacteria.All subjects consumed 200 ml/day of fermented legume through two months of experiment period.

Biochemical analysis

Kidney functions : serumcreatinineconcentration was determined according to the method described by (***Bartels* and Boehmer (1971).**

Serum uric acid was determined according to the method described by ***(Fossati et al., 1980).*** Concentration of blood urea nitrogen was determined according to the method of***Patton* and *Crouch 1977).***

Determination of hematological indices

Glycatedhaemoglobin,hemoglobin andhematocritwere measured according to (***Peterson et al1998),Mc-Inory(1954)*** respectively.

Estimation of lipid parameters

Lipid parameters were estimated (ml/dl) using enzyme-spectrophotometry kits (Spainreact,S.A. Ctra. Santa Coloma, 7 E-17176 SantEsteve De Bas (GI)Spain).

Total cholesterol,triglycerides (TG) and high density lipoprotein cholesterol (HDL- c) were measured according to ***Richmond (1973) Buccolo and David(1873) and Castelli et al., (1977)*** respectively.

Low density lipoprotein (LDL- c) and very low density lipoprotein werecalculated according to ***Castelli et al., (1977)***as follows:LDL = total cholesterol – (HDL- c + vLDL- c); vLDL- c = TG/5.r (1977).

Statistical analysis

The collected data were statistical analyzed, using SPSS version 18.0 following descriptive statistics (mean and standard deviation) as well as analytical tests such as t-test and one-way ANOVA.A paired samples t-test was used to explain the significance of difference between before and after the intervention.

Results and Discussion

Sensory evaluation

Sensory attributes of boiled faba bean, chick pea and soy bean purees fermented by yogurt orprobiotic bacteria are represented in table (2).Data indicated that both yogurt (Y) and probiotic (P) soy bean puree recorded the highest scores in appearance (8.5 ± 0.2), however P faba bean and p chickpea pureehad the best color (8.5 ± 0.2). Taste was the best for Y faba bean (8.2 ± 0.2), and the most acceptable odor, mouth feeling and overall acceptability scores were observed for Y chick pea puree (8.2 ± 0.2), Y soy bean puree (8.4 ± 0.2) and Y faba bean. On the other hand; the lowest sensory attributes was noticed for Yfaba bean in appearance (7.6 ± 0.3),mouth feeling(7.5 ±0.3)and odor (6.9±0.4). Also P soy bean and Y soy bean had the lowest scores in taste (7.5± 0.3) and overall acceptability (7.7 ± 0.1). Studies indicated that lactic acid bacteria can contribute to the taste, overall appearanceand aroma and generally produce anmoreover pleasing sourness.

Chemical composition of faba bean, chickpea and soy bean purees fermented by yogurt or probiotic bacteria are shown in Table (3). Results indicated that the highest values ofchemical parameters were recorded forY and Psoy Beaninmoistureas it was55.9±0.1 and 56.6±0.1, lipids as1.92± 0.1 and1.90±0.2 and protein which had26.47± 0.0and 26.20±0.1%respectively. On the handChickpearecorded 2.3±0.2% as the richest ash content, followed byP. faba bean (2.3±0.2%).P.chickpea and Y.chickea had the highest carbohydrates content (23.48±0.4and 23.38± 0.1%

respectively), while the lowest content was found for P soy bean (13.10±0.1 %)

Kidney functions of type 2 diabetic patients groups received fermented legumes puree are presented in table (4). Data show that the differences between legumes were insignificant in creatinine, urea and uric acid levels except in creatinine after feeding. The insignificant differenceswerefound in all groups after in comparing to them before treatments except in uric acid value as it increased from 8.00 to 9.00 after receiving fermented legumes puree.YSoy bean and P chickpea recorded the highest increase in urea level 11.00 and 12.00, respectively.Vegetables rich in purine (suchleguminous plants, white beans, green peas, lentils) should be excluded from the gout diet leguminous plants are a purines-rich source; however, their effect on uric acid levels depends on the size and make-up of dietary portions. However later studies pointed outthe beneficial effect on uric acid levels that soy products may have(***Chuang et al., 2011).***

