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Subacute oral toxicity of ayurvedic anti-diabetic preparation *Jambadyarista* in Sprague-Dawley rats

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ABSTRACT

Background: Jambadyarista is an Ayurvedic polyherbal formulation widely prescribed by Ayurvedic practitioners for the management of diabetes and its associated complications. About 39 companies have marketed this formulation in Bangladesh with consent from the Directorate General of Drug Administration (DGDA).
Aim: This study investigated the sub-acute oral toxicity of Jambadyarista in the Sprague-Dawley rat model.
Methods: The sub-acute toxicity studies were executed in Sprague-Dawley rats. Jambadyarista formulation was given for 28-days through oral gavage at 10 mL/kg and 20 mL/kg dose to two different groups comprising 6 rats of both sex/groups. Across the experimental period mortality, adverse reactions were closely monitored. After 28-day feeding hematological, biochemical, and relative organ weights were quantified.
Results: No mortality and/or signs of morbidity were observed for 28-day of repeated-dose sub-acute toxicity. Any pernicious change in body weight, biochemical, and hematological parameters along with relative organ weight were not observed for Jambadyarista. Correlation study among parameters of the renal profile, liver profile, lipid profile also metabolic hormones (T_3 and TSH), and enzymes showed the non-toxic rather beneficial role (hypolipidemic) of Jambadyarista in Sprague-Dawley rats.
Conclusion: Jambadyarista preparation did not cause any potential toxic effect in repeated dose subacute toxicity study over Sprague-Dawley rats orally. Therefore, low dose administration of Jambadyarista could have a beneficial effect on diabetes and can be considered safe before the chronic study.

1. Introduction

From the very dawn of civilization plants and humans are closely related to each other as plants provide both essential commodities like shelter, food medicine, and life surviving oxygen gas. The practice of natural medicine has been increased in developed and developing countries due to their affordability, availability, and safety [1–3]. Often plants and plants derived products have been a therapeutic tool for treating disease and health hazards [4]. Nowadays the number of people affected with complex chronic diseases is increasing and drugs derived from medicinal plants are being proved to be an effective treatment for such complex disease and many plant biochemicals proved to be very effective in treating many diseases [5–7]. The use of plant extract in the treatment of diseases and disorders is popular in Europe and Asia [8]. For instance, *Galega officinalis* has been traditionally used to treat diabetes mellitus type-2 due to its less toxic effect though metformin belongs to the biguanide class is considered one of the first-line treatments [9]. In India, over 80 % of the people get used to taking Ayurveda as a traditional medicine [10,11]. The world health organization (WHO) did fix a strategy for traditional medicine or alternative medicine based on

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the 2008 Beijing declaration and World Health Assembly [12]. The first evidence sourcing of Ayurveda was found in Vedas and then in Atharvaveda [13,14]. Herbal and Ayurvedic medicine concern with any plant parts including seeds, roots, bark, flower for the medicinal purpose [15]. As for better cultural and ethnic acceptability and compatibility with the body with minimal side effects Ayurvedic medicine is still used by a large number of population in the world mainly in the Indian sub-continent and also in Europe and South America reportedly 64 % of the world population still employ traditional medicine and Ayurvedic preparations in versatile diseases [16,17]. In Bangladesh 449 medicinal plants with their effective chemical constituents and their uses are listed for beneficial effect [18].

