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Effect of Novel fruit jams onSelected Biochemicals in Streptozotocin-Induced diabetic Wistar rats

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Abstract
Objective: *To investigate the biochemical effect of Syzygiummalascence (Malay rose apple), Cola lepidota(yellow monkey kola), andSpondiasmombin (hog plum) fruit jams fortified with soybeanusing sucrose, fructose, and palm date as sweetenersin streptozotocin-induced diabetic rats.*
Method*: Sixty Wistar rats were randomly separated into 12 groups each containing five rats. Experimental diabetes was induced in overnight fasted rats by intraperitoneal injection of Streptozotocin (STZ) at a single dose of 60 mg/kg body weight dissolved in 0.1M freshly prepared citrate buffer. After injection, the rats had free access to food and water ad libitum. Induction of diabetes was confirmed after four days by testing the fasting blood glucose level using a digital glucometer. Animals with fasting blood glucose of 200mg/dl and above were selected for this study. The animals were subsequently fed with 10% inclusion of the formulated fruit jams to their normal chow for a period of 40 days. Evaluations were made for body weight, fasting blood sugar, lipid profile, liver and kidney function indices, haematological parameters and endogenous antioxidants in all the rats.*
Results*: Compared to the normal control group, the treatment of rats with a single dose of STZ at 60mg/kg body weight revealed a significant ($p<0.05$) decrease in body weight and increase in fasting blood glucose. Lipid profile analysis showed a significant ($p<0.05$) increase in serum levels of total cholesterol (TC), triglycerides (TAG), low- density lipoprotein (LDL) with a significant decrease in high density lipoprotein (HDL). Haematological parameters showed a significant ($p<0.05$) decrease in red blood cells (RBC) and haemoglobin (HGB), packed cell volume, and platelet counts. Also, studies on liver and kidney function indices showed a significant ($p<0.05$) increase in aspartate aminotransferase (AST), alanine aminotransferase (ALT), bilirubin,urea, and creatinineand a significant ($p<0.05$) decrease in total protein and albumin levels. Oxidative stress studies revealed a significant ($p<0.05$) increase in malonaldehyde (MDA),and a significant decrease in reduced glutathione (GSH), Catalase (CAT), superoxide dismutase (SOD), glutathione peroxidase (GPx) of the pancreas homogenate. Treatment of the diabetic rats with 10% inclusion of formulated fruit jams to their normal chow for 40 days alleviated these altered parameters.*
Conclusion:*It can be concluded from this study that date based jams, followed by fructose and sucrose based jams have antidiabetic effects through the ability to scavenge free radicals elicited by STZ thereby improving lipid profile, liver, and kidney function parameters. The study, suggests that the nutritional management of the quality of life of diabetic patients could be better managed using thedate-based formulated jam.*
Keywords*: Novel fruit jams, Wistar rats, Streptozotocin, Diabetes*

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I. Introduction

Worldwide diabetes occurrence is estimated to reach 9.3% (463 million people) in 2019, increasing to 10.2% (578 million) by 2030 and 10.9 percent (700 million) by 2045 [1]. Substantial quantities of sucrose intake have been associated with health problems such as obesity, diabetes, coronary heart disease, and high blood pressure [2]. The majority of people are anticipating forward to low-calorie foods that are high in dietary fibre and have several health benefits [3].

Jams with reduced calories are prepared with low-calorie sweeteners and low-calorie ingredients [4]. To minimize overall calories while maintaining palatability, low-calorie sweeteners are used. A sweetener is any naturally occurring or synthetically produced substance that gives food and beverages a sweet taste. Sucrose (table sugar) is the most commonly used sweetener in the food industry and is considered the "gold" criterion for sweet taste [5]. Fructose is a monosaccharide sweetener that can be found in a variety of foods, including fruits, vegetables, and berries. It is a popular traditional energy source. It has long been thought to be beneficial and thus encouraged for the dietary or nutritional control of diabetes mellitus and insulin resistance [6]. Because

of its effects on appetite, food choices, and non-insulin dependent/thermogenesis, fructose may be beneficial in diets for weight loss [7].

The date palm (*Phoenix dactylifera* L.) is a fruit-bearing tree with a lot of prospects. The fruit has nutritional and medicinal properties. Date fruits and seeds, on the other hand, are high in nutrients like amino acids, vitamins, minerals, dietary fibre, and phenolics. Dates fruits and seeds have been shown to have antioxidant, antifibrotic, anti-diarrhoea [8], anti-inflammatory [9], antimutagenic [10], and immune-modulatory properties [11], which are enhanced by the presence of phytochemicals such as carotenoids, phenolic acid, flavonoids, tocopherol, and phytosterol. Date fruit has not been fully utilized as a good functional ingredient in many health-promoting diets in terms of commercial value [12].

There is a need to systematically explore the health benefits of date fruit and date pits as well as the use of their functional components in the development of various value-added food products and supplements. The objective of this study was to investigate the biochemical effect of soybeans fortified fruit jams produced from Malay rose apple, yellow monkey kola, and hog plum fruit using sucrose, fructose, and date as sweeteners on streptozotocin-induced diabetic rats.

II. Materials And Methods

2.1 Samples collection and preparation

Malay rose apple, yellow monkey kola, hog plum, and palm date fruitswere purchased from a local market in Obio/akpor local government area of Rivers State, Nigeria. The samples were purchased from six randomly selected vendors in the market. Mature and undamaged fruits were selected for this research.

2.1.1Sample preparation

The palm date fruits (driedDeglet Noor variety) were hand-picked from unwanted materials, quickly and thoroughly washed in clean tap water to remove dust and adhere specks of dirt. The palm fruit dates were then deseeded by using stainless steel knife to open up the fruit, removed the seed, and cut the fruit into smaller pieces. The bad date palm fruits that were seen as the fruits were opened up were also removed and discarded. The pulp with pericarp was cut into smaller pieces, spread on a foil paper, and then oven-dried at 50^0Cfor 60 hours. The dried broken-up dates were ground into powder and allowed to pass through a clean 0.35mm mesh sieve to obtain a fine homogenised powdery substance (date palm fruit pulp). The palm date pulp produced was stored in a clean airtight container at room temperature till further use.

The yellow monkey kola and Malay apple fruits were separately washed in clean water and were longitudinally sliced with the help of stainless steel knives to remove the seeds (after which the outer skin of yellow monkey kola was peeled off) and dipped in 0.2% citric acid solution that was already prepared to avoid browning. The sliced fruits were weighed and blended with a home blender grinder. The whole hog plum fruits were washed, weighed, and blended in a blender. Water was added and sieved using a coarse sieve to separate the seeds from the pulp, then the weight of the seeds was taken to know the weight of the pulp obtained. Soybean powder was soaked in water for 6 hours and the pulps of the three fruits were refrigerated until further use.

2.1.2 Preparation of Jams

Twelve fruit jam formulations were prepared according to the method described by [13] with slight modifications as shown in Table 1. The fruit pulp was boiled while mixing the earliest soaked soybean flour was added alongside either sucrose, fructose, or date fruit pulp (powder) and pectin was mixed with part of the date fruit pulp and added to the mixture. The mixture was boiled until the desired concentration was reached, and citric acid and sodium benzoate were added with continuous mixing for an additional 1 minute. The mixture was poured directly into an already sterilized jar and lid and then cooled in cold water. The jams were refrigerated at 10^0C until further use and all thesoybeans fortified fruit jams were used for animal studies.