Results in Table (5) show significant decreases in fasting blood glucose, post blood glucose and hba1c for all groups either in treatment groups comparing to positive control or in treated groups after experiment comparing to levels before receiving fermented legumes. The lowest level offasting blood glucose was recorded for Y. chickpea (169.2 ±2.7), followed by P. fababean (169.3±3.0) representing a significant decrease ($p<0.05$) comparing to both positive control group and the level before treatment. However Y faba bean was the best treatment in decreasing post blood glucose (259.2±7.9). P faba bean group had the lowest level of hba1c (6.4±0.1), followed by P soy protein group (6.5±0.1) with highly significant difference.In management of blood glucose levels pulses are elective foods its dietary strategies. Pulses provide high amounts of resistant starch, generally known as starch products that not digested in the small intestine, which produce lowglucose and low insulin resistance . Fermented legumes have been recommended to manage diabetes due to its low-GI, high-fiber content, and phenolic compounds, which improve oxidative stress-induced hyperglycemia ***(Atkinson et al.,2008 Landete et al., 2015 and Mait and Majumdar, 2012)*** **.**

Lipids profile of type 2 diabetic patients as affected by receiving probiotic legumes puree is shown in Table (6).

The decrease after experiment in total cholesterol level was by 4.40, 5.20, 4.00, 5.90, 5.40, 3.6, 5.2 and 3.6(mg/dl)with significant differences at normalfor positive, Y. fababean, Y. chickpea, Y. soy bean, P. fababean, P. chickpea, P.soybean and P.fababean,respectively.

Howevertheconcentration of triglyceridessignificantly decreased by 2.10, 2.40, 3.10, 2.80, 2.90, 2.00, 2.70 and 2.40(mg/dl), respectively.LDL- c differences were 3.30, 3.10, 4.40, 4.10, 4.50, 3.10, 3.20 and 3.80(mg/dl), respectively. A decrease in vLDL was observed in all groups.

The highest decrease in treated group was in Y and P Chickpea (1.80) (mg/dl). HDL- c significantly decreased after experiment with insignificant differences between treatments each other.A few human intervention studies have also reported the ability of milk fermented products to restore the serum lipid profile in women ***(Andrade and Borges, 2009 and Sadrzadeh-Yeganeh***

et al., 2010) and to reduce abdominal adiposity (***Kadooka et al., 2010).Pintus et al. (2013***) reported improvement of the lipid profile and reduction of endocannabinoid synthesis in the plasma .Insulinotropic effects of yogurt peptides and vitamins and minerals such as vitamin D, calcium, and magnesium may act positively to reduce type 2 diabetes risk ***(Chen et al., 2014).***

Moreover, the low glycemic load of yogurt, its protein and lipid content, texture, and acidity could also impact satiety and obesity-related mechanisms, lowering type 2 diabetes incidence.Pulses contain significant content of α-galactosides ranged between 0.5 and 12%.Animal studies have showed that besides the prebioticeffect,αgalactosides areacting as antioxidants ,lipidprofileenhancers,immunestimulators and blood-glucose regulators in animal trials ***(Chen et al., 2010 and Xie et al., 2012).*** in Table(7)hematological indices of type 2 diabetic patients as affected by receiving probiotic legumes puree are included.

Data show insignificant increase in Hemoglobin concentration for all patient groups received fermented legumes. Leucocytes recorded less change only in P. fababeanand P. chickpea. Also slight increase in red blood cells was observed in YandPchickpea and Y. soy bean. A decrease in platelets concentration after feeding can benoticed. The highestdecrease was observed for Y. Fababean (5.00) with significant difference comparing to it before feeding and insignificant difference comparing to positive control group after feeding.Complementary foodsproducted from locally available cereals and legumes were investigated. High levels of carbohydrate, hematological properties (red blood cells, packed cell volume, mean corpuscular hemoglobin concentration, hemoglobin, mean corpuscular volume and mean corpuscular hemoglobin) of the formulated diets were higher than those of ogi (a commercial formula), but lower than those of cerelac (a commercial formula).These high values indicate the adequacy of the formulated diets for boosting good blood health status ***(Ijarotimi and Keshinro 2005).***