Jambadyarista (JDR) is one of the prominent Ayurvedic preparation used all over Bangladesh because of its indication to treat diabetes and obesity [19]. The toxicological profile of the most Ayurvedic drugs used in Bangladesh has not yet been well established. JDR was embraced in BDNF (Bangladesh National Formulary) in 1992 [20,21]. The composition of JDR is 4.79 mL fruit extract and 0.19 mL seed extract of *Syzygium cumini*, 0.19 mL leaves extract of *Coccinea indica*, 0.19 mL *Centella asiatica* leaves extract and 0.19 mL leaves extract of *Mesua ferrea,* and this composition has been used in the treatment of non-insulin-dependent diabetes mellitus (NIDDM) and obesity. The mentioned plants have ethnopharmacological relevance for treating such conditions [22]. Mycaminose extracted from *Syzygium cumini* seeds has reported anti-diabetic action [23] also anti-hyperglycemic and hypoglycemic action of *Syzygium cumini* fruits was described [24]. According to Pari et al. (2003) [25] leaves of *Coccinea indica* has potential hypoglycemic and hypolipidaemic property besides asiaticoside and saponin-rich fraction from *Centella asiatica* leaves enhance secretion of insulin form β-cell of the pancreas [26]. Even more, inhibiting α-amylase enzyme *Mesua ferrea* show anti-diabetic along with anti-oxidant action [27] which further assures all the plant extracts used in JDR has established anti-diabetic action. The quality and safety parameter of Ayurvedic formulation still is of questionable authenticity and some empirical data provide only information about pH, density, and viscosity which are physical parameters. The manufacturing process and toxicological profiling of JDR preparation and/or medicine are enigmatic and need to be investigated as it is widely used by many people. In this study, we devised our work to determine the toxicological profiles of JDR in vivo.

2. Materials and methods

2.1. Collection of samples

The sample of JDR was collected from Sree Kundeshwary Aushadhalaya Ltd., Chittagong, Bangladesh with brand name *Jambadyarista* to perform the toxicological study. It was preserved at room temperature during the whole experimental period. For the toxicological experiments, the drug was administered per oral (p.o.) route at 10 mL/kg and 20 mL/kg dose.

2.2. Selection of experimental animals

A total of 36 adult Sprague-Dawley rats collected also husbanded in the animal house at the Department of Pharmacy, Jahangirnagar University. Selected animals were healthy and weighed 120 ± 10 g. The experiments were placed in a properly ventilated designed animal house where throughout the experimental period good hygiene and regular food and water were supplied to the animals. Cages with dimensions of 30 × 20 × 13 cm^3 with shavings of softwood as bedding was used to confirm the comfortable condition of the animals, where the cage body is fully made of plastic. Animal feeding is followed by *ad libitum* with a perfect supply of drinking water along maintaining the usual day-night cycle. Rats were nourished with 'mouse chow' which preparation recipe was devised by BCSIR, Dhaka. 'Principles of laboratory animal care' (National Institute of Health, publication no. 85-23, 1985) abided completely while handing animals for study.

2.3. Experimental design

Animal studies were executed at the Laboratory of Pharmacology, Pharmacy Department, Jahangirnagar University, Dhaka with subsequent ethical approval. Adult Sprague-Dawley rats were picked up from animal house utilized for the present experimentation. The rats were contained at room temperature (27 ± 2 °C) in polypropylene cages. All the animals under study were randomized and classified into the normal group and experimental groups of rats body weight ranging in between 110 g–130 g. The animals received a diet of standard 'rat pellet'. Rats were provided access to freshwater *ad libitum* and food throughout the timeframe of acclimatization to the surrounding environment for a minimum two weeks period prior beginning of the research experiment. All animal experiments were carried out by following Bangladesh Medical Research Council guidelines and Helsinki declarations.

Group- I (Control): Normal rats, received water (10 ml/kg p.o.) and standard rat pellet for 28 days, and served as normal control.

Group- II (JDR1X- 10 mL/kg): Normal rats, received JDR (10 mL/kg p.o.) for 28 days.

Group- III (JDR2X- 20 mL/kg): Normal rats, received JDR (20 mL/kg p.o.) for 28 days.

2.4. Repeated oral dose 28-days (sub-acute) toxicity of JDR in Sprague-Dawley rats

The study was conveyed by following the OECD guideline number 407 [28] entitled "Repeated Dose 28-day Oral Toxicity Study in Rodents" where all rats from both study groups were given JDR orally. There were 6 rats in every 3 groups of both genders, by placing all animal conditions the study was conducted. By considering Group- I as control the other two groups were regarded as study groups both the study groups were treated with JDR 10 mL/kg and 20 mL/kg dose for successive 28 days [29].