Table 1: Ingredient used for Preparing the Twelve fruit Jams formulations

formulations	Fruits (g)	Sucrose (g)	Fructose (g)	DatesPulp (g)	Citric acid(g)	Sodium benzoate(g/kg)	Pectin(g)	Soaked Soybeans (g)
NAJ	1000	1000	-	-	-	-	-	-
SSAJ	950	1000	-	-	-	-	-	50
FSAJ	950	-	625	-	2.5	-	-	50
DSAJ	950	-	-	900	7.0	0.8	2	50
NMJ	1000	1000	-	-	-	-	-	-
SSMJ	950	1000	-	-	-	-	-	50
FSMJ	950	-	625	-	2.5	-	-	50
DSMJ	950	-	-	900	7.0	0.8	2	50
NPJ	1000	1000	-	-	-	-	-	-
SSPJ	950	1000	-	-	-	-	-	50
FSPJ	950	-	625		2.5	-	-	50
DSPJ	950	-	-	900	7.0	0.8	2	50

NAJ: Normal Apple Jam, SSAJ: Sucrose Soybeans Apple Jam FSAJ: Fructose Soybeans Apple Jam, DSAJ: Date Soybean Apple Jam, NMJ: Normal Monkey kola Jam, SSMJ Sucrose Soybeans Monkey Kola Jam, FSMJ Fructose Soybeans Monkey kola Jam, DSMJ: Date Soybean Monkey kola Jam, NPJ- Normal Plum Jam, SSPJ- Sucrose Soybeans Plum Jam, FSPJ- Fructose Soybeans Plum Jam, DSPJ- Date Soybean Plum Jam.

2.2 ExperimentalAnimals

A total of 60 healthy Wistar albino rats of both sexes weighed between 100 – 130g were obtained from the Animal House, Department of Biochemistry, University of Port Harcourt, Rivers State. The animals were separated into male and female to prevent pregnancy complications in well-aerated laboratory cages, fed with feed and water *ad libitum*, and were acclimatized for two weeks before the commencement of the experiment. The experiment was approved by the Research Ethics Committee of the University of Port Harcourt (UPH/CERAMAD/REC/MM78/002).

2.3 Induction of diabetes mellitus

Experimental diabetes was induced in overnight fasted rats by intraperitoneal injection of STZ (Sigma-Aldrich Corp, St. Louis, MO, USA) at a single dose of 60 mg/kgbody weight [14]. The STZ was dissolved in 0.1M freshly prepared ice-cold citrate buffer. After injection, diabetes mellitus was confirmed after four days by testing the fasting blood glucose level using a digital glucometer. Animals with fasting blood glucose of 200mg/dl and above were selected for this study

2.4 Animal grouping and treatments

A total of 60 rats were used. The rats were randomly divided into 12 groups of 5 rats each and were fed 10% inclusion of the soybean fortified fruit jams to their normal chow and their fasting plasma glucose level was monitored every 10 days for forty days.

Grouping (n=5)	**Treatments**
Group 1(NC)	Normal fed a standard diet
Group 2 (STZ)	Induced not treated (diabetic control)

Group 3 (STZ+CFJ)	Fed a standard diet containing 10% commercial fruit jam
Group 4 (STZ+SSAJ)	Fed a standard diet containing 10% sucrose soya beans apple jam
Group 5 (STZ+ FSAJ)	Fed a standard diet containing 10% fructose soya beans apple jam
Group 6 (STZ+DSAJ)	Fed a standard diet containing 10% dates soya bean apple jam
Group 7 (STZ+SSMJ)	Fed a standard diet containing 10% sucrose soya bean monkey kola jam
Group 8 (STZ+FSMJ)	Fed a standard diet containing 10% fructose soya bean monkey kola jam
Group 9 (STZ+DSMJ)	Fed a standard diet containing 10% dates soya bean monkey kola jam
Group 10 (STZ+SSPJ)	Fed a standard diet containing 10% sucrose soya bean plum jam
Group 11 (STZ+FSPJ)	Fed a standard diet containing 10% fructose soya bean Plum jam
Group 12(STZ+DSPJ)	Fed a standard diet containing 10% dates soya bean plum jam

At the end of the experimental period, overnight fasted animals were weighed and humanely sacrificed using chloroform anaesthesia and blood samples were collected from the heart by cardiac puncture in a bottle without disodium ethylene diamine tetra-acetate for the estimation of the biochemical parameters. Immediately after the blood was collected pancreas was surgically dissected out, weighed, and suspended in ice-cold 0.25M Sucrose solution (1:5 w/v) which was thenhomogenised for oxidative stress studies.

2.5 Measurement of Body weight and Glucose level

The body weight and blood glucose levels were measured on 0, 10, 20, 30, and 40 days periodically. The fasting blood glucose was determined using a glucometer (Accu-Chek Active, Roche, Mannheim, Germany).

2.6Measurement of liver and kidney function, lipid profile parameters

Activities of alanine aminotransferase (ALT), Alkaline phosphatase (ALP), Aspartate aminotransferase (AST), Albumin, Total bilirubin, and Conjugated bilirubin, Creatinine, and Urea, as well as high-density lipoprotein (HDL), total cholesterol (TC) triglycerides (TG), were determined using assay kits from Randox Laboratories Ltd. The LDL level was calculated by the following equation [15]:

LDL= TC-HDL-TG/5

2.7 Haematological Analysis

Blood samples were also collected from the heart of each animal by cardiac puncture into K^+ EDTA bottles. An auto haematologicalanalyser (XE-2100 by Sysmex Corporation) was used to determine the haemoglobin concentration (Hb), red blood cell count (RBC), white blood cell count (WBC), platelets, lymphocytes, Monocytes, Eosinophils and Packed cell volume (PCV), using the method of Dacie and Lewis [16].

2.8 Assessment of endogenous antioxidant activities and lipid peroxidation

2.8.1 Reduced glutathione (GSH) level

GSH was determined usingSedlak& Lindsay [17] method. 1 mL sample of 10% homogenate was precipitated with 1 mL of (4%) sulfosalicylic acid. The samples were maintained at 4°C for 1 hr and then centrifuged at 1200× g for 20 min at 4°C. Added 0.1 mL filtered aliquot, 0.2 mL of 100 mM DTNB, 2.7 mL phosphate buffer (0.1 M, pH 7.4) in the cuvette. The yellow colour of the mixture was developed, and read immediately at 412 nm.

2.8.2 Catalase Activity

Catalase activity was determined using the method described by Sinha [18].Exactly 1ml of phosphate buffer, 0.2ml of tissue homogenate, and 0.4ml of H_2O_2 were added into two separate test tubes each, 1ml of potassium dichromate/glacial acetic acid was added to one of the test tubes immediately after the addition of H_2O_2 (blank), while 1ml of potassium dichromate was also added to the second test tube 10 minutes after the addition of H_2O_2 (Test). The mixture in the test tubes was heated in a water bath for 10 minutes at 80^0C. Absorbance was read at 570nm.

2.8.3 Super oxide dismutase

SOD activity was evaluated according to the method described by Atawodi [19] Exactly 920 µL of assay buffer was added into a clean test tube containing 40 µL of tissue homogenate, mixed, and incubated for 2 min at 25 °C, after which 40 µL of haematoxylin solution was added, mixed quickly and the absorbance was measured immediately at 560 nm.

2.8.4 Glutathione Peroxidase

Glutathione peroxidase was determined according to the method described by Rotruck*et al.* [20].The assay mixture contained 0.5ml of sodium phosphate buffer, 0.1ml sodium azide, 0.2ml of reduced glutathione, 0.1ml of H_2O_2 and 0.5ml of 1:10 dilution of the sample, and 0.6ml of distilled water making a total of 2.0ml. The tubes

were incubated at 37^{o}C for 3mins and the reaction was terminated by the addition of 0.5ml of 10% TCA. To determine the residual glutathione content, 1ml of the supernatant was added to 4.0ml of disodium hydrogen phosphate and 1ml of DTNB was added. The colour developed was read at 412nm.

