Pharmacophore, 10(4) 2019, Pages: 49-56

Pharmacophore

ISSN-2229-5402

Journal home page: http://www.pharmacophorejournal.com

GROUND *LEPIDIUM SATIVUM LINN* SEEDS MIXED WITH THE REGULAR DIET OF RATS LEAD TO HIGHER BODY WEIGHT AND BODY WEIGHT GAIN

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ARTICLE INFO

Received:
29th Mar 2019
Received in revised form:
30th Jul 2019
Accepted:
04th Aug 2019
Available online:
28th Aug 2019

Keywords: *Body weight, Body weight gain, Garden cress seeds, Lepidium sativum Linn, Rat*

ABSTRACT

Many people have problems with body weight gain or loss leading to excess weight and obesity or underweight, which lead to higher mortality and morbidity and increased risk for many diseases. In addition, body weight abnormalities may coexist with malnutrition. Garden cress *(Lepidium sativum Linn*, LS) seeds are widely used in many countries in the Middle East and Asia for their nutritive value and the treatment of many diseases and ailments. This study aimed to determine whether 10% and 15% LS seeds (seeds weight/feed weight) mixed with the diet of rats increase or decrease body weight and weight gain so that users may be able to decide to use them or not according to their needs and weight status. This is the first study to use 15% LS seeds mixed with the diet of rats. The mean weekly body weights and weekly body weight gains were determined in rats consuming ground LS seeds for six weeks. Ground LS seeds mixed with the regular feed were administered to rats at a low dose (LD, 10% LS seeds, 12 rats) and high dose (HD, 15%, 10 rats) and the findings were compared to the control group rats (12 rats) that were not given the seeds. The findings showed that the addition of LS seeds to the diet of rats led to increased mean body weights and body weight gains for the first three weeks with the effects being higher for the HD group. Subsequently, the increases started to diminish becoming not different from the control. Thus, LS seeds may be ingested for weight gain for three weeks, while if they are taken for any medicinal purposes any gain in weight will diminish after around three weeks.

To Cite This Article: Sawsan Hassan Mahassni, Maryam Abdulaziz Munshi (2019), "Ground *Lepidium sativum Linn* Seeds Mixed with the Regular Diet of Rats Lead to Higher Body Weight and Body Weight Gain ", ***Pharmacophore, 10(4)***, *49-56*.

Introduction

Both body weight gain and loss are major problems in many parts of the world. Overweight and obesity are widespread in developed and rich countries, while malnutrition and low body weight are found mainly in developing countries. In addition, individuals who are underweight and ones with excess weight may suffer from malnutrition due to micronutrient and macronutrient deficiencies. In overweight or obese individuals, malnutrition may be due to different factors, one of which is the overconsumption of fast foods and foods that are calorie-dense but low in needed nutrients. Both overweight and underweight are associated with increased morbidity, mortality, and the high incidence of many diseases.

For centuries, plants and their seeds have been used for their nutritive value and in traditional medical systems for the prevention and treatment of many diseases, with varying degrees of success and, in many cases, with no scientific evidence. The World Health Organization (WHO) stated that around 88% or more of the world populations use plants for the treatment of diseases and ailments [1]. In addition, many of the medicines used in conventional medicine contain components derived from plants and their parts.

Some of the most widely used seeds that have been used for thousands of years for the treatment of many ailments and diseases and for culinary uses are aniseed, nigella sativa, sesame, flax, chia, and garden cress seeds. Additionally, many people use specific natural foods, termed functional foods, to help them lose or gain weight in addition to their effects on diseases and ailments. Seeds that have been used for weight loss or gain are flax, pumpkin, chia, and fenugreek.

Garden cress seeds *(Lepidium sativum Linn*, LS) belong to the *Brassicaceae* (Cabbage) family and they are cultivated and commonly used in Saudi Arabia in traditional medicine because of their low cost and many benefits. LS seeds are rich in macronutrients and micronutrients, containing proteins, fats, crude fiber, essential amino acids, and carbohydrates. Some of the constituent minerals are calcium, magnesium, phosphorus, iron, potassium, sodium, and zinc. The seeds also contain vitamins, mainly thiamine, riboflavin, and niacin. They contain essential fatty acids, such as arachidic, linoleic, and alpha-linolenic acids [2, 3]. Therefore, LS seeds may be used as a food supplement due to their high content of many important and essential nutrients.