2.5. Blood collection and estimation of biochemical parameters

After repetitive oral dosing of JDR for 28 days, on the 29th-day rats were desensitized using anesthesia using ketamine (500 mg/kg, i.p.) before sacrifice, then blood sample from each rat of each group collected in test tubes with and without EDTA containing blood collecting tubes. Blood collected without EDTA permit to clot then the serum was distinguished by centrifuging the blood (3000 rpm, 10 min). Serum samples were subjected to determine biochemical parameters and serum samples were stored at −25 °C before biochemical testing. These biochemical parameters were tested: serum urea, serum uric acid, bilirubin, creatinine, serum glutamic-oxaloacetic-transaminase (SGOT), serum glutamic-pyruvic-transaminase (SGPT), serum albumin, serum protein, triglyceride (TG), cholesterol, LDL cholesterol, and HDL cholesterol. Some metabolic enzymes such as T_3, TSH, and alkaline phosphatase (ALP).

2.6. Measurement of hematological parameters in rats

The blood collected and stored with EDTA to avoid clotting was used for hematological determination. Hematology analyses were performed on whole blood, using the automatic hematology system, (Abbott Cell-Dyn 3200 SI-21, Abbott Laboratories, IL, USA) to evaluate these parameters: red blood cell, white blood cell, Neutrophils, Lymphocyte, Monocyte, Eosinophils, platelet, packed cell volume, mean-corpuscular-volume (MCV), mean-corpuscular-hemoglobin (MCH), mean-corpuscular-hemoglobin concentration (MCHC).

Table 1
Body Weight of rats treated with JDR and observed for 28 days.

Days	Control	JDR1X (10 mL/kg)	JDR2X (20 mL/kg)
Day 0	124 ± 4.41	122.82 ± 2.76	119.62 ± 3.06
Day 1	124.5 ± 3.94	122.88 ± 2.72	119.69 ± 3.07
Day 4	125.5 ± 2.58	123.58 ± 2.58	120 ± 3.005
Day 8	128.33 ± 2.95	124.17 ± 2.55	120.23 ± 2.90
Day 12	129.22 ± 3.36	124.5 ± 2.56	120.8 ± 2.90
Day 16	129.93 ± 3.55	125.10 ± 2.57	121.70 ± 3.19
Day 20	132.33 ± 2.39	126.21 ± 2.38	122.87 ± 3.37
Day 24	134.4 ± 3.10	127.23 ± 2.30	123.73 ± 3.55
Day 28	135.85 ± 2.09	128.10 ± 2.62	123.70 ± 4.59

Values are expressed as Mean ± SEM, n = 6, *$p < 0.05$ (Significant difference between the control group and study groups at 95 % confidence interval).

Table 2
Biochemical parameters of rats treated with JDR.

Parameters	Control	JDR1X	JDR2X
Serum urea (mg/dl)	25.5 ± 0.921	21.666 ± 1.308	22.166 ± 1.470
Serum creatinine (mg/dl)	0.755 ± 0.027	0.755 ± 0.033	0.738 ± 0.033
Serum uric acid (mg/dl)	2.316 ± 0.130	1.9 ± 0.073	1.8 ± 0.081*
Liver Profile			
Serum bilirubin (IU/L)	0.193 ± 0.011	0.166 ± 0.005	0.171 ± 0.007
SGPT (IU/L)	76.666 ± 11.271	58.333 ± 2.776	40.333 ± 2.170*
SGOT (IU/L)	123 ± 12.055	112.333 ± 2.894	91.166 ± 3.280
Serum protein (g/L)	6.983 ± 0.192	7.05 ± 0.150	6.983 ± 0.079
Serum albumin (g/L)	3.150 ± 0.111	3.0 ± 0.089	2.9 ± 0.051
Lipid Profile			
Serum cholesterol (mg/dl)	74.833 ± 1.400	61.833 ± 1.851*	60.333 ± 1.054*
Serum Triglyceride (mg/dl)	48.333 ± 1.584	39.666 ± 1.706*	36.333 ± 1.145*
HDL (mg/dl)	43.666 ± 1.358	45.166 ± 1.249	48.500 ± 1.477
LDL (mg/dl)	16.333 ± 1.520	9.0 ± 1.064*	9.333 ± 1.054*
Metabolic Hormones and Enzymes			
Serum T_3 (μIU/mL)	0.535 ± 0.021	0.574 ± 0.034	0.578 ± 0.037
Serum TSH (ng/mL)	0.001 ± 0.001	0.0013 ± 0.001	0.001 ± 0.001
Alkaline Phosphatase (IU/L)	293.666 ± 7.897	218.166 ± 8.897*	203 ± 4.753*