2.8.5 Thiobarbituric Acid Reactive Substances Determination

Lipid peroxidation of LDL was assessed by the Determination ofThiobarbituric acid reactive substances (TBARS) [21]. 0.2ml of normal saline was pipetted into test tubes labelled as; sample test and sample blank, 0.2ml of tissue homogenate were pipetted into the sample test tube only, 0.5ml of TCA solution was added to each of the sample tests, and sample blank tubes followed by the addition of 0.1ml of TBA solution, 0.2ml of distilled water was added into sample blank tube in place of tissue homogenate. The mixture in each test tube was heated for 60 minutes in a water bath at 95^{o}C. After cooling to room temperature on an ice bath, 3ml of n-butanol was added to the content in each test tube and then mixed vigorously, the butanol phase was mixed by centrifugation at 1000 X g for 5 minutes and the absorbance of the sample test was read against the absorbance of the sample blank at 532nm and the concentration of TBARS was expressed in terms of Malondialdehyde (MDA).

2.9Statistical analysis

The data were analysed by the analysis of variance (ANOVA) using the SPSS program (version 20.0 SPSS Inc., Chicago, IL, USA). The differences among the various treatment groups were compared using the Duncan Multiple Range Test.The results were expressed as mean ± standard deviation (SD) and p-value less than 0.05 was considered as significant ($p< 0.05$).

III. Results

3.1 The effect of the formulated fruit Jams on body weight of diabetic rats.

The effect of the formulated fruit Jams on the body weight of Diabetic rats is represented in Table 2. There was a significant ($p<0.05$) increase in the body weight of all the diabetic groups treated with the formulated fruit jam (date> fructose> sucrose) and a significant ($p<0.05$) decrease in the body weight of the diabetic group fed with commercial jam when compared to diabetic control.

Table 2: The effect of the formulated fruit jams onbody weight in gramsof Diabetic animals (n=5)

Treatments	Day 0	Day 10	Day 20	Day 30	Day 40
NC	137.20±8.58^{a}	159.00±8.34^{d}	166.60±8.02^{d}	174.00±7.65^{e}	205.00±8.22^{h}
STZ	137.60±8.02^{a}	131.80±10.14^{a}	128.00±9.19^{a}	124.00±6.32^{b}	119.40±7.23^{b}
STZ +CFJ	137.20±5.72a	132.00±11.34^{a}	132.00±11.43^{a}	107.40±3.94^{a}	101.60±2.51^{a}
STZ +SSAJ	139.60±3.05^{a}	137.80±4.44^{abc}	139.80±5.40^{b}	150.00±7.01^{c}	155.40±5.32^{c}
STZ +FSAJ	138.80±6.61^{a}	142.60±5.81^{bc}	146.20±9.31^{bc}	152.60±10.16^{c}	159.20±9.58^{cd}
STZ +DSAJ	141.00±5.10^{a}	144.20±7.29^{bc}	152.20±5.63^{c}	158.80±7.53^{cd}	173.40±7.20^{ef}
STZ +SSMJ	134.80±5.17^{a}	136.40±4.83^{ab}	140.40±8.32^{b}	150:.20±4.55^{c}	161.40±4.93^{cd}
STZ +FSMJ	135.20±6.98^{a}	138.40±5.81^{abc}	143.80±6.53^{bc}	157.00±5.00^{c}	165.20±11.34^{de}
STZ +DSMJ	134.20±5.22^{a}	140.8±4.92^{abc}	149.20±4.27^{bc}	166.40±5.68^{de}	175.00±5.70^{f}
STZ +SSPJ	138.20±7.66^{a}	143.40±7.37^{bc}	146.80±6.76^{bc}	151.80±6.50^{c}	162.20±5.36^{cd}
STZ+FSPJ	140.00±4.95^{a}	147.60±4.77^{c}	153.00±4.12^{c}	159.40±5.46^{cd}	164.40±3.29^{cd}
STZ +DSPJ	135.60±8.61^{a}	143.80±9.01^{bc}	154.00±8.43^{c}	168.40±8.62^{e}	188.40±5.27^{g}

Values are means ± SD. Values with different superscripts down the column are significantly different ($p<0.05$).(NC): Normal control (STZ): Diabetic Control (STZ +CFJ): Diabetic animals fed a standard diet containing 10% commercial fruit jam(STZ +SSAJ): Diabetic animals fed a standard diet containing 10% sucrose soya beans apple jam (STZ +FSAJ): Diabetic animals fed a standard diet containing 10% fructose soya beans apple jam (STZ +DSAJ): Diabetic animals fed a standard diet containing 10% dates soya bean apple jam (STZ +SSMJ): Diabetic animals fed a standard diet containing 10% sucrose soya beans monkey kola jam (STZ +FSMJ): Diabetic animals fed a standard diet containing 10% fructose soya beans monkey kola jam (STZ +DSMJ): Diabetic animals fed a standard diet containing 10% dates soya bean monkey jam(STZ +SSPJ): Diabetic animals fed a standard diet containing 10% Sucrose soya bean plum jam (STZ +FSPJ): Diabetic animals fed a standard diet containing 10% fructose soya bean plum jam (STZ +DSPJ): Diabetic animals fed a standard diet containing 10% dates soya bean plum jam. PWC: Percentage weight change

3.2 The effect of the formulated fruit Jams on blood glucose of diabetic rats.

Figure 1 presents the blood glucose of normal control and diabetic animals. An increase in blood glucose level, significantly ($p<0.05$) decreased with an increase in experimental days for the formulated jam treated groups when compared with the diabetic untreated group.

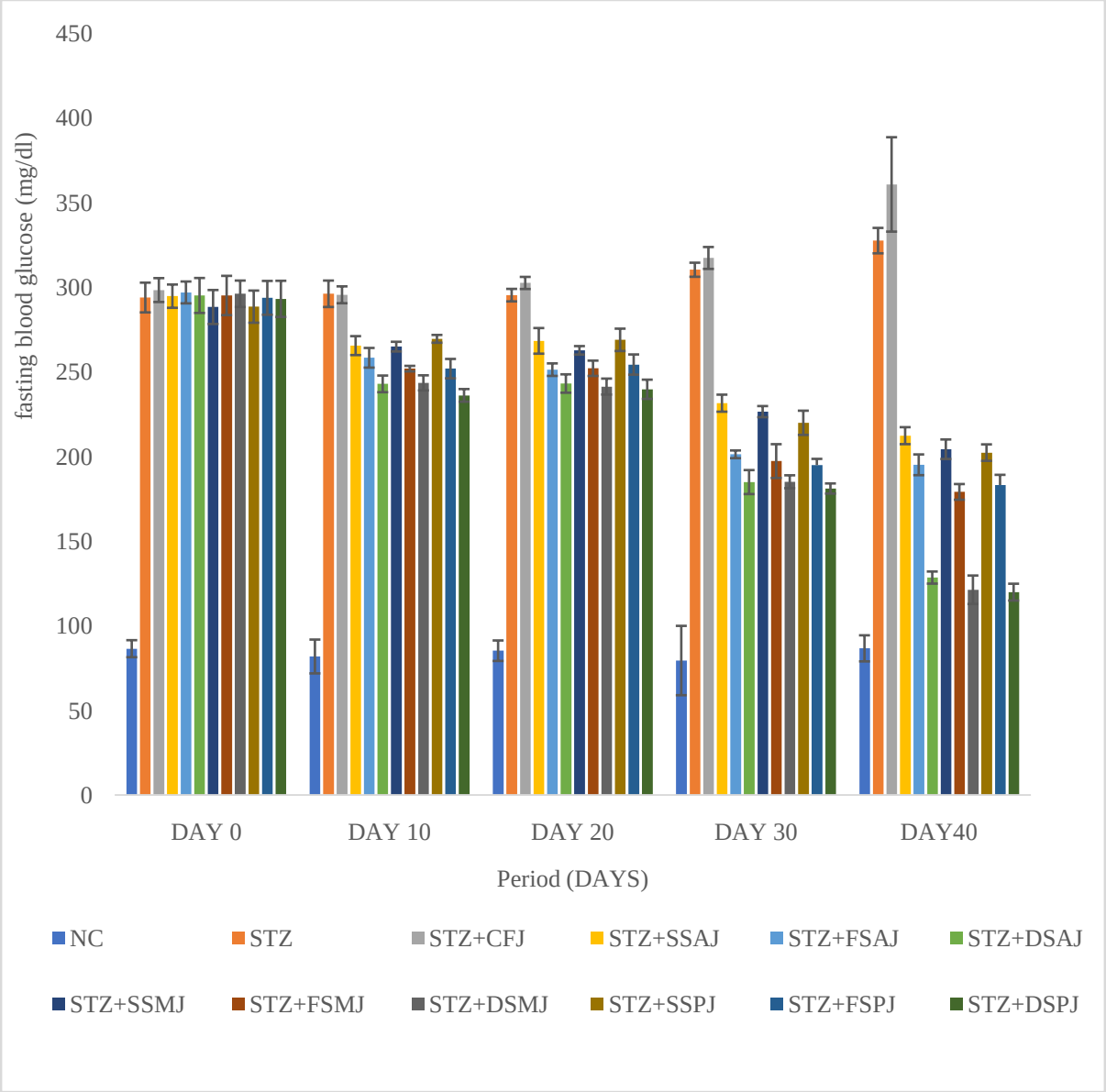

Figure 1: The effect of the formulated fruit jams on blood glucose of STZ-induced diabetic rats