Table 1: Characteristics of subjects subjected to the experiments

Characteristics	Values
Age (mean ± SE)	44.50 ± 1.38
Weight (g)	81.24 ± 17.21
Hight (cm)	175.04 ± 9.98
BMI	26.63 ± 6.00

Table 2: Sensory attributes of legumes puree fermented by yogurt or probiotic bacteria

Samples	Appearance	Color	Taste	Odor	Mouth feeling	Over all acceptability
Y.Fababea	8.2 ^{a}± 0.3	7.9 ^{a}± 0 .2	8.2 ^{a}± 0.2	6.9 ^{a}± 0.4	7.5 ^{a}± 0.3	8.2 ^{a}± 0 .1
Y.Chickpea	8.3 ^{a}± 0.2	7.9 ^{a}± 0. 2	8.00 ^{a}± 0.2	8 2 ^{b}± 0.2	7.9 ^{b}± 0.2	8 ^{b}± 0.1
Y. Soy bean	8.5 ^{a}± 0.2	8.3 ^{a}± 0. 2	8 ^{a}± 0.2	7.8 ^{b}± 0.2	8.4 ^{b}± 0.2	7.7 ^{b}± 0.1
P.Fababea	7.6 ^{a}± 0.3	8.5 ^{a}± 0.2	7.9 ^{a}± 0. 2	8.2 ^{a}± 0.2	7. 9 ^{a}± 0.2	8.1 ^{a}± 0.1
P.Chickpea	8.3 ^{b}± 0.2	8.5 ^{a}± 0.1	7.8 ^{a}± 0.2	7.9 ^{a}± 0.2	7.6 ^{a}± 0.2	8.0 ^{a}± 0.1
P. Soy bean	8.5 ^{b}± 0.2	8.3 ^{a}± 0.2	7.5 ^{a}± 0. 3	7.8 ^{a}± 0.2	7.7 ^{a}± 0.2	7.9 ^{a}± 0.1

Means in column with different letters are significantly different (P<0.05).

Table 3: Chemical composition of legumes puree fermented by yogurt or probiotic bacteria

	Moisture	Ash	Lipids	Proteins	Carbohydrates
Y. Fababea	$54.80^{b}\pm$ 0.2	$2.25^{a}\pm$ 0. 2	$1.40^{b}\pm$ 0.1	$18.31^{b}\pm$ 0.2	$23.24^{a}\pm$ 0.14
Y. Chickpea	54:40± 0.1	$2.50^{ab}\pm$ 0.2	$1.50^{b}\pm$ 0.0	$18.67^{b}\pm$ 0.0	$23.38^{a}\pm$ 0.1
Y. Soy bean	$55.90^{a}\pm$ 0.1	$2.25^{a}\pm$ 0.2	$1.92^{a}\pm$ 0.1	$26.47^{a}\pm$ 0.0	$13.48^{b}\pm$ 0.3
P. Fababea	$54.70^{b}\pm$ 0.1	$2.30^{a}\pm$ 0.2	$1.30^{b}\pm$ 0.1	$18.40^{b}\pm$ 0.3	$23.30^{a}\pm$ 0.2
P. Chickpea	$54.20^{c}\pm$ 0.2	$2.15^{ab}\pm$ 0.1	$1.50^{b}\pm$ 0.1	$18.67^{b}\pm$ 0.3	$23.48^{a}\pm$ 0.4
P. Soy bean	$56.60^{a}\pm$ 0.1	$2.20^{ab}\pm$ 0.2	$1.9.0^{a}\pm$ 0.2	$26.20^{a}\pm$ 0.1	$13.10^{b}\pm$ 0.1

Means in column with different letters are significantly different ($P<0.05$)