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LS seeds have been used as a functional food and in traditional and folk medicines worldwide for the treatment of many diseases, such as hypertension, renal diseases, gastrointestinal disorders, and inflammatory diseases such as diabetes mellitus, arthritis, and hepatitis. The seeds have many important effects, such as anti-cancer, anti-asthmatic, anti-inflammatory, antihypertensive, antioxidant, and analgesic effects [3-7]. In addition, LS seeds help in bone healing [8] and to alleviate anemia due to their high iron content. The seeds stimulate appetite and contain high amounts of nutrients, which can combat malnutrition and other micronutrient deficiencies [9].

There are a limited number of studies on the effect of LS seeds on body weight and body weight gain in healthy laboratory animals, while no such studies have been done on healthy humans. Most studies on LS seeds have been done using alcoholic extracts, aqueous extracts, powdered, or whole seeds mixed with either drinking water or feed. Studies used various amounts and preparations of LS seeds fed to normal or sick laboratory animals and their findings on the effect of the seeds on body weight were contradictory. A previous study [10] showed that administration of LS seeds powder to rats did not lead to any changes in body weights. Other researchers [11-13] showed that administration of LS seeds, either as a powder or aqueous extracts, to rats led to a decrease in body weights. Still other researchers [6, 14-16] showed that administration of LS seeds in the form of powder or either aqueous or alcoholic extracts in laboratory animals led to an increase in body weights.

Therefore, studies on the effect of LS seeds on weight and weight gain in animals are scarce and contradictory in their results. In addition, there are no previous studies that showed the effect of ground LS seeds mixed with the regular diet of rats on body weights. Thus, the aim of this study was to explore the effect of LS seeds mixed with the regular diet at different concentrations on body weight and gain in rats.

Materials and Methods

Experimental animals

A total of 34 Wistar albino male rats, at eight weeks of age and weighing 200-287 g, were randomly assigned to three different groups. There were two experimental groups, the low dose (LD) LS seed group (10% ground LS seeds, 12 rats), the high dose (HD) LS seed group (15% ground LS seeds, 10 rats), and one control group (with no LS seeds, 12 rats). The rats were housed at room temperature (25℃), with exposure to artificial light during working hours and free access to feed and water during the entire experimental period. Body weights for the rats were measured 6 days per week, while water and feed consumption were measured daily. The experimental period was 38 days for the HD group, 39 days for the LD group, and 37 days for the control group. Therefore, the last week for each group had a different number of days. For the LD group it was 4 days, for the HD group it was 3 days, and for the control group it was 2 days.

Preparation of the experimental diets

Fresh LS seeds were purchased from a local herb shop in Jeddah, Saudi Arabia. The obtained seeds were grown in Al-Qaseem region of Saudi Arabia. The seeds were manually cleaned from foreign materials, after which they were ground to powder and stored in airtight plastic bags in a refrigerator.

To prepare the experimental diets, the ground LS seeds were mixed with the ground regular rat feed at two different concentrations (10% and 15% seeds weight/feed weight). Subsequently, a small amount of water was added to the mixture and it was kneaded into a paste. Finally, the paste was shaped into pellets and left to air dry. After drying completely, the pellets were stored at room temperature in clean boxes. The two experimental diets were prepared fresh every three days.

The regular rat feed pellets (Grain Silos and Flour Mills Organization, Jeddah, Saudi Arabia) contain fiber, fat, protein, salt, ash, phosphorus, calcium, vitamin A, vitamin D, and vitamin E. The diet also contains the trace minerals iodine, iron, copper, selenium, zinc, cobalt, and manganese. The diet provides 2850 Kcal/kg energy. The energy of whole LS seeds ranges from 454 to 474 Kcal per 100 g [3, 17].

Calculation of the mean weekly body weight and weekly body weight gain

To calculate the mean weekly body weight for each group, the mean daily weights for the rats of each group were calculated. Subsequently, the mean daily weights for the days of each week were summed and this sum was divided by the number of days per week to give the mean weekly body weight for each group. The mean weekly body weight was determined for each week of the experimental period.

The mean weekly body weight gain for each group was calculated by subtracting the mean weekly body weight gain for each week from the week before it. The total mean weekly body weight gain is the difference in the mean weekly body weight gain between the last and first weeks.