(NC): Normal control (STZ): Diabetic Control(STZ +SSAJ): Diabetic animals fed a standard diet containing 10% sucrose soya beans apple jam (STZ +FSAJ): Diabetic animals fed a standard diet containing 10% fructose soya beans apple jam (STZ +DSAJ): Diabetic animals fed a standard diet containing 10% dates soya bean apple jam (STZ +SSMJ): Diabetic animals fed a standard diet containing 10% sucrose soya beans monkey kola jam (STZ +FSMJ): Diabetic animals fed a standard diet containing 10% fructose soya beans monkey kola jam (STZ +DSMJ): Diabetic animals fed a standard diet containing 10% dates soya bean monkey jam(STZ +SSPJ): Diabetic animals fed a standard diet containing 10% sucrose soya bean plum jam (STZ +FSPJ): Diabetic animals fed a standard diet containing 10% fructose soya bean plum jam (STZ +DSPJ): Diabetic animals fed a standard diet containing 10% dates soya bean plum

3.3The effectof the formulated fruit Jams on Lipids profile of Diabetic rats.

The diabetic control had a significant ($p<0.05$) increase in total cholesterol TC (141.79±7.74mg/dl), triglycerides TAG (141.88±3.14mg/dl), low density lipoprotein LDL (93.95± 19.66mg/dl) and a significant ($p<0.05$) decrease in high density lipoprotein HDL (19.46±2.58mg/dl) when compared to the normal control(TC 95.39±17.14mg/dl,TAG 106.28±8.85mg/dl,LDL 43.26± 7.14mg/dl and HDL 30.87±0.12mg/dl). However, after treatment for 40 days, all the formulated fruit jams significantly ($p<0.05$) decreased TC, TAG, LDL and significantly ($p<0.05$) increased HDL while commercial jam significantly ($p<0.05$) increased TC, TAG, LDL and significantly ($p<0.05$) decreased HDL when compared to diabetic control (STZ). However, the reduction effect of date based jams was significantly ($p<0.05$) higher than fructose and sucrose based jams.

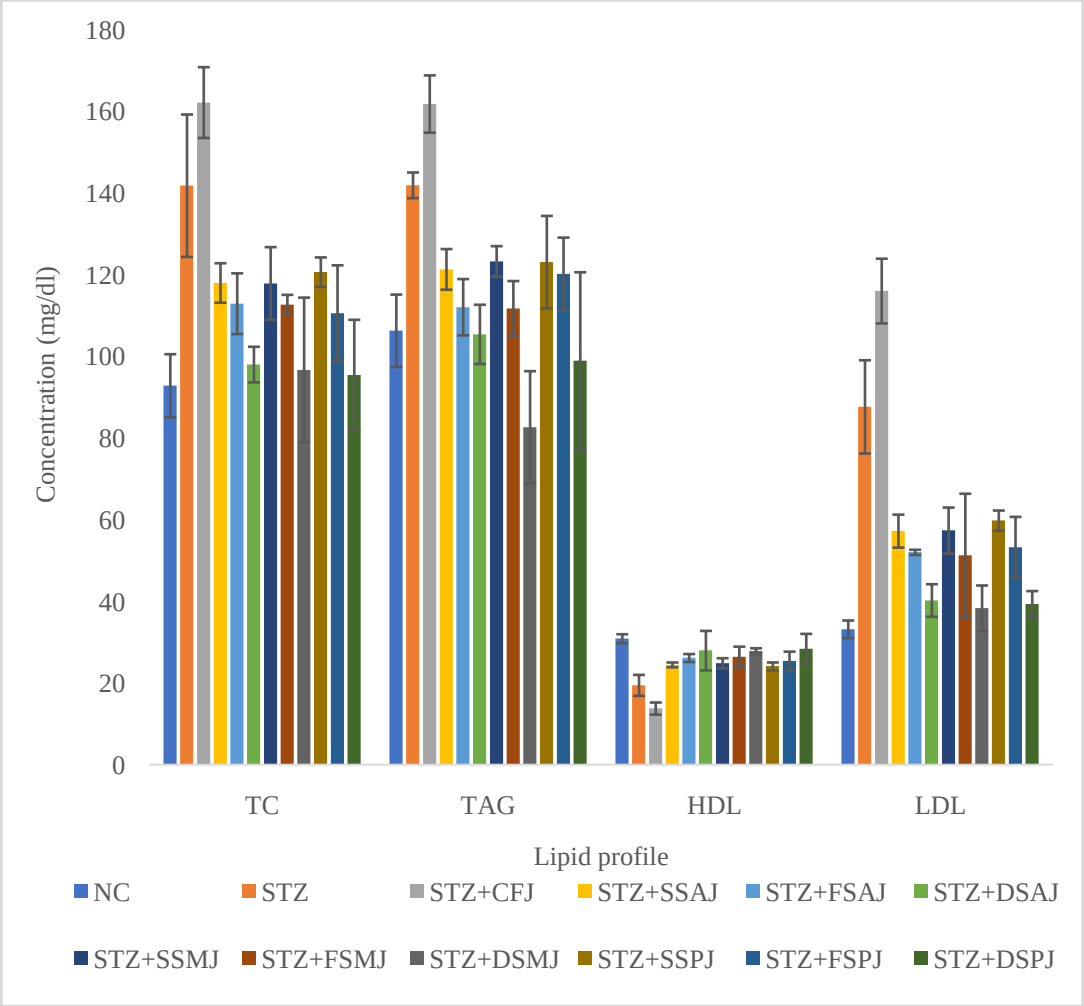

Figure 2: Lipid Profile of STZ-Induced Diabetic Rats treated with the formulated fruit Jams.

(NC): Normal control (STZ): Diabetic Control(STZ +SSAJ): Diabetic animals fed a standard diet containing 10% sucrose soya beans apple jam (STZ +FSAJ): Diabetic animals fed a standard diet containing 10% fructose soya beans apple jam (STZ +DSAJ): Diabetic animals fed a standard diet containing 10% dates soya bean apple jam (STZ +SSMJ): Diabetic animals fed a standard diet containing 10% sucrose soya beans monkey kola jam (STZ +FSMJ): Diabetic animals fed a standard diet containing 10% fructose soya beans monkey kola jam (STZ +DSMJ): Diabetic animals fed a standard diet containing 10% dates soya bean monkey jam(STZ +SSPJ): Diabetic animals fed a standard diet containing 10%Suctose soya bean plum jam (STZ +FSPJ): Diabetic animals fed a standard diet containing 10% fructose soya bean plum jam (STZ +DSPJ): Diabetic animals fed a standard diet containing 10% dates soya bean plum jam. TC: total cholesterol, TAG: triglycerides, HDL: high density lipoprotein, LDL: low density lipoprotein.