Values are expressed as Mean ± SEM, n = 6, *$p < 0.05$ (Significant difference between the control group and study groups at 95 %confidence intervals).

2.7. Bodyweight to organ weight ratio analysis

After blood collection, the rats of both JDR and control groups were sacrificed by cervical dislocation. The liver, kidneys, spleen, lungs, and heart were excised, rapidly took out then each organ individually measured. Each organ to body weight ratio (relative organ weight) was enumerated as described by Abdullah et al. [30].

$$\text{Relative organ weight} = \frac{\text{Weight of organ (g)}}{\text{Bodyweight of the rat on the day of sacrifice (g)}} \times 100\%$$

2.8. Statistical analysis

Statistical calculations of animal experimentations were executed through one-way ANOVA using SPSS, version-20.0 for windows following Dunnet's post hoc t-test, and Pearson correlation (r = correlation coefficient, p = significance value). Data were presented as the average value ± standard error of the mean (Mean ± SEM). The results incurred from study groups then compared with the control group and $p < 0.05$, $p < 0.01$, and $p < 0.001$ were statistically significant, highly significance plus very majorly significant individually.

Table 3
Represents correlation among the renal profile.

Parameters	Control groups		Study groups	
	r	p	r	p
Serum urea and serum creatinine	0.149	0.778	0.298	0.346
Serum urea and serum uric acid	−0.718	0.108	−0.67	0.837
Serum creatinine and serum uric acid	−0.718	0.108	−0.167	0.605

r = Correlation co-efficient; p = Significance value; Negative values specify opposite correlation. *Correlation is significant at 0.05 levels (two-tailed).

Table 4
Shows correlation among the liver profile.

Parameters	Control group		Study groups	
	r	p	r	p
Bilirubin and SGPT	0.806	0.053	0.046	0.88
Bilirubin and SGOT	−0.859	0.028*	−0.184	0.567
Bilirubin and serum protein	0.725	0.103	0.288	0.364
Bilirubin and serum albumin	−0.317	0.540	0.080	0.806
SGPT and SGOT	−0.918	0.010	0.860	0.05*
SGPT and serum protein	0.315	0.543	0.601	0.039*
SGPT and serum albumin	−0.398	0.435	0.271	0.395
SGOT and serum protein	−0.344	0.504	0.331	0.293
SGOT and serum albumin	0.442	0.380	0.208	0.517
Serum protein and serum albumin	0.318	0.539	0.495	0.102

r = Correlation co-efficient; p = Significance value; Negative values specify opposite correlation. *Correlation is significant at 0.05 levels (two-tailed).

3. Results

3.1. Bodyweight of control and JDR treated rat from day 0–28

In our recent study, we have observed that the bodyweight of Sprague- Dawley rats does not increase in a dose-dependent manner. Among three doses, the dose 10 mL/kg (JDR1X) showed statistically substantial ($p < 0.05$) increment of body weight on day 4, 8, 12, 16 respectively compared to control and for 20 mL/kg (JDR2X) rats body weight increased on day 4, 8 and 12 with statistical validity but the trend of the overall increase in body weight remained constant. As the long-term impact in body weight on JDR1X and JDR2X groups represented in Table 1 confirming JDR does not affect body weight and a common trend in increasing body weight observed in a dose-independent manner.