Statistical Analysis

The MegaStat statistical program (version 9.4) was used to analyze the data and calculate the mean, ± SD (standard deviation), ± SE (standard error), and P-value. The GraphPad Prism program (version 6.01) was used to generate the figures. For the normally distributed parameters, the one-way ANOVA test was used for significance testing, while for the post hoc analysis the t-test was used. As for the parameters that were not normally distributed, the Kruskal-Wallis test was used for the unmatched groups while the Friedman test was used for the matched groups. For the post hoc analysis, the Wilcoxon signed-rank test was used for the matched groups and the Mann-Whitney test was used for the unmatched groups.

Results

Mean weekly body weights for the groups

Using the Kruskal-Wallis test, there were significant differences between the mean weekly body weights for the groups for weeks 3 and 5 (Table 1). For the post hoc analysis, using the Mann-Whitney test, the mean weekly body weight for the HD group for the third and fifth weeks were both significantly higher compared to the respective controls. On the other hand, there were no significant differences for the mean weekly body weights between the LD and control groups and the LD and HD groups for both weeks. There were no significant differences between the mean weekly body weights of the groups in weeks 1 and 2, using the one-way ANOVA test; and weeks 4 and 6, using the Kruskal-Wallis test.

Table 1: Statistical analysis for the mean weekly body weights (g) for the groups.

Week	Group	Minimum	Maximum	Mean	± SD	± SE	P value	Post hoc P value
1*	Control	212	294	245	25	7	0.321^{NS}	
	LD	201	268	237	20	6		
	HD	222	275	252	19	6		
2*	Control	220	308	248	26	8	0.084^{NS}	
	LD	211	278	245	20	6		
	HD	235	290	266	21	7		
3**	Control	219	311	248	27	8	0.049^{S}	0.281^{NS1}
	LD	220	293	256	20	6		0.027^{S2}
	HD	234	297	274	22	7		0.098^{NS3}
4**	Control	222	322	255	30	9	0.075^{NS}	
	LD	220	304	262	23	7		
	HD	240	303	277	20	6		
5**	Control	220	326	254	31	9	0.046^{S}	0.230^{NS1}
	LD	226	305	265	22	7		0.019^{S2}
	HD	239	303	277	19	6		0.170^{NS3}
6**	Control	224	334	262	32	9	0.130^{NS}	
	LD	233	315	268	24	7		
	HD	241	315	281	21	7		

*One-way ANOVA test, **Kruskal-Wallis test, Post hoc test: Mann-Whitney test

[1]Comparison between control and LD group, [2]comparison between control and HD group, [3]comparison between LD and HD group

S: Significant ($P < 0.05$), NS: Non-significant ($P \geq 0.05$)

Comparing the mean weekly body weights between weeks of the experimental period for each group

Comparing the mean weekly body weights at all weeks in each group (Table 2), there was a highly significant difference between the weeks in the control, using the Friedman test, and in the LD and HD groups, using the one-way ANOVA test. For the post hoc analysis, the mean weekly body weights at weeks 4 to 6 in the control, using the Wilcoxon signed-rank test, were significantly higher than the mean weekly body weight at week 1. Weeks 2 and 3 in the control were not significantly different compared to week 1.

As for the LD and HD groups, the mean weekly body weights at weeks 3 to 6 were significantly higher compared to the respective mean weekly body weights at week 1. Mean weekly body weight at week 2 for both the LD and HD groups were not significantly different from the respective mean weights at week 1.

Table 2: Statistical analysis of the comparison between the mean weekly body weights (g) at the weeks of the experimental period for each group. The post hoc compares each week with week 1.

Group	Week	Minimum	Maximum	Mean	± SD	± SE	P value	Post hoc P value
Control**	1	212	294	245	25	7	0.000^{HS}	-
	2	220	308	248	26	8		0.067^{NS2}
	3	219	311	248	27	8		0.080^{NS2}
	4	222	322	255	30	9		0.008^{HS2}
	5	220	326	254	31	9		0.033^{S2}
	6	224	334	262	32	9		0.006^{HS2}
LD*	1	201	268	237	20	6	0.008^{HS}	-
	2	211	278	245	20	6		0.393^{NS1}
	3	220	293	256	20	6		0.040^{S1}
	4	220	304	262	23	7		0.009^{HS1}
	5	226	305	265	22	7		0.004^{HS1}
	6	233	315	268	24	7		0.001^{HS1}
HD*	1	222	275	252	19	6	0.024^{S}	-
	2	235	290	266	21	7		0.109^{NS1}