3.4**The effect of the formulated fruit Jams on Liver indices ofDiabetic rats.**

The results showed that the diabetic control had significantly ($p<0.05$) increased Alanine aminotransferase (ALT),(30.00±2.65 IU/l), Aspartate aminotransferase(AST)(72.35±2.90 IU/l) and Alkaline phosphatase (ALP)(70.72±7.37 IU/l) compared to normal control with ALT(16.33±1.53 IU/l), AST (54.71±5.51 IU/l)and ALP (54.23±14.05IU/l)). After 40 days of treatments, all the formulated fruit jams, significantly ($p<0.05$) decreased ALT, AST, ALP while commercial jam significantly ($p<0.05$) increased ALT, AST, and ALP (34.00±1.73 IU/l, 83.33±3.21 IU/l and 85.00±4.58 IU/l) when compared to diabetic control (ALT 30.00±2.65 IU/l, AST 72.35±2.90 IU/l, ALP 70.72±7.37 IU/l).

The diabetic control had significantly ($p<0.05$) decreased serum total protein, (50.71±7.23g/l), albumin ALB (23.00±4.38g/l) and significantly ($p<0.05$) increased conjugated bilirubin CB (5.40±0.66mg/dl), total bilirubin, TB (8.27±0.75mg/dl)when compared to normal control (TP 69.00±7.94g/l, ALB 35.33±3.06 g/l,CB 3.50±0.30 mg/dl, TB 3.65±0.22mg/dl). After 40 days of treatment, the formulated fruit jams, significantly($p<0.05$) increased TP, ALB and significantly ($p<0.05$) decrease CB and TB when compared to diabetic control. Commercial fruit jam significantly($p<0.05$) decreased TP (42.00±2.65g/l) but no significant($p>0.05$) effect on ALB (18.00±2.00g/l), CB(6.23±0.67mg/dl) and TB (9.73±0.35mg/dl) when compared to diabetic control (TP 50.71±7.23g/l, ALB 23.00±4.38g/l CB 5.40±0.66mg/dl, TB 8.27±0.75mg/dl)

Table 3: Liver Function Indices of Diabetic Rat Fed With formulated fruitJams

Treatments	ALT (IU/l)	AST (IU/l)	ALP(IU/l)	TP (g/l)	ALB (g/l)	CB (mg/dl)	TB (mg/dl)
NC	17.00±1.73^{a}	54.33±3.79^{b}	51.33±2.31^{b}	69.00±7.94^{de}	35.33±3.06 ^{bc}	3.50±0.30^{ab}	3.65±0.22^{a}
STZ	30.00±2.65^{e}	72.35±2.90^{d}	70.72±7.37^{d}	50.71±7.23^{b}	23.00±4.38^{a}	5.40±0.66^{c}	8.27±0.75^{b}
STZ +CFJ	34.00±1.73^{f}	83.33±3.21^{e}	85.00±4.58^{e}	42.00±2.65^{a}	18.00±2.00^{a}	6.23±0.67^{c}	9.73±0.35^{b}
STZ +SSAJ	24.00±1.00^{d}	62.00±2.65^{c}	61.95±4.73^{c}	60.67±4.16^{c}	29.33±1.15^{b}	4.00±1.14^{b}	5.61±2.27^{a}
STZ +FSAJ	20.00±1.09^{bc}	60.15±5.51^{c}	52.67±5.03^{bc}	69.33±2.18^{de}	39.67±2.89^{bc}	3.02±0.15^{ab}	3.87±0.47^{a}
STZ +DSAJ	17.53±1.15^{a}	48.00±3.61^{a}	40.33±8.02^{a}	74.34±2.08^{e}	40.00±2.00^{c}	2.55±0.20^{a}	4.67±0.21^{a}
STZ +SSMJ	23.33±1.58^{d}	63.33±2.57^{c}	55.00±2.00^{bc}	64.00±4.58^{cd}	28.00±2.01^{b}	3.93±1.21^{b}	5.84±2.15^{a}
STZ +FSMJ	22.00±2.00^{cd}	58.63±2.52^{bc}	53.35±1.54^{bc}	67.00±2.00^{cde}	36.68±6.11^{bc}	2.67±0.53^{ab}	4.00±0.10^{a}
STZ +DSMJ	18.33±1.58^{ab}	47.10±2.74^{a}	41.67±10.12^{a}	70.00±5.00^{de}	39.28±2.52^{c}	2.40±0.35^{a}	4.70±0.26^{a}
STZ +SSPJ	23.66±1.53^{d}	62.67±2.46^{c}	54.37±1.15^{bc}	64.00±1.09^{cd}	28.30±1.53^{b}	3.97±1.17^{b}	5.61±2.27^{a}
STZ +FSPJ	20.33±1.67^{bc}	59.12±3.21^{bc}	52.00±2.74^{b}	68.00±2.1^{cde}	33.61±4.16^{bc}	3.30±0.44^{ab}	4.42±0.33^{a}
STZ +DSPJ	17.00±1.08^{a}	48.25± 3.25^{a}	40.66±1.53^{a}	71.28±1.89^{de}	40.00±2.00^{c}	2.40±0.66^{a}	4.00±0.15^{a}

Values are means ± SD. Values with different superscripts down the column are significantly different (P<0.05). (NC): Normal control (STZ): Diabetic Control(STZ +SSAJ): Diabetic animals fed a standard diet containing 10% sucrose soya beans apple jam (STZ +FSAJ): Diabetic animals fed a standard diet containing 10% fructose soya beans apple jam (STZ +DSAJ): Diabetic animals fed a standard diet containing 10% dates soya bean apple jam (STZ +SSMJ): Diabetic animals fed a standard diet containing 10% sucrose soya beans monkey kola jam (STZ +FSMJ): Diabetic animals fed a standard diet containing 10% fructose soya beans monkey kolajam (STZ +DSMJ): Diabetic animals fed a standard diet containing 10% dates soya bean monkey jam(STZ +SSPJ): Diabetic animals fed a standard diet containing 10% Sucrose soya bean plum jam (STZ +FSPJ): Diabetic animals fed a standard diet containing 10% fructose soya bean plum jam (STZ +DSPJ): Diabetic animals fed a standard diet containing 10% dates soya bean plum jam. jam ALB: Albumin TP: Total protein CB: Conjugated bilirubin TB: Total Bilirubin

3.5The effect of the formulated fruit Jams on kidney function parameters of Diabetic rats.

It was observed that the induction of diabetes by STZ significantly ($p<0.05$) raised the serum levels of urea (10.43±0.78 mmol/l) and creatinine (161.67±6.81 µmol/l) when compared to normal control (5.07±0.46 mmol/l, 51.00±2.00 µmol/l). After treatments, all theformulated fruit jams significantly ($p<0.05$) reduced the serum levels of urea and creatinine when compared to diabetic control. The commercial jam significantly ($p<0.05$) increased creatinine (178.00±7.00 µmol/l) but had no significant ($p>0.05$) effect on urea (11.13±0.67 mmol/l) when compared to diabetic control (Creatinine 161.67±6.81 µmol/l, Urea 10.43±0.78 mmol/l).