3.2. Biochemical parameters of control and treated rats

Various biochemical parameters such as renal, liver, lipid, hormones, and enzymes are represented in Table 2. Only serum uric acid levels in the renal profile are significantly ($p < 0.05$) decreased in contrast to control. In the liver profile study, significant ($p < 0.05$) mean differences observed in SGPT levels although the values of serum bilirubin, SGOT, serum protein, serum albumin are lowering than their control individuals. The most promising mean differences have been seen in the lipid profile where serum cholesterol, serum triglyceride, and LDL levels are decreased significantly ($p < 0.05$) when compared with control. Values of hormones and enzymes level have shown no significant changes except alkaline phosphatase enzyme.

3.3. Correlation among observed study parameters

The correlation between control and study groups was done by Pearson correlation was done to investigate the inter-biochemical relationship among the reported parameters. The correlation coefficient and p-value for each correlation are shown in Tables 3–5. Amongst renal profile correlation studies, there has no statistically significant correlation among serum urea, serum creatinine, and serum uric acid either it is positive or negative (Table 3). There have been negative and statistically

Table 5
Shows correlation among lipid profile.

Parameter	Control		Study groups	
	r	p	r	p
Serum cholesterol and serum triglyceride	0.330	0.523	0.238	0.456
Serum cholesterol and HDL	0.527	0.283	0.734	0.007**
Serum cholesterol and LDL	0.205	0.689	0.436	0.157
Serum triglyceride and HDL	0.028	0.957	0.242	0.488
Serum triglyceride and LDL	0.000	1.000	−0.211	0.509
HDL and LDL	−0.695	0.125	−0.266	0.403

r = Correlation co-efficient; p = Significance value; negative values specify opposite correlation. *Correlation is significant at 0.05 levels (two-tailed).

substantial correlation for lipid profiles (Table 4) found on serum bilirubin and SGOT (r = -0.859, $p = 0.028$) compared to control group, a positive correlation for serum SGPT and serum SGOT (r = 0.860, $p = 0.05$) study group also a positive correlation between SGPT and serum protein (r = 0.601, $p = 0.039$). Correlation between lipid profiles is depicted in Table 4, where all positive and negative correlations among bilirubin, SGPT, SGOT, serum protein, and serum albumin are not found significant statistically in both control and study groups. A notable significant and positive correlation has been found between serum cholesterol and HDL (r = 0.734, $p = 0.007$) of study groups in Table 5 but correlation among other parameters in lipid profile is not statistically significant.

3.4. Hematological parameters of rats

Hematological values found in this study are in the normal range as compared to control, where the doses of JDR do not affect the regular hematological parameters of rats shown in Table 3. There is a significant ($p < 0.05$) weight variation in lung and liver at different doses but other organ weights remain close to the control value.

3.5. Relative organ weight of rats

Again the values of relative organ weight of rats show no significant changes other than the weight of lung and liver which varies significantly comparing to control.

4. Discussion

According to Laksmi et al. (2011) [31], the term "Ayurveda" may be coined as the 'science of life' or 'knowledge of life'. The word is derived from Sanskrit "*ayus*" and "*veda*" where *ayus* suggest life and "*veda*" implies science or knowledge. As it is a traditional system of medicine [32], it is being used to restore physical, mental, and emotional balance and helps to ameliorate disease conditions [33]. The World Health Organization (WHO) and the National Institute of Health, USA have been suggested ayurvedic drugs are safe and can be employed as complementary/alternative medicine [34–36].