Table 4: kidney functions of type 2 diabetic patients as affected by receiving yogurt or probiotic legumes puree

groups	Creatinine(mg/dl)		Urea(mg/dl)		Uric Acid(mg/dl)	
	Before	After	Before	After	Before	After
Normal group	0.9^{a}± 0.1	1.0^{b}± 0.2	20.1^{a}± 1.8	20.4^{a}± 1.9	5.5^{a}± 0.1	6.3^{a}± 0.1
Patients group	0.8^{a}± 0.1	1.0^{b}± 0.3	18.8^{a}± 1.8	19.3^{a}± 1.7	5.2^{a}± 0.1	6.1^{a}± 0.1
Y. FabaBean	0.7^{a}± 0.2	0.9^{b}± 0.3	18.2^{a}± 1.6	18.8^{a}± 1.3	5.3^{a}± 0.2	6.2^{a}± 0.1
Y. Chickpea	0.6^{a}± 0.1	0.8^{a}± 0.0	18.6^{a}± 1.5	19.1^{a}± 1.8	5.1^{a}± 0.1	6.0^{a}± 0.1
Y. Soy Bean	0.7^{a}± 0.2	0.9^{b}± 0.1	16.6^{a}± 1.3	17.8^{a}± 1.2	5.2^{a}± 0.1	6.1^{a}± 0.1
P. FabaBean	0.6^{a}± 0.1	0.7^{b}± 0.1	19.3^{a}± 1.9	19.4^{a}± 1.5	5.3^{a}± 0.1	6.0^{a}± 0.1
Probiotic Chickpea	0.5^{a}± 0.1	0.9^{b}± 0.3	16.7^{a}± 1.4	17.8^{a}± 1.4	5.3^{a}± 0.2	6.2^{a}± 0.1
P. Soy Bean	0.8^{a}± 0.2	1.2^{b}± 0.1	19.8^{a}± 1.9	20.0^{a}± 1.6	5.2^{a}± 0.1	6.1^{a}± 0.1

Means in column with different letters are significantly different ($P<0.05$)

Table 5:Fasting Blood Glucose, Post Blood Glucose and HbA1cof type 2 diabetic patients as affected by receiving yogurt or probiotic legumes puree

groups	Fasting Blood Glucose(mg/dl)		Post Blood Glucose(mg/dl)		HbA1c (%)	
	Before	After	Before	After	Before	After
Normal group	87.9^{a***} ± 1.6	88.0^{a***} ± 1.3	112.9^{a***} ± 1.5	110.7^{a***} ± 1.5	5.5^{a***} ± 0.1	5.4^{a***} ± 0.2
Patients group	176.7^{b}± 3.2	178.7^{c}± 2.8	266.8^{b}± 7.9	269.2^{b}± 8.1	7.9^{b}± 0.2	7.1^{c}± 0.1
Y. FabaBean	178.7^{b}± 2.8	170.4^{c*}± 2.6	269.2^{b}± 8.1	259.2^{b}± 7.9	7.7^{b}± 0.2	6.7^{b**}± 0.1
Y. Chickpea	176.3± 2.9^{b}	169.2^{b**}± 2.7	272.7^{b}± 7.1	262.5^{b}± 7.1	7.5± 0.3^{b}	6.8± 0.1^{b**}
Y. Soy Bean	179.1^{b}± 3.4	172.2^{c}± 3.2	275.7^{b}± 5.4	266.5^{b}± 5.7	7.4^{b}± 0.2	6.9^{b***}± 0.1
P. FabaBean	176.6^{b}± 3.2	169.3^{b**}± 3.0	273.5^{b}± 5.2	263.4^{b}± 5.3	7.6^{b}± 0.2	6.4^{b***}± 0.1
P. Chickpea	178.3^{b}± 2.9	172.7^{c}± 3.4	273.3^{b}± 6.6	264.3^{b}± 6.7	7.0^{b}± 0.1	6.7^{b**}± 0.1
P. Soy Bean	175.1^{b}± 3.0	167.9^{b**}± 2.8	273.3^{b}± 5.6	262.9^{b}± 5.7	7.5^{b}± 0.1	6.5^{b***}± 0.1

Means in column with different letters are significantly different ($P<0.05$).