Table 4:Kidney Function Indices of STZ-induced Diabetic Rats Treated with the Formulated Fruit Jams

Treatments	Urea (mmol/l)	Creatinine (µmol/l)
NC	5.07 ± 0.46^{ab}	51.00 ± 2.00^{a}
STZ	10.43 ± 0.78^{c}	161.67 ± 6.81^{f}
STZ +CFJ	11.13 ± 0.67^{c}	178.00 ± 7.00^{g}
STZ +SSAJ	7.50 ± 2.04^{ab}	113.33 ± 12.22^{e}
STZ +FSAJ	6.80 ± 0.80^{ab}	101.23 ± 4.93^{cd}
STZ +DSAJ	5.43 ± 0.45^{ab}	64.00 ± 7.25^{b}
STZ +SSMJ	7.57 ± 1.94^{ab}	110.33 ± 2.52^{de}
STZ +FSMJ	6.00 ± 0.60^{ab}	96.00 ± 4.00^{c}
STZ +DSMJ	5.63 ± 0.61^{ab}	63.11 ± 2.00^{b}
STZ +SSPJ	6.57 ± 2.96^{ab}	118.33 ± 10.41^{e}
STZ +FSPJ	6.00 ± 0.10^{ab}	101.67 ± 4.16^{cd}
STZ +DSPJ	5.00 ± 1.00^{a}	64.00 ± 1.92^{b}

Values are means ± SD. Values with different superscripts down the column are significantly different (P<0.05). (NC): Normal control (STZ): Diabetic Control (STZ +CFJ): Diabetic animals fed a standard diet containing 10% commercial fruit jam (STZ +SSAJ): Diabetic animals fed a standard diet containing 10% sucrose soya beans apple jam (STZ +FSAJ): Diabetic animals fed a standard diet containing 10% fructose soya beans apple jam (STZ +DSAJ): Diabetic animals fed a standard diet containing 10% dates soya bean apple jam (STZ +SSMJ): Diabetic animals fed a standard diet containing 10% sucrose soya beans monkey kola jam (STZ +FSMJ): Diabetic animals fed a standard diet containing 10% fructose soya beans monkey kola jam (STZ +DSMJ): Diabetic animals fed a standard diet containing 10% dates soya bean monkey jam(STZ +SSPJ): Diabetic animals fed a standard diet containing 10% sucrose soya bean plum jam (STZ +FSPJ): Diabetic animals fed a standard diet containing 10% fructose soya bean plum jam (STZ +DSPJ): Diabetic animals fed a standard diet containing 10% dates soya bean plum jam

3.6 The effect of the formulated fruit Jams on haematological parameters of Diabetic rats.

The significant decrease in the levels of WBC, RBC, Hb, PCV and PLT observed in the diabetic animals wasincreased to near normal level after treatment with the formulated fruit jams but commercial jam had no significant ($p>0.05$) effect. The significant ($p<0.05$)decrease in neutrophils count also observed in diabetic animals was also increased to near normal after the treatment with formulated fruit jams whereas commercial jam had no significant ($p>0.05$)effect on the neutrophils count of diabetic animals.No significant($p>0.05$)difference between the lymphocytes, monocytes, and Eosinophilsof all the diabetic groupswhen compared to the normal control group (Figure 3).

Table5: Haematological Parameters of STZ-Induced Diabetic Rats Treated with the Formulated Fruit Jams

Treatments	WBC ($x10^9$/L)	RBC($x10^{12}$/L)	HGB (g/dl)	PCV (%)	PLT ($x10^9$/L)
NC	7.07±0.68^b	4.23±0.25^c	10.89±0.83^b	32.67±2.52^b	353.67±12.50^d
STZ	5.32±0.24^a	3.27±0.25^a	9.00±0.33^a	27.00±2.00^a	226.67±9.53^a
STZ +CFJ	5.40±0.30^a	3.40±0.30^{ab}	8.89±0.25^a	26.67±1.53^a	228.77±7.57^a
STZ +SSAJ	7.25±0.48^b	4.07±0.12^{bc}	10.67±0.67^b	32.00±1.00^b	268.00±17.09^b
STZ +FSAJ	7.17±0.85^b	4.73±0.25^{cd}	11.67±0.53^b	35.00±4.00^b	271.67±42.34^{bc}
STZ +DSAJ	6.58±0.99^b	4.33±0.41^{cd}	11.33± 1.23^b	34.00±2.00^b	298.33±6.51^{bc}
STZ +SSMJ	7.62±0.58^b	4.50±0.20^{cd}	11.00±0.76^b	33.00±4.73^b	267.00±14.80^b
STZ+FSMJ	7.32±0.45^b	4.53±0.76^{cd}	11.11±1.58^b	33.33±2.00^b	298.33±8.50^{bc}
STZ +DSMJ	7.28±1.08^b	4.67±0.15^{cd}	11.67±0.67^b	35.00±2.65^b	262.67±29.26^b
STZ +SSPJ	7.20±0.95^b	4.27±0.25^c	11.00±0.88 ^{b}	33.00±4.04^b	298.33±17.56^{bc}
STZ +FSPJ	7.15±0.41^b	4.67±0.76^{cd}	11.44±1.35^b	34.33±2.00^b	290.67±25.03^{bc}
STZ +DSPJ	7.17±0.65^b	5.17±0.81^d	12.22± .0.83^b	36.66±1.00^b	307.00±19.39^c

Values are means ± SD. Values with different superscripts down the column are significantly different (P<0.05). (NC): Normal control (STZ): Diabetic Control(STZ +CFJ): Diabetic animals fed a standard diet containing 10% commercial jam (STZ +SSAJ): Diabetic animals fed a standard diet containing 10% sucrose soya beans apple jam (STZ +FSAJ): Diabetic animals fed a standard diet containing 10% fructose soya beans apple jam (STZ +DSAJ): Diabetic animals fed a standard diet containing 10% dates soya bean apple jam (STZ +SSMJ): Diabetic animals fed a standard diet containing 10% sucrose soya beans monkey kola jam (STZ +FSMJ): Diabetic animals fed a standard diet containing 10% fructose soya beans monkey kola jam (STZ +DSMJ): Diabetic animals fed a standard diet containing 10% dates soya bean monkey jam(STZ +SSPJ): Diabetic animals fed a standard diet containing 10% Sucrose soya bean plum jam (STZ +FSPJ): Diabetic animals fed a standard diet containing 10% fructose soya bean plum jam (STZ +DSPJ): Diabetic animals fed a standard diet containing 10% dates soya bean plum jam.WBC: white blood cells, RBC: red blood cells, HGB: haemoglobin, PCV: packed cells volume

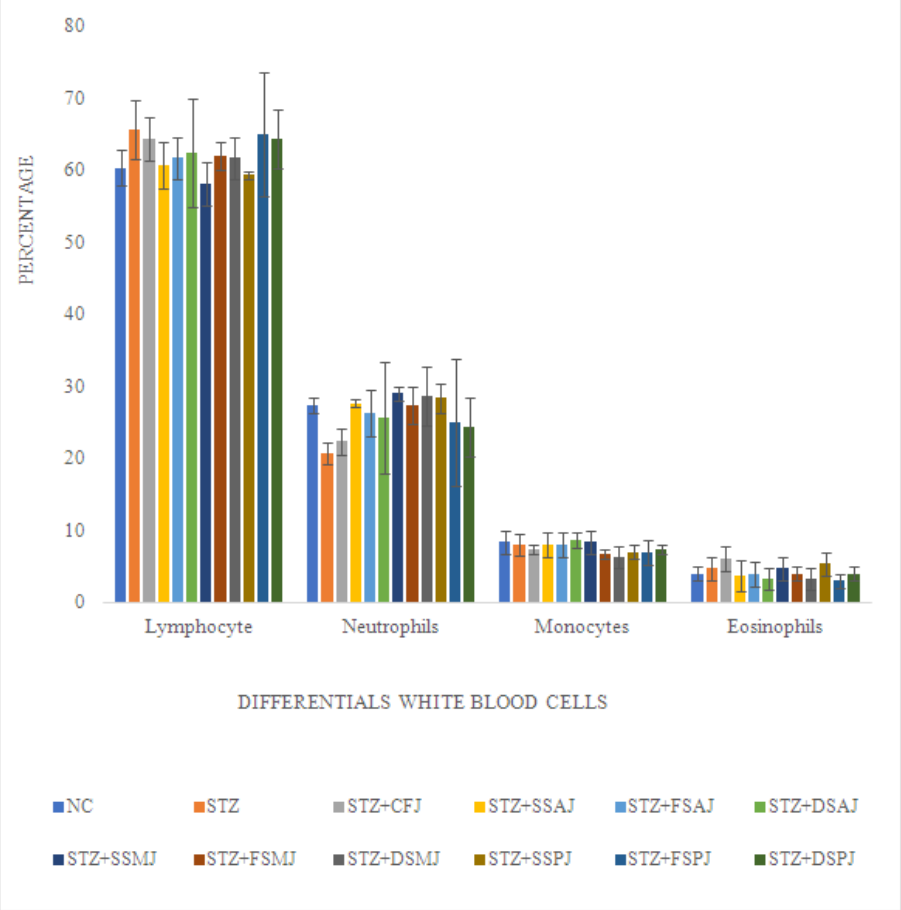

Figure 3: White Blood Cell Indices (%) of Diabetic Rats Treated with the Formulated Fruit Jams