In this study, JDR is non-toxic and shown to increase body weight after consequent dosing (Table 1). However, the increase in and the increase in body weight was observed with no statistical significance, indicating regular weight gain in rats. In chronic disorders such as diabetes if JDR is safe and with no effect on vital organs, then biochemical parameters, hematological parameters, relative organ weight data should be involved for confirming safety against sub-acute toxicity study [37]. Decrease and heighten in body weight are linked to chemicals and drugs for their toxic effect. Arsad et al. (2013), [38] demonstrated that fat aggregation is related to body weight gain or loss and a physiological adaption reaction might occur for plant extracts other than a toxic impression of drug or chemicals present in extract leading to low-calorie intake in animals. Relative organ weight in animals has been observed in toxicity studies which is a highly sensitive indicator of the specific organ so, toxicity can be represented in those specific organs as a significant change in particular body organs [39]. At sub-acute oral dosing with JDR vital body organs for instance- heart, kidney, liver, and spleen showed no significant variation in organ weight but for lung, a slight decline in weight observed (Table 7). We used weighing organs for toxicity study to predict the sensitivity of specific organs in acute injury, physiologic perturbation, and enzyme induction causing histopathological changes [40]. As the decline in the lung weight might be due to hypoxia [41] which causes diminished pulmonary vascularization and both up and downregulation of genes responsible for vascular development [41]. There might be respiratory hypoxia or downfall of vascularization in rats responsible for the lung-weight reduction but the lung weight for the JDR2X group is higher than the JDR1X group which might ignore our speculation on respiratory toxicity with JDR intake. Furthermore, lung weight analysis in oral dosing adds little scope to microscopic evaluation [42].

Biochemical parameters have a critical role in determining the sub-acute toxicity of plant extracts because these parameters are represented by disease signs and/or symptoms [43]. Serum uric acid levels, SGPT levels, and serum cholesterol, triglyceride, and LDL of levels were decreased according to the dose although these values were close to the reference value of Witthawaskul et al. (2003) and Abdullah et al. (2009) [30,44]. As most proteins are synthesized in the liver so plasma protein albumin concentration can reflect the synthetic capacity of the liver. A prevalent scenario after hepatocellular damage is a decline in albumin levels and almost no change in total protein concentration [45] but in our observation no significant change in serum albumin and total protein levels. A significant diminution of SGPT and serum uric acid for JDR2X comparing to control supporting that JDR has a beneficial effect on liver and kidney function. Hypercholesterolemia and alkaline phosphatase increment is an important indicator of failure liver function [46]. There was a significant reduction in serum cholesterol and alkaline phosphatase for both study groups confirming the hepatoprotective action of JDR. Similarly, after the sub-chronic administration of JDR in *Sprague-Dawley* rats no substantial increase but the decrease in serum uric acid, urea and creatinine were observed because of increment in uric acid, urea, and creatinine levels represent marked impairment in functional nephrons [47]. Correlation study among renal profile (Table 3), liver profile (Table 4), and lipid profile (Table 5) show there are associations among several biochemical parameters. A positive association between SGPT and SGOT, between SGPT and serum protein, was observed for study groups compared to healthy controls and the association was statistically substantial. A collaborative Asian Pacific Cohort Study demonstrated that [48], low HDL and a rise in LDL and total cholesterol levels were observed for Asian peoples with type-II diabetes. Where, increased LDL levels are positively associated with atherosclerosis [49], also Yang et al. (2012) [50] in their Diabetes and Metabolic Syndrome Study demonstrated that LDL-levels in serum is also increased for both increased BMI and waist circumference. Also, triglyceride levels are highly associated with blood pressure because an increment in triglyceride levels by itself causes arterial stiffness [51], reactivity loss of vasomotor [52], and vascular endothelium dysfunction [53]. Hypercholesterolemia is positively associated with obesity or increased BMI, as represented by Gostynski et al. (2004) [54]. Serum reduction of triglyceride, LDL, and cholesterol levels with statistical significance (Table 2) reflected a lipid-lowering, anti-obese, and anti-atherosclerotic action of JDR used by diabetic individuals as a traditional anti-diabetic preparation.

Hematological parameters were used to assess the injurious consequences of JDR in the blood of the tested animals. Hematological parameters could be investigated for expressing blood-related functions after the ingestion of plant products [55]. Such hematological analysis has high relevance for risk-evaluation and high predictive value toward toxicity on humans when data from the animal are translated into human subjects [56]. There was a non-significant and nearly no change in hemoglobin, platelets, MCV, MCH, MCHC values compared to

Table 6
Hematological parameters of rats treated with JDR.