	3	234	297	274	22	7		0.018[S1]
	4	240	303	277	20	6		0.007[HS1]
	5	239	303	277	19	6		0.006[HS1]
	6	241	315	281	21	7		0.002[HS1]

*One-way ANOVA test, **Friedman test

Post hoc: [1]T-test, [2]Wilcoxon signed-rank test

HS: Highly significant (P < 0.01), S: Significant (P < 0.05), NS: Non-significant (P ≥ 0.05)

Total mean weekly body weight gain and mean weekly body weight gain for the groups

Table 3 shows that the mean total weekly body weight gain, analyzed using the one-way ANOVA test, was significantly different between the groups. As for the post hoc analysis, using the t-test, there were no significant differences between the LD and control groups, and between the LD and HD groups, but the HD group was significantly lower compared to the control.

The mean weekly body weight gain (Figure 1) for each group at each week showed that the group with the highest gain was different. At the second week, the HD group showed the highest mean weekly body weight gain, which was also higher than the mean weekly body weight gains in the three groups. At both the third and fifth weeks, the LD group showed the highest mean weekly body weight gain. At the fourth week, the control group showed the highest mean weekly body weight gain. The figure shows that the mean weekly body weight gain in the HD group was the highest at week 2 and then it declined every week to reach its minimum by the last week, although it was higher than the mean weekly body weight gain in the control at all weeks except at week 4. On the other hand, the LD group mean weekly body weight gain increased at week 3 compared to week 2, and then it decreased up to the last week.

Table 3: Statistical analysis of the total mean weekly body gain per group (g).

Group	N	Minimum	Maximum	Mean	± SD	± SE	P value	Post hoc P value
Control	12	-6	16	5	8	2	0.010[HS]	0.059[NS1]
LD	12	-26	17	-4	17	5		0.003[HS2]
HD	10	-19	-2	-11	6	2		0.173[NS3]

One-way ANOVA test, Post hoc: T-test

[1]Comparison between the control and LD group, [2]comparison between the control and HD group, [3]comparison between the LD and HD group

HS: Highly significant (P < 0.01), NS: Non-significant (P ≥ 0.05)

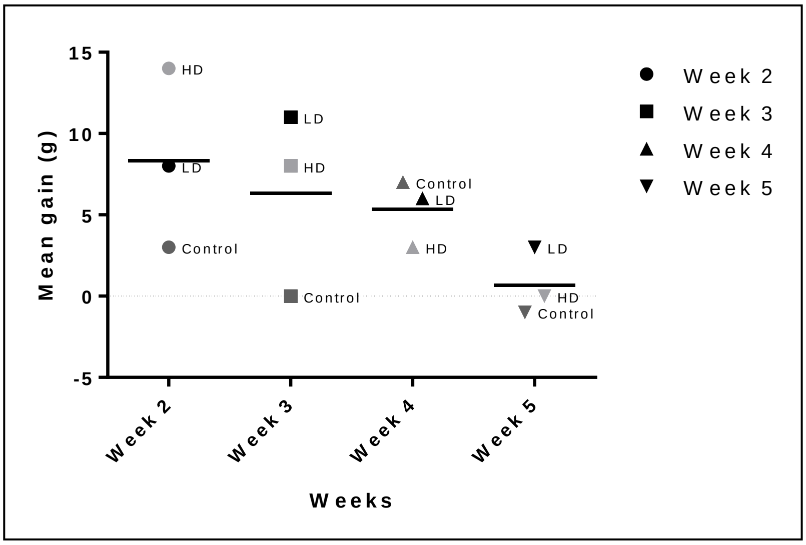

Figure 1: Mean weekly body weight gain (g) for each group in each week. The horizontal lines are the weekly mean for the three groups.

The comparison between the mean weekly body weight gains for the weeks of the experimental period

The mean weekly body weight gains in the groups at each week and the comparisons between the gains at the weeks are shown in Table 4. For the control group (Table 4), using the t-test, the mean weekly body weight gains significantly increased at week 4 compared to week 3 and for week 6 compared to weeks 2, 3, and 5, while they significantly decreased for week 5 compared to weeks 2 and 4. As for the LD group, using the t-test, the only significant difference between the weeks was the significantly decreased gain at weeks 5 and 6 compared to week 3. Finally, for the mean weekly body weight