(NC): Normal control (STZ): Diabetic Control (STZ +CFJ): Diabetic animals fed a standard diet containing 10% commercial jam (STZ +SSAJ): Diabetic animals fed a standard diet containing 10% sucrose soya beans apple jam (STZ +FSAJ): Diabetic animals fed a standard diet containing 10% fructose soya beans apple jam (STZ +DSAJ): Diabetic animals fed a standard diet containing 10% dates soya bean apple jam (STZ +SSMJ): Diabetic animals fed a standard diet containing 10% sucrose soya beans monkey kola jam (STZ +FSMJ): Diabetic animals fed a standard diet containing 10% fructose soya beans monkey kola jam (STZ +DSMJ): Diabetic animals fed a standard diet containing 10% dates soya bean monkey jam(STZ +SSPJ): Diabetic animals fed a standard diet containing 10%sucrose soya bean plum jam (STZ +FSPJ): Diabetic animals fed a standard diet containing 10% fructose soya bean plum jam (STZ +DSPJ): Diabetic animals fed a standard diet containing 10% dates soya bean plum jam.

3.7The effect of the formulated fruit Jams on endogenous antioxidant enzymes and TBARS of Diabetic rats.

The result showed that diabetic control (STZ) had a significant (P<0.05) decrease in reduced glutathione GSH (0.21±0.04µg/mg), glutathione peroxidase GPx (0.04±0.01µg/mg), catalase CAT(0.48±0.11U/g), superoxidedismutase SOD (0.17±0.02U/mg) and a significant (P<0.05) increase in MDA (0.89±0.04) when compared to the normal control groupwith GSH (0.38±0.04 µg /mg), GPx (0.10±0.01 µg/mg), CAT(2.29±0.19U/g), SOD (0.47±0.14U/mg) and MDA(0.42±0.05µmol/mg). However, after 40 days of feeding, all the formulated fruit jams significantly (p<0.05) increased the endogenous antioxidants and significantly (p<0.05) decreased MDA while the commercial jam significantly (p<0.05) decreased allthe endogenous antioxidants and significantly (p<0.05) increased MDA when compared to the diabetic control. However, dates sweetened jams significantly (p<0.05) increased the endogenous antioxidant enzymes and significantly (p<0.05) decreased MDA when compared to fructose and sucrose sweetened fruit jams.

TABLE 6: Endogenous Antioxidant and Lipid Peroxidation in the Pancreas of Diabetic Rats Treated with the Fruit Jam

Treatments	GSH(µg /mg)	GPx (µg/mg)	CAT (U/g)	SOD (U/mg)	MDA (µmol/mg)
NC	0.38 ±0.04^{de}	0.10 ±0.01^{def}	2.29±0.19^{g}	0.47±0.14^{f}	0.42± 0.05^{a}
STZ	0.21± 0.04^{b}	0.04± 0.01^{b}	0.48± 0.11^{b}	0.17± 0.02^{ab}	0.89± 0.04^{e}
STZ +CFJ	0.15±0.02^{a}	0.02±0.01^{a}	0.27±0.01^{a}	0.11±0.02^{a}	0.98±0.02^{f}
STZ +SSAJ	0.28± 0.02^{c}	0.06± 0.01^{c}	0.90± 0.01^{c}	0.20± 0.03^{b}	0.73± 0.04^{d}
STZ +FSAJ	0.32± 0.01^{cd}	0.09± 0.01^{d}	1.14± 0.08^{d}	0.35± 0.05^{cd}	0.62± 0.03^{c}
STZ +DSAJ	0.36± 0.02^{e}	0.12± 0.01^{ef}	2.08± 0.07^{f}	0.46± 0.05^{ef}	0.48± 0.02^{b}
STZ +SSMJ	0.28± 0.02^{c}	0.07± 0.01^{c}	0.90± 0.04^{c}	0.21± 0.03^{b}	0.70± 0.02^{d}
STZ +FSMJ	0.32± 0.01^{c}	0.09± 0.01^{de}	1.14± 0.02^{d}	0.30± 0.02^{c}	0.60± 0.01^{c}
STZ +DSMJ	0.36± 0.01^{e}	0.10± 0.01^{ef}	2.05± 0.05^{f}	0.44± 0.04^{def}	0.49± 0.01^{b}
STZ +SSPJ	0.28± 0.01^{cd}	0.07± 0.01^{c}	1.02± 0.04^{cd}	0.20± 0.01^{b}	0.74± 0.04^{d}
STZ +FSPJ	0.32± 0.01^{d}	0.09± 0.01^{de}	1.29± 0.04^{e}	0.37± 0.02^{cde}	0.61± 0.01^{c}
STZ +DSPJ	0.37± 0.01^{e}	0.11± 0.01^{f}	2.08± 0.07^{f}	0.45± 0.02^{ef}	0.43± 0.02^{a}

Values are means ± SD. Values with different superscripts down the column are significantly different (p<0.05). (NC): Normal control (STZ): Diabetic Control (STZ +CFJ): Diabetic animals fed a standard diet containing 10% commercial fruit jam(STZ +SSAJ): Diabetic animals fed a standard diet containing 10% sucrose soya beans apple jam (STZ +FSAJ): Diabetic animals fed a standard diet containing 10% fructose soya beans apple jam (STZ +DSAJ): Diabetic animals fed a standard diet containing 10% dates soya bean apple jam (STZ +SSMJ): Diabetic animals fed a standard diet containing 10% sucrose soya beans monkey kola jam (STZ +FSMJ): Diabetic animals fed a standard diet containing 10% fructose soya beans monkey kola jam (STZ +DSMJ): Diabetic animals fed a standard diet containing 10% dates soya bean monkey jam(STZ +SSPJ): Diabetic animals fed astandard diet containing 10% sucrose soya bean plum jam (STZ +FSPJ): Diabetic animals fed a standard diet containing 10% fructose soya bean plum jam (STZ +DSPJ): Diabetic animals fed a standard diet containing 10% dates soya bean plum jam. GSH: Reduced glutathione GPx: Glutathione peroxidase, CAT: Catalase, SOD: Superoxide dismutase.

IV. Discussion

Streptozotocin, a well-known diabetogenic agent, prevents Deoxyribonucleic acid (DNA) synthesis in mammalian and bacterial cells by entering the pancreatic cell through the glucose transporter GLUT2 (Glucose transporter 2) and causing DNA alkylation. As a result, free radicals are produced, which cause necrosis in the pancreatic β-cells, causing the inability of the pancreas to secrete insulin. Insulin-dependent diabetes is the overall effect, which causes a variety of metabolic modifications in the animals, including an increase in blood glucose, total cholesterol, and triacylglycerol levels [22].

The result of the present study showed that all the formulated fruit jams significantly reduced the serum blood sugar elicited by STZ and significantly increased the weight of diabetic animals.This observation agrees with the report of El-Fouhil*et al* [23] who reported the hypoglycaemic effect of extract from date seed on diabetic rats. The hypoglycaemic effect observed in the present study is a result of the combined effect of various components of the ingredients used in the formulation of the fruit jams. The nutraceutical potentials of these fruits and the high viscosity nature of the soluble fibres in soybeans slow down gastric movement of food, thereby limiting the rate of intraluminal diffusion of glucose to the absorption surface [24].