Table 6: Lipids profile of type 2 diabetic patients as affected by receiving yogurt or probiotic legumes puree

groups	Total Cholesterol(mg/dl)		TriGlycride(mg/dl)		LDL- c(mg/dl)		v.LDL- c(mg/dl)		HDL- c(mg/dl)	
	Before	After	Before	After	Before	After	Before	After	Before	After
Normal group	196.7^{a}± 6.4	192.3^{a}± 5.9	96.2^{a}± 6.5	94.1^{a}± 6.2	93.5± 3.7^{a}	90.2^{a}± 3.8	19.7^{a}± 0.3	17.9^{a}± 0.4	55.2± 3.5^{a}	53.9^{a}± 3.1
Patients group	210.9^{a}± 6.2	205.7^{a}± 5.5	97.7^{a}± 6.9	95.3^{a}± 6.8	97.8± 3 4^{a}	94.7^{a}± 3.2	19.8^{a}± 0.3	17.9^{a}± 0.4	57.1^{a}± 4.2	55.2^{a}± 3.6
Y. FabaBean	192.7^{a}± 7.9	188.7^{a}± 7.1	114.3± 5.0^{a}	111.2^{a}± 5.1	98.2± 2.3^{a}	93.8^{a}± 2.1	20.1^{a}± 0.2	18.7^{a}± 0.3	56.7^{a}± 3.5	54.4^{a}± 3.3
Y. Chickpea	211.4^{a}± 7.2	205.5^{a}± 6.4	93.9^{a}± 6.2	91.1^{a}± 6.0	97.2± 3.5^{a}	93.1^{a}± 3.1	19.6^{a}± 0.3	17.8^{a}± 0.4	60.8^{a}± 4.2	58.7^{a}± 3.6
Y. Soy Bean	202.5^{a}± 7.5	197.1^{a}± 6.8	102.3^{a}± 6.0	99.4± 6.0^{a}	98.1± 3.3^{a}	93.6^{a}± 2.8	19.8^{a}± 0.3	18.2^{a}± 0.4	58.1^{a}± 4.1	56.1^{a}± 3.6
P. FabaBean	197.7^{a}± 7.5	194.1^{a}± 6.6	113.3^{a}± 6.7	111.3^{a}± 6.6	98.3± 2.0^{a}	95.2^{a}± 2.1	20.2^{a}± 0.3	18.7^{a}± 0.3	55.3^{a}± 3.7	53.1^{a}± 3.3
P. Chickpea	208.4^{a}± 7.1	203.2^{a}± 6.3	96.8^{a}± 6.7	94.1^{a}± 6.5	97 1^{a}± 3.5	93.9^{a}± 3.3	19.7^{a}± 0.3	17.9^{a}± 0.5	58.5^{a}± 4.0	56.5^{a}± 3.5
P. Soy Bean	197.9^{a}± 7.0	194.3^{a}± 6.2	111.1^{a}± 6.5	108.7^{a}± 6.6	99.9^{a}± 2.3	96.1^{a}± 2.3	20.1^{a}± 0.3	18.6^{a}± 0.4	55.7^{a}± 3.8	53.4^{a}± 3.5

Means in column with different letters are significantly different (P<0.05).

Table 7: Hematological indices of type 2 diabetic patients as affected by receiving yogurt or probiotic legumes puree

groups	Hemoglobin(g/dl)			Leucocytes (10³/ Ul)			Red Blood Cells (million/Ul)			Platelets(10³/ Ul)		
	Before	After	Sig	Before	After	Sig	Before	After	Sig	Before	After	Sig
Normal group	12.1^{a} ±0.4	12.2^{a} ±0.4	0.157	5.9^{a} ±0.1	5.9^{a} ±0.1	1.000	4.2^{a} ±0.1	4.2^{a} ±0.1	0.095	244.2^{a} ±13.5	238.3^{a} ±13.9	0.030
Patients group	12.0^{a} ±0.4	12.2^{a} ±0.4	0.006	5.8^{a} ±0.1	6.0^{a} ±0.1	0.009	4.2^{a} ±0.1	4.3 ±0.1^{a}	0.019	276.3^{a} ±12.2	272.3^{a} ±12.5	0.006
Y. FabaBean	12.3^{a} ±0.4	12.4^{a} ±0.4	0.073	6.0^{a} ±0.1	6.0^{a} ±0.1	0.305	4.3^{a} ±0.1	4.3^{a} ±0.1	0.151	251.9^{a} ±13.5	246.4^{a} ±13.9	0.000
Y. Chickpea	12.2^{a} ±0.4	12.4^{a} ±0.4	0.070	5.9^{a} ±0.1	5.9^{a} ±0.1	0.061	4.2^{a} ±0.1	4.3^{a} ±0.1	0.040	270.5^{a} ±12.9	268.8^{a} ±12.9	0.426
Y. Soy Bean	12.3^{a} ±0.4	12.4^{a} ±0.4	0.072	6.0^{a} ±0.1	6.0^{a} ±0.1	0.145	4.2^{a} ±0.1	4.3^{a} ±0.1	0.065	266.5^{a} ±12.9	264.5^{a} ±13.3	0.431
P. FabaBean	12.4^{a} ±0.4	12.6^{a} ±0.4	0.062	5.8^{a} ±0.1	5.9^{a} ±0.1	0.009	4.3^{a} ±0.1	4.3^{a} ±0.1	0.001	275.1^{a} ±12.7	271.1^{a} ±12.6	0.028
P. Chickpea	12.2^{a} ±0.4	12.4^{a} ±0.4	0.057	5.9^{a} ±0.1	6.0^{a} ±0.1	0.043	4.2^{a} ±0.1	4.3^{a} ±0.1	0.040	278.5^{a} ±11.6	277.3^{a} ±11.7	0.541
P. Soy Bean	12.4^{a} ±0.4	12.5^{a} ±0.4	0.087	5.9^{a} ±0.1	5.9^{a} ±0.1	0.126	4.2^{a} ±0.1	4.3^{a} ±0.1	0.020	262.5^{a} ±14.1	260.6^{a} ±14.1	0.366

Means in column with different letters are significantly different ($P<0.05$)

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البقوليات المتخمره كمضادات لمرض البول السكرى من النوع الثانى

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الملخص العربى

هدف هذا البحث هو دراسة تأثيرتناول البقوليات المتخمرة على مرضى البول السكرى من النوع الثاني.حيث تم تخمير الفول و الحمص و الصويا بعد نقعهم و طهيهم وذلك ببكتيريا الزبادي (***Lactobacillus*** **delbrueckii Sub sp.** ***bulgaricus*and*Streptococcussalivarius subsp. thermophilus)*** أو بمزرعة مختلطة من البكتيريا الحيوية ***Lactobacillus acidophilus,Bifidobacterium*sp.and*S. thermophilus)***
قيمت المنتجات حسيا و كيميائيا وكذلك بيولوجيا على مرضى السكر. أظهرت النتائج أن أفضل درجات الرائحة و التأثير عند التذوق و القابلية العامة سجلت في بيوريه الحمص و الصويا و الفول المتخمرة ببادىء الزبادي.وقد لوحظت زيادة غير معنوية في كل المجموعات المغذاة على بيوريه البقول. بينما سجل بيوريه الصويا و الحمص بالزبادي أعلى قيمة لليوريا. كذلك انخفاض في السكر بالدم سواء الصيام أو الفطار و الهيموجلوبين السكري في كل المجموعات المعاملة بالبقول المتخمرة و قد لوحظ ايضاانخفاضا معنويا في مستوى الكوليسترول الكلي و الجليسريدات الثلاثية في جميع المجموعات المتناولة.