Assessment of nutritional value, chemical composition and anti-obesity effect of dried Jojoba leaves in North Sinai.

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Abstract

This study aimed to determine the nutritional value, chemical composition and anti-obesity effect of dried Jojoba leaves, and to evaluate its histopathology and hematology parameters effects in rats fed diet provided the aqueous extract of Jojoba leaves. Jojoba leaves were dried by shadow, sun, and oven at 100°C for 30, 60 and 90 min and the chemical composition was determined. The oven dried at 100°C for 30 min (OD1 treatments) have been chosen to evaluate its effect on rat's body as the balanced drying treatments. 1%, 2% and 3% concentrates of OD1 Jojoba leave aqueous extract evaluate its effect on fat, protein and water content of rats feed on them for 12 weeks. Body weight, histopathology and hematology parameters were analyzed. The results indicated that the aqueous extract of OD1 Jojoba is rich in protein, phenolic, tannins compounds, and low percent of simmondsin. Animals fed diet with 3% (AEJL) showed decreased 24% of body weight. Non-significant effects on hematology parameters and no remarkable histopathologic changes were noted in the liver and kidney weights. in our study, aqueous Jojoba leaves extract with low percent amount of simmondsin, at both the 1%, 2% and 3% concentrations were significantly reduced body weight without significant negative effects.

Keywords: Jojoba leaves, Anti-obesity, *Simmondsia chinensis, Simmondsin ferulates*, Drying process.

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Introduction

Obesity is a worldwide medical concern, it considered to be a serious health problem, medically it is a complex disease caused by the interaction of a myriad of genetic, dietary, lifestyle, and environmental factors, in which excess body fat has accumulated to the extent that it may have an adverse effect on health and leads to increased body fat mass. Obesity facilitates the development of metabolic disorders such as diabetes, hypertension, and cardiovascular diseases in addition to chronic diseases and so reduced life expectancy and/or increased health problems. Recently there is a huge concern for the usage of natural plant in remedy obesity due to the several phytochemical that contain which may result in exhibit advantages over chemical medication [1].

Jojoba (*Simmondsia chinensis*), family Simmondsiaceae, it is a woody, evergreen perennial shrub, reaching about 3 m in height. It is known as coffee berry, wild hazel and goat nut [2]. It is growing in desert and semi-desert areas and have been invasive in several countries predominantly in Argentina, Peru, Australia, Israel, Palestinian Authority and Egypt due to its high economic value. It has been introduced to Egypt in 1991 and cultivated by seeds from USA [3]. Jojoba Leaves are small, ovate with 1-2 inches long and shiny bright green color. They are used for the medicinal purposes as a folk remedy for cancer, cold, dysuria, obesity, parturition, sore throat warts and treatment of various skin diseases [4,5] highlights deeply on the phenolic content of Jojoba leaves and their potential biological activities and shows the importance of this plant as a good source of phenolic compounds in particular the flavonoid content which showed a strong antioxidant and lipoxygenase-inhibiting activities.

Drying process is one of the oldest known herbs preservation techniques. The primary objective of drying is to extend the shelf-life of leaves by reducing their water content and so prevents leaves from spoilage. In addition to preservation, drying is also used to reduce the cost or difficulty of packaging, handling, storage and transportation. The nutritional value and chemical composition of *S. chinensis* leaves is not well known because most of the studies was focusing on its seed oil and neglecting other constituents [6].

Justification of the study

Therefore, the aim of this study is to determine the nutritional value and chemical composition of dried Jojoba leaves planted in Middle Sinai, Egypt. Also, assessment the effects of various drying methods on quality parameters of Jojoba leaves especially simmondisine concentration and anti-obesity effect of dried Jojoba leaves, and to evaluate its histopathology and hematology parameters effects in rats fed diet provided the aqueous extract of Jojoba leaves. As well as study the anti-obesity potential effect of Jojoba leaves which have not been previously reported yet.