Diabetes mellitus leads to fatty liver, hypercholesterolemia, and hypertriglyceridemia [25]. The marked hyperlipidemia that characterizes diabetes may be regarded as a consequence of unlimited actions of lipolytic hormones on the fat depots, for energy purposes due to underutilization of glucose, which in the process releases fatty acids that are converted to triglycerides [26]. A rise in serum total cholesterol, triglycerides, low density lipoproteins, and low high density lipoprotein observed in this study indicates derangement of lipid metabolism and amplified incidence of cardiac dysfunction in diabetic rats. This result is in agreement with most other researchers [27, 28]. The dietary fibre and phenolic compounds present in Malay rose apple, yellow monkey kola and hog plum fruits [29,30,31], the antihyperlipidemic effect of dates [32,33] together with the additional components of soybeans such as isoflavones, lecithins, saponins and fibrewhich could improve cardiovascular health through independent mechanisms may explain the antilipidemic effect of the formulated fruit jams in diabetic animals observed in this study. These mechanisms may include an interruption of the intestinal absorption of bile acids and dietary cholesterol, direct effects on the hepatic metabolism of cholesterol, alteration of the hormone concentration involved in cholesterol metabolism by increasing the activity of 3-hydroxy-3-methylglutaryl coenzyme A (HMG CoA) reductase, thereby inhibiting hepatic cholesterol synthesis.

Assessment of serum activities of alanine aminotransferase ALT, aspartate aminotransferase AST, and alkaline aminotransferase ALP are known to be the most sensitive marker for the diagnosis of hepatic injury. These enzymes are located in the cytoplasm, and after hepatocellularinjury, they rapidly leak into the bloodstream in proportion to the extent of liver damage [34]. The present study showed that STZ-induced diabetes results in hepatocellular damage, which was indicated by the marked elevation of serum enzymes (AST, ALT, and ALP) activities, total bilirubin, conjugated bilirubin, and reduction in the serum total protein and albumin which are in agreement with previous studies [35,36]. According to Al-Jaghthm and Abu Zeid [35], a decreased serum total protein level in diabetic rats may be due to the elevated protein muscular breakdown, diminished amino acid uptake, increased glycogenic conversion of amino acid to carbon dioxideand water, besides reduced protein biosynthesis and protein absorption. The reduced serum albumin level of STZ-induced diabetic rats could be due to hepatic dysfunction.

The breakdown of haemoglobin to biliverdin and then bilirubin produces bilirubin in the macrophage-monocyte system. Bilirubin is transported through the bloodstream to the liver, where it is conjugated into bilirubin diglucuronide and excreted in the bile. As a result, bilirubin levels are used to properly evaluate liver and bile tract function. The conjugated and unconjugated (free) forms of bilirubin are both included in total bilirubin. It is usually indicative of liver damage or haemolysis if it is elevated. Increased total bilirubin levels (TBL) can indicate problems with liver metabolism, such as decreased hepatocyte uptake, impaired bilirubin conjugation, or decreased bilirubin secretion [37]. As a result, serum bilirubin concentration is used as a biomarker for liver function, as it evaluates the ability of the liver to eliminate bilirubin from the blood as it circulates through the liver.

The improvements in the levels of serum liver marker enzymes, total bilirubin, conjugated bilirubin, total protein and albumin in STZ-induced diabetic rats after 40 days of 10% inclusion of the formulated fruit jams to their normal chows observed in this study may be due to the prevention of the leakage of intracellular enzymes by the presence of phenolics and flavonoids components of the formulated fruit jams and their membrane stabilizing activity [38]. This is in agreement with the commonly accepted view that serum levels of transaminases return to normal with the healing of hepatic parenchyma and the regeneration of hepatocytes [39]. It is, therefore, a clear manifestation of hepatocurative effect of the formulated fruit jams.

Diabetic nephropathy is a serious complication in which the kidneys are destroyed and stop functioning. In the current study, STZ-induced diabetic rats had a significant increase in urea and creatinine levels, suggesting impaired renal function. The increased serum creatinine and urea levels observed in diabetic rats are attributable to increase proteolysis in blood and tissues caused by a negative nitrogen balance, which is linked to a decrease in protein synthesis and increased oxidative stress. In a living organism, urea is the main end product

of protein catabolism. Amino acid deamination occurs in the liver, which is also the site of the urea cycle, in which ammonia is converted to urea and excreted in the urine.It represents 90% of the total urinary nitrogen excretion. Creatinine is a waste product formed in muscles by creatine metabolism. Creatine is synthesized in the liver, passes into the circulation, and is taken up almost entirely by skeletal muscle. Creatinine retention in the blood isevidence of kidney impairment. The treatment of diabetic rats with the formulated fruit jams improved the altered levels of urea and creatinine, indicating the renocurative effect of the formulated fruit jams in diabetic nephropathy.

Haematological investigations provide information on the general pathophysiology of the blood and reticuloendothelial system [40]. It is also used to investigate the injurious effect of foreign compounds on the blood constituents of animals. Of interest is the significant reduction in white blood cells (WBC), red blood cells (RBC), platelet, packed cell volume (PCV), and haemoglobin concentration of the diabetic control group. Thisobserved reduction in WBC, RBC, platelet, and PCV of diabetic animals is in agreement with data reported by Oyedemi*et al.* [41], who reported the Antidiabetic and haematological effect of aqueous extract of stem bark of *Afzeliaafricana* (Smith) on streptozotocin-induced diabetic.

White blood cells (WBC) are a diverse group of nucleated cells found in the circulatory system. They are significantly vital in phagocytosis and immunity, and thus in infection defence. Neutrophils, eosinophils, basophils, lymphocytes, and monocytes are the different types of white blood cells. A significant decrease in neutrophiland nonsignificant change in the levels of lymphocytes, monocytes, eosinophils of diabetic animals wasobserved in this study as compared to a decrease in neutrophils counts and increase in lymphocytes count reported byOgunmefun*et al.*,[42] in haematology and serum biochemistry of alloxan-induced diabetic rats administered with extracts of *Phragmantheraincana* (Schum.) Balle. Oyedemi*et al.* [41], on the other hand, reported a significant decrease in neutrophils, eosinophils, basophils, lymphocytes, and monocytesof diabetic animals in streptozotocin-induced diabetic Wistar rats.

Free radicals-induced lipid peroxidation associated with diabetes caused protein glycation of erythrocytes membrane protein which brings about a biochemical modification effect [43]. The modification may involve haemolysis of red blood cell membrane which results in anaemia. The formulated fruit jams appeared to cure the haemolyticanaemia associated with diabetes and thereby improving the haematological parameters of the diabetic animals. It could be concluded that the formulated fruit jams may have a free radical scavenging system that prevents haemolysis and an erythropoietic system that improves the production of red blood cells.A significant increase in radical generation, or a decrease in radical elimination from the cell, results in oxidative cellular stress. There is convincing experimental and clinical evidence that the generation of reactive oxygen species (ROS) increases in both types of diabetes and that the onset of diabetes is closely associated with oxidative stress [44]. STZ-induced diabetes is also associated with cytotoxicity and the generation of ROS that cause oxidative damage [45]. A decrease in antioxidant enzymes with an elevation of lipid peroxidation markers in the pancreas homogenate of diabetic animals observed in this study was ameliorated after treatment with the formulated fruit jams and the best ameliorative effect was observed in groups treated with date based jams.A decrease in antioxidant enzymes with an elevation of lipid peroxidation markers in the pancreas homogenate of STZ-induced diabetic rats was also reported by Al-Salmi*et al.*, [46].This result is an indication that the formulated fruit jams contain free radical scavenging activity, which could exert a beneficial action against pathophysiological alterations caused by STZ-induced radicals in the pancreas indicating the regeneration of the damaged pancreatic cells.

V. Conclusion

Thedate based jams, followed by fructose based jams and sucrose based jams possessed anti-diabetic effects through the ability to scavenge free radicals elicited by STZ thereby improving lipid profile, liver, and kidney function parameters. The study, suggests that the nutritional management of the quality of life of diabetic patients could be better managed using the date-based formulated jams.

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