Parameters	Control	JDR1X	JDR2X
Hemoglobin	13.13 ± 0.43	13.51 ± 0.27	13.70 ± 0.38
ESR	2.33 ± 0.42	3 ± 0.44	2.83 ± 0.40
WBC	7466.67 ± 244.49	8650 ± 574.31	8133.33 ± 330.32
RBC	7.8850 ± 0.27	7.98 ± 0.251	8.0967 ± 0.21
Platelet	734166.66 ± 16835.31	672833.33 ± 32226.71	708333.33 ± 33315.32
Neutrophils (%)	29.67 ± 2.01	32.6667 ± 1.54	28.17 ± 1.68
Lymphocytes (%)	66.17 ± 1.95	62.5000 ± 1.76	68.17 ± 1.79
Monocytes (%)	2.50 ± 0.22	3.5000 ± 0.428	3.00 ± 0.51
Eosinophils (%)	1.33 ± 0.21	1.33 ± 0.21	1.50 ± 0.34
HCT (%)	49.92 ± 1.27	49.78 ± 1.02	51.23 ± 0.332
MCV	60.42 ± 4.412	59.07 ± 1.37	64.01 ± 3.93
MCH	16.78 ± 0.35	16.67 ± 0.11	17.31 ± 0.35
MCHC	27.25 ± .32	27.37 ± 0.33	26.57 ± 0.55
RDW-SD	32.33 ± 2.13	32.53 ± 0.35	38.38 ± 4.07
RDW-CV (%)	17.25 ± 0.46	18.57 ± 0.41	19.65 ± 1.09
PDW	8.58 ± 0.27	9 ± 0.12	8.77 ± 0.22
MPV	7.70 ± 0.26	8 ± 0.07	7.92 ± 0.14
PLCR (%)	10.22 ± 0.14	11.32 ± 0.34	11.28 ± 0.89
PCT (%)	0.55 ± 0.02	0.54 ± 0.02	0.55 ± 0.02

Values are expressed as Mean ± SEM, n = 6,*$p < 0.05$ (Significant difference between the control group and study groups at 95 % confidence intervals).

Table 7
The relative organ weight per 100 g body weight observed at the termination of the study.

Organ	Control	JDR1X	JDR2X
Heart	0.266 ± 0.01	0.256 ± 0.008	0.248 ± 0.004
Kidney	0.307 ± 0.004	0.273 ± 0.010	0.324 ± 0.006
Lung	0.502 ± 0.009	0.367 ± 0.006*	0.445 ± 0.007*
Liver	3.668 ± 0.017	2.843 ± 0.015*	3.683 ± 0.011
Spleen	0.242 ± 0.006	0.238 ± 0.006	0.236 ± 0.008

Values are expressed as Mean ± SEM, n = 6, **$p < 0.05$ (Significant difference between the control group and study groups at 95 % confidence interval).

control, indicating JDR preparation did not affect erythropoiesis, osmotic fragility property of RBC [57]. Leukocytes provide cellular defense response against tissue injury and infectious agents and no change was observed for lymphocytes, WBC, monocytes, and neutrophils also for the hematological parameters, which found congruent with Ping et al. [58]. The non-toxic nature of JDR is further justified by the regular observation of hematological profiles (Table 6).

Investigating JDR to protect blood and liver functions were not investigated in the study, so metabolic enzymes and/or electron micrograph imaging of organs are required to be investigated. Chronic toxicity, genotoxicity, target organ toxicity, and mutagenicity study could be performed to support the safety profile of JDR further. There is a possibility of drug-drug interaction of JDR with some other anti-diabetic and anti-obesity drugs, needed to be investigated in future studies.

5. Conclusion

All the scientific pieces of evidence presented above for sub-acute oral toxicity of JDR in Sprague-Dawley rats should be safe in the doses mentioned above and showed no evident toxic signs in the subacute oral toxicity study. JDR preparation produces no lethality any in rats or any toxic change in serum chemicals. These preliminary data suggest that JDR could be a promising pharmaceutical interest having little untoward effects.

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Ethical statements

The study was approved by the Institution Review Board of Pharmacy Department, Jahangirnagar University.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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