Material and Methods

The following procedure were adopted by the researcher for the purpose to reach at certain findings and conclusion.

Plant material

The fresh green Jojoba leaves (*Simmondsia chinensis*) cultivated in Middle Sinai Research Station (El Maghara in Sinai)-desert research center-Egypt, were collected in August 2015. The

green fresh leaves were dried using three different drying methods Shadow drying, Sun drying, Oven drying (Oven DGG-9070A: China) at 100°C for 30, 60 and 90 min, respectively.

The dried Jojoba leaves were then grinded into powder using a high-speed blender mill (25000/min), WK-1000A; Qing Zhou Machinery Co., Ltd. The dried Jojoba leaves powder (DJLP) samples were then stored in polyethylene bags at 4°C until analyzed.

Proximate analysis

The DJLP samples were analyzed for moisture, protein, fat, crude fiber and ash according to the methods described in the A.O.A.C. (2000). The carbohydrate content was determined by subtracting the total crude protein, crude fiber, ash and fat from the total dry weight (100 g) of the food sample differences (calculated by difference).

Determination of total phenols and total tannins in DJLP samples

Total phenols were determined with the Folin-Ciocalteau reagent according to [7]. Extractable tannins were determined as the differences in total phenols (measured by Folin-Ciocalteau reagent) before and after treatment with insoluble polyvinyl polypyrrolidone (PVPP), as this polymer binds strongly to tannins [8]. Total phenols (TP) and total tannins (TT) were expressed as tannic acid equivalents. Condensed tannins were measured by the HCl-butanol method and results were expressed as leucocyanidin equivalent [7].

Determination of total simmondsins

Simmondsins were determined in the Jojoba leaves extracts according to [8] by using HPLC apparatus with a L-6200 pump (Merck-Hitachi, Germany) equipped with a L-3000 photo diode array detector (Merck-Hitachi, Germany). Total simmondsins (TS) determined as summation of (Simmondsin, *Simmondsin ferulate*, demethylsimmondsin (DMS), and didemethylsimmondsin (DDMS).

Hemolysis assay

The hemolytic activity of aqueous Jojoba leaves extract was evaluated using human erythrocytes. Different extracts at the concentrations ranging from 0.05 $mg.ml^{-1}$ to 10 $mg.ml^{-1}$, were incubated with washed erythrocytes (10^8 cells) in PBS (Dulbecco's phosphate-buffered saline) pH 7.4 (100 µl) for 1 h at 37°C. After centrifugation (1000 g for 5 min), the absorbance at 450 nm of the supernatant was measured. A parallel erythrocytes incubation in the presence of Triton × 0.1% and PBS served as controls inducing 100% and 0% hemolysis, respectively. Extracts hemolytic activities were expressed as LC50 corresponding to the concentration inducing 50% hemolysis (Feten et al. 2014).

Preparation of Jojoba leaves extract

The aqueous extract of Jojoba leaves (AEJL) with simmondsi prepared from fine powdered samples (20 g) of leaves were extracted with 100 ml of boiling water at pH 3 (water with acetic acid) until cooled, then saved at room temperature for 24 h and filtered using Whatman No. 1 filter paper.

Animals and diets protocol

Hundred male, rats weighing 375 gm ± 25 gm, on arrival, were housed individually in suspended stainless steel cages. All rats were fed a high fat diet for two months to induce obesity prior to being allocated to experimental groups. Food and water were allowed to all animals throughout the study. Body weight were measured 3 times/week. This experiment was done in the Egyptian National Cancer Institute which cared for the animals in accordance with a protocol approved by the Institutional Animal Care and Use Committee.

Experimental design

After two months of feed and observation, a 100 rats in where weight-matched were divided into the following four groups (of 25 rat per group):

- Group (1): Provided with commercial ground rat chow without aqueous extract of Jojoba leaves (control sample).
- Group (2): Provided with commercial ground rat chow with 1% (AEJL).
- Group (3): Provided with commercial ground rat chow with 2% (AEJL).
- Group (4): Provided with commercial ground rat chow with 3% (AEJL).

After 4, 8 and 12 weeks, rats were sacrificed and:

- Blood collected from each group at 4, 8 and 12 weeks and analyzed (vet screen) by Egyptian National Cancer Institute.
- Liver and kidney of carcasses of each group were removed, cleaned from the fat and weighted.
- Five rats from each group were killed and blood clotting was timed and gross necropsy performed that included the examination of external surfaces of the body and all viscera.
- Tissues subjected to total chemical analysis for fat, nitrogen and water by frozen carcasses.

Determine of water content: Carcasses were autoclaved (125°C) in 500 mL distilled water for 1 hour in large beakers with covered tops, then homogenized with a large-bore Polytron (PT 6000; Brinkman Instrument, Westbury, NY). After weighing, aliquots (in duplicate) were dried to stable weight to determine water content.

***Determine of total fat and protein*:** Total carcass lipids were determined by chloroform: methanol extraction of homogenate samples according to, Nitrogen content and protein was determined according to [9,10].

Results and Discussion

Nutritional value

Results in Table 1 illustrate the effect of using shadow drying (ShD), sun drying (SD), oven drying at 100°C for 30 min. (OD1), oven drying at 100°C for 60 min. (OD2) and oven

Table 1. *Nutritional value of dried jojoba leaves (%) dry weight.*

Parameter Analysis (%)	ShD	SD	OD1	OD2	OD3
Moisture content	9.3[a]	8.6[b]	7.4[b]	5.7[c]	4.6[d]
Ash	12.2[a]	11.8[b]	11.3[b]	9.6[c]	8.8[d]
Crude fiber	39.7[c]	39.4[c]	39.7[c]	41.9[b]	42.6[a]
Crude protein	11.4[a]	11.2[b]	11.6[a]	10.3[b]	9.8[c]
Fat	5.2[b]	5.8[a]	5.8[a]	4.7[c]	4.1[d]
Carbohydrate	22.1[e]	22.6[d]	23.8[c]	27.3[b]	29.4[a]

ShD: Shadow drying, SD: sun drying, Od1: Oven drying at (100°C/30 min.), Od2: Oven drying at (100°C/60 min.), Od3: Oven drying at (100°C/90 min.). values are expressed as a mean ± SD; n=3, Means (± SD) sharing similar superscripts in a row are statistically non-significant (p<0.05)

drying 100°C for 90 min. (OD3) treatments on the nutritional value of Jojoba leaves and found that the moisture content of dried Jojoba leaves was 9.3%, 8.6%, 7.4%, 5.7% and 4.6% for ShD, SD, OD1, OD2 and OD3 treatments, respectively. There was a significant difference between the ash values where the maximum values of ash observed with the ShD treatments (12.2%) followed by SD (11.8%), OD1(11.3%), OD2 (9.6%) then OD3 (8.8%).

The crude fiber content of OD3 sample (42.6%)was significantly higher than the other four treatments, where the ShD, SD, OD1 and OD2 samples of Jojoba leaves exhibited a minor variation in the amount of crude fiber.

The crude protein content of dried Jojoba for OD3 treatment (9.8%) was significantly ($p<0.05$) lower than the other treatments. there was no significant difference in the crude protein content of SD, OD1and ShD treatments. In the same time OD2 treatment was found to be the most significantly lower value in crude protein content (10.3%).

The maximum value of fat content (5.8%) was observed for the SD and OD1 treatments which were significantly ($p<0.05$) higher than the other three treatments. On the other hand, the fat content values of OD2 and OD3 treatments (4.7% and 4.1%), respectively, was significantly lower than the ShD treatment (5.2%).

Total carbohydrate content of the OD3 treatment (29.4%) was found to be significantly ($p<0.05$) higher compared to the other four treatments which was OD2 (27.3%) followed by OD1 (23.8%) then SD (22.6%) and finally 22.1% for the ShD treatment.

However, From the data discussed above we found that the OD1 treatments contained appreciable amount of crude protein, ash, crude fiber and carbohydrate and so it could be improving protein deficiency, digestive health, be a good source of mineral element and energy making required for normal development of a body.

The chemical composition of dried Jojoba leaves (DJLP)

No previous reports on the total phenol, total tannin and total simmondisin content of Jojoba leaves are available in literature. Thus, it was important to determine these parameters in the DJLP.

Total phenols (TP) content considered to be one of the most important quality parameter due to its higher activity as antioxidant. There is a growing interest in the development and evaluation of natural antioxidants from different plant materials in the food industry. From Table 2, it could be noticed that there was a significant difference in the total phenols values of the dried Jojoba leaves treatments where the higher value obtained by the ShD treatment followed by OD1>SD>OD2>OD3 treatments.

Table 2. *Chemical composition of dried jojoba leaves (%) dry weight.*

Parameter (%)	ShD	SD	OD1	OD2	OD3
TP (mg/100 g)	36.4[a]	25.3[c]	28.7[b]	18.4[d]	13.1[e]
TT (mg/100 g)	34.8[a]	27.9[c]	30.4[b]	22.6[c]	17.6[d]
TS (mg/100 g)	13.9[a]	9.7[b]	7.3[c]	5.8[d]	3.9[e]

ShD: Shadow drying, SD: sun drying, Od1: Oven drying at (100°C/30 min.), Od2: Oven drying at (100°C/60 min.), Od3: Oven drying at (100°C/90 min.). values are expressed as a mean ± SD; n=3, Means (± SD) sharing similar superscripts in a row are statistically non-significant (p<0.05)

Total Tannins, commonly referred to as tannic acid, are a kind of polyphenols compound that are found in many plant foods. They are responsible for decreases in feed intake and decrease the serum lipid level. It also has the power to inhibitor the foodborne bacteria and off-flavor-producing microorganisms. A significant difference in the TT values was obtained all over the treatments under study. The maximum TT value observed with the ShD treatments (34.8%) followed by OD1 treatments (30.4%). Where the maximum decrease resulted with the OD3 treatment (17.6%).

Simmondsins are a group of cyanocyclohexyl glycoside compounds found in Jojoba plant, it has a very powerful advantage that it could affect the food intake and appetite [11] but in the same time, several studies mention that this compound is an anti-nutritional compound and toxic [12] because of this disadvantage, investigation focused on how to inactive or remove Simmondsin compounds were done in order to possibility utilize it in controlling appetite.

Different drying treatment under study significantly affected the TS content, it was found to be 13.9%, 9.7%, 7.3%, 5.8% and 3.9% for ShD, SD, OD1, OD2 and OD3 treatments, respectively. These TS percentage is lower than the percent obtained by *[5] who found the* simmondisin content in ethanol extract of Jojoba seeds reached to 12.43 mg/g.

The most remarkable decrement in TS appeared with the oven treatments at 100°C with varying the exposure time. This positively effect of drying treatments on TS content may be due to thermal decomposition or thermolysis caused by heat. Besides that, the 100°C found to be the decomposition temperature at which the TS chemically decomposed even at different time of exposure and explained why the oven treatment had to be the most effective treatment that eliminate the TS content in DJLP. So the oven drying treatments led to decrement the TS percent and resulted in a DJLP with appetite suppressing activity and in the same time decreasing the hazard effect of toxicity.

Reports dealing about aqueous Jojoba leaves extract toxicity, we have observed that the don't exhibited hemolytic activity against human erythrocytes at concentrations ranging from 1 ml/kg to 20 ml/kg body weight. From this report, we can concluded, that Jojoba leaves with deferent dry method were safe for edible.

From the above results, we can recommend the OD1 treatments as the balanced drying treatments to the Jojoba leaves which resulted a DJLP with a considerable crude protein, crude fiber, fat and carbohydrate with high content of TP, TT and low percent of TS contents.

Effect of DJL extract on body weight gain

From the above results, The OD1 treatments have been chosen to evaluate its effect on rats' body 1%, 2% and 3% of oven dried Jojoba leaves aqueous extract (JLE) have been prepared to evaluate its effect on fat, protein and water content of rats feed on them for 12 weeks. Results in Table 3, illustrated that there was no significant effect on the water content and protein percent observed among the experimental groups throughout the 12 weeks, where a significant decrement was reported in the fat percent with the three experimental groups in comparison with the control group. The higher decrement weight value of fat was 14 gm (4.6%) obtained by the group of rat feed on 3% JLE in comparison with the control group which was 51 gm (12.2%) after 12 weeks. Also from Figure 1, we could notice that the rate of decreasing in fat weight values inside each treatment through the 12 weeks of the experiment found with group number 4 (3% JLE) followed by group (3) and (2) then group (1) which have the most minimum rate of decreasing. From this results, we can conclude that the decreasing in carcasses body weight of group 2, 3 and 4 was due to the decreasing in rate of fat absorbed from the diets containing JLE in comparison with group (1) which feed on a diet does not contain JLE. The decreasing in body weight gain due to the presence of simmondsin residue which was reported to induce food restriction and growth retardation as reported by [12,13]. Our results not in accordance with *[5]* who treated animals with the ethanol extract of Jojoba seeds at both the low (0.5 mg/kg) and high (1.0 mg/kg) doses did not

Table 3. *Effect of dried Jojoba leaves extract on fat, protein and water contents of rats.*

Concentration	Weight of Carcass	Fat (g)	Fat (%)	Pro (g)	Pro (%)	Water (g)	Water (%)
(control)							
Initial week	397 ± 20^{b}	43 ± 6^{b}	10.8 ± 0.9^{d}	90 ± 4^{ab}	22.6 ± 0.1^{ab}	294 ± 17^{b}	74 ± 0.5^{ab}
4 Week	408 ± 18^{ab}	49 ± 9^{ab}	12 ± 1.6^{b}	87 ± 6^{b}	21.3 ± 0.5	298 ± 13^{a}	73 ± 0.1^{b}
8 Week	406 ± 21^{ab}	48 ± 11^{ab}	11.8 ± 1.1^{c}	89 ± 3^{b}	21.9 ± 0.4^{b}	289 ± 16^{c}	71.1 ± 0.3
12 Week	415 ± 16^{a}	51 ± 7^{a}	12.2 ± 1.3^{a}	91 ± 3^{ab}	21.9 ± 0.1^{b}	296 ± 18^{a}	71.3 ± 1.5
(1%)							
Initial week	402 ± 15^{ab}	45 ± 3^{b}	11.2 ± 0.3^{c}	93 ± 2^{a}	23.1 ± 0.4^{a}	295 ± 14^{a}	73.3 ± 0.7^{b}
4 Week	383 ± 12^{c}	41 ± 4^{b}	10.7 ± 0.6^{d}	87 ± 3^{b}	22.7 ± 0.1^{ab}	279 ± 16^{d}	72.8 ± 1.8^{b}
8 Week	357 ± 14^{d}	34 ± 2^{c}	9.5 ± 0.2^{e}	81 ± 3^{c}	22.6 ± 0.2^{ab}	259 ± 13^{e}	72.5 ± 0.4^{c}
12 Week	324 ± 13^{e}	26 ± 3^{d}	8 ± 0.6^{f}	74 ± 2^{e}	22.8 ± 0.3^{ab}	241 ± 12^{g}	74.3 ± 0.7^{a}
(2%)							
Initial week	406 ± 16^{ab}	42 ± 5^{b}	10.3 ± 0.8^{d}	91 ± 5^{ab}	22.4 ± 0.1^{b}	293 ± 15^{b}	72.1 ± 1.8^{c}
4 Week	371 ± 13^{cd}	37 ± 3^{c}	9.9 ± 0.5^{d}	84 ± 2^{c}	22.6 ± 0.3^{ab}	276 ± 11^{d}	74.3 ± 0.4^{a}
8 Week	339 ± 14de	30 ± 4^{d}	8.8 ± 0.8^{c}	76 ± 3^{e}	22.4 ± 0.1^{b}	248 ± 16^{f}	73.1 ± 1.6^{b}
12 Week	316 ± 11^{f}	22 ± 3^{e}	6.9 ± 0.7^{e}	69 ± 2^{f}	21.8 ± 0.1^{b}	236 ± 13^{h}	74.6 ± 1.6^{a}
(3%)							
Initial week	398 ± 17^{b}	43 ± 7^{b}	10.8 ± 1.2^{d}	93 ± 4^{a}	23.3 ± 0.1^{a}	294 ± 13^{b}	73.8 ± 0.1^{ab}
4 Week	374 ± 15^{cd}	31 ± 4^{d}	8.2 ± 0.7^{c}	81 ± 2^{c}	21.6 ± 0.3^{c}	271 ± 16de	72.4 ± 1.3^{c}
8 Week	328 ± 12^{f}	22 ± 3^{e}	6.7 ± 0.6^{e}	73 ± 4^{e}	22.2 ± 0.4^{b}	241 ± 11^{g}	73.4 ± 0.7^{b}
12 Week	304 ± 14^{g}	14 ± 4^{f}	4.6 ± 1^{f}	62 ± 3^{f}	20.3 ± 0.1^{d}	226 ± 13^{i}	74.3 ± 1.8^{a}

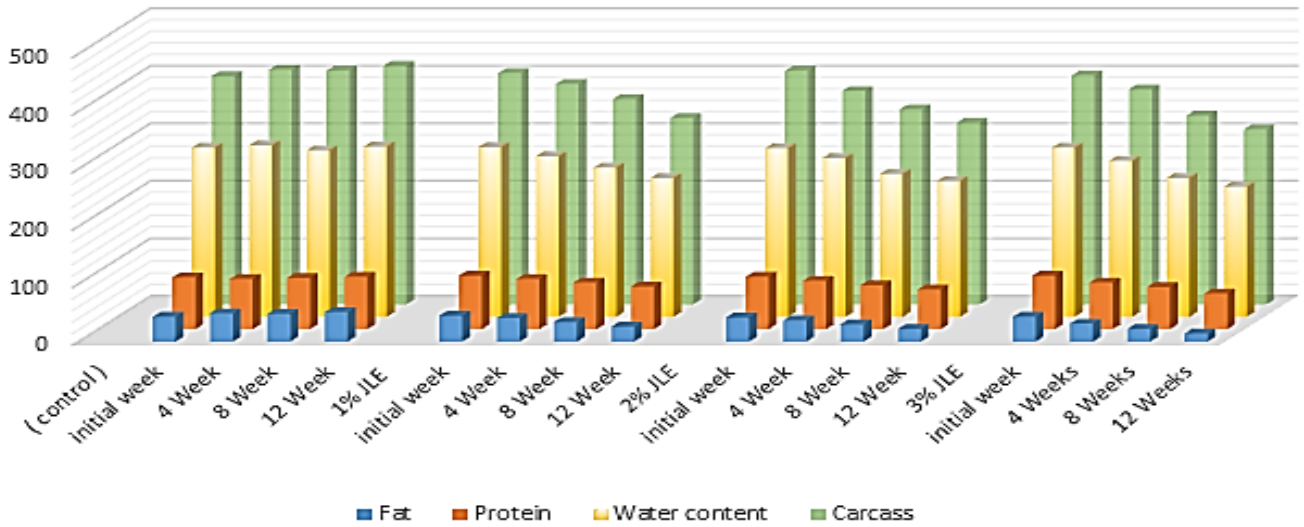

Figure 1. *Effect of dried jojoba leaves extracts on body weight of rats.*

show an acute decrease in body weight and food intake which may be due to the low levels of simmondsin due to the ethanol extraction. So, dried Jojoba leaves considered to be a good anti-obesity natural factor that could use for controlling rate of fat gained from diets by the body.

Histopathology and Hematology parameters

Table 4 lists the value of rat's metabolic profile tests that include (CBC) complete blood count analysis among the different concentration of Jojoba leave extract (OD1) during 12 weeks. Concerning the hematological parameters, WBC, RBC, MCV, MCH, MCHC and hemoglobin were non-significantly different in all treated group compared to control during the periods. There were no indications for severe anemia as shown in the red cell indices. Histopathology, There were no remarkable histopathologic effects in the liver, kidney compared to control, all treated group showed did not differ in liver and kidney (mean) weights (Table 5). Similar results were obtained by [14-17] who reported non-significant different in hematological parameters and no differ in liver and kidney weight in rats fed 3, 5, 10% Jojoba meal during time.

Table 4. *Effect of dried Jojoba le aves extract on complete blood count of rats.*

Concentration	Hemoglobin (g/dl)	WBC (10^3/µl)	RBC (10^3/µl)	MCV	MCH	MCHC
Control						
Initial week	16.8 ± 0.4^{b}	7.6 ± 1.9^{a}	8.4 ± 0.3^{b}	58.4 ± 2.4^{d}	20.4 ± 1.1^{e}	34.9 ± 2.4^{d}
4 Week	16.3 ± 0.7^{c}	7.1 ± 2.3^{a}	8.2 ± 0.5^{b}	60.7 ± 1.9^{c}	21.7 ± 0.7^{b}	35.4 ± 1.9^{c}
8 Week	16.6 ± 0.2^{b}	7.7 ± 1.4^{a}	8.7 ± 0.1^{a}	59.3 ± 2.7^{c}	21.4 ± 0.3^{c}	36.1 ± 1.2^{a}
12 Week	16.5 ± 0.6^{b}	7.3 ± 1.2^{a}	8.2 ± 0.7^{b}	61.1 ± 3.1^{c}	20.9 ± 0.9^{d}	35.8 ± 2.1^{b}
1%						
Initial week	17.2 ± 0.3^{a}	6.9 ± 2.1^{b}	7.9 ± 0.5^{c}	63.8 ± 2.8^{b}	22.4 ± 0.6^{a}	35.7 ± 1.7^{b}
4 Week	17.4 ± 0.6^{a}	6.7 ± 1.8^{b}	7.6 ± 0.3^{c}	68.2 ± 1.2^{a}	20.8 ± 1.3^{d}	36.3 ± 1.5^{a}
8 Week	17.1 ± 0.4^{a}	6.2 ± 2.4^{c}	7.5 ± 0.5^{c}	64 5 ± 2.1^{b}	21.4 ± 0.7^{c}	35.2 ± 1.8^{c}
12 Week	16.9 ± 0.3^{a}	5.7 ± 2.1^{d}	7.8 ± 0.1^{c}	59.2 ± 2.9^{c}	22.3 ± 0.5^{a}	36.1 ± 1.3^{a}
2%						
Initial week	16.6 ± 0.7^{b}	7.4 ±1.5^{a}	8.3 ± 0.6^{b}	61.7 ± 3.1^{c}	21.6 ± 0.4^{b}	34.7 ± 2.8^{d}
4 Week	16.1 ± 0.4^{c}	6.9 ± 1.8^{b}	8.9 ± 0.3^{a}	58.9 ± 2.5^{d}	21.2 ± 1.5^{c}	35.1 ± 2.1^{c}
8 Week	16.3 ± 0.5^{c}	6.5 ± 2.6^{c}	8.5 ± 0.7^{a}	60.4 ± 3.6^{c}	22.1 ± 0.3^{c}	35.6 ± 1.8^{b}
12 Week	15.8 ± 0.5^{d}	5.9 ± 1.6^{d}	8.3 ± 0.2^{b}	57.2 ± 2.9^{d}	21.4 ± 0.2^{c}	34.9 ± 2.3^{d}
3%						
Initial week	17.1 ± 0.4^{a}	7.3 ± 1.3^{a}	8.1 ± 0.3^{b}	56.8 ± 1.4^{e}	20.9 ± 0.8^{d}	35.6 ± 2.6^{b}
4 Week	16.7 ± 0.6^{b}	6.7 ± 1.7^{b}	7.8 ± 0.2^{c}	51.3 ± 2.7^{f}	21.1 ± 0.4^{c}	35.2 ± 1.9^{c}
12 Week	16.2 ± 0.2^{c}	6.2 ± 2.1^{c}	7.7 ± 0.5^{c}	53.5 ± 1.9^{f}	20.5 ± 1.7^{e}	36.4 ± 1.4^{a}
12 Week	15.9 ± 0.5^{d}	5.6 ± 1.4^{d}	7.9 ± 0.7^{c}	50.2 ± 3.4^{f}	20.8 ± 0.9^{d}	36.1 ± 2.3^{a}

Different superscripts within each series indicate statistically significant (P<0.05) differences between means. Means sharing the same superscript are not different (P<0.005). values are expressed as a mean ± SD; n=5

Table 5. *Liver and kidney weights.*

Concentration	Liver (g)	Kidney (g)
Control		
Initial week	15.43 ± 0.8^{c}	1.43 ± 0.6^{b}
4 Week	15.86 ± 0.4^{a}	1.47 ± 0.3^{a}
8 Week	15.24 ± 0.9^{e}	1.41 ± 0.7^{b}
12 Week	15.57 ± 0.2^{b}	1.45 ± 0.9^{c}
1%		
Initial week	14.93 ± 0.6^{g}	1.38 ± 0.9^{c}
4 Week	15.07 ± 0.3^{e}	1.35 ± 0.5^{b}
8 Week	14.98 ± 0.8^{g}	1.36 ± 0.3^{c}
12 Week	15.04 ± 0.4^{f}	1.39 ± 0.8^{c}
2%		
Initial week	15.01 ± 0.5^{e}	1.47 ± 0.6^{a}
4 Week	14.94 ± 0.7^{g}	1.43 ± 0.2^{b}
8 Week	14.96 ± 0.3^{g}	1.41 ± 0.4^{b}
12 Week	15.02 ± 0.9^{f}	1.46 ± 0.8^{a}
3%		
Initial week	15.64 ± 0.8^{ab}	1.48 ± 0.5^{a}
4 Week	15.19 ± 0.4^{e}	1.45 ± 0.7^{b}
12 Week	15.38 ± 0.5^{d}	1.47 ± 0.7^{a}
12 Week	15.52 ± 0.7^{bc}	1.51 ± 0.8^{a}

Different superscripts within each series indicate statistically significant (P<0.005) differences between means. Means sharing the same superscript are not different (P<0.005). values are expressed as a mean ± SD; n=5

Conclusion

Based on findings the researcher concluded that the aqueous extract of OD1 Jojoba is rich in protein, phenolic, tannins compounds, and low percent of simmondsin. Animals fed diet with 3% (AEJL) showed decreased 24% of body weight. Non-significant effects on hematology parameters and no remarkable histopathologic changes were noted in the liver and kidney weights. In this research study, aqueous Jojoba leaves extract with low percent amount of simmondsin, at both the 1%, 2% and 3% concentrations were significantly reduced body weight without significant negative effects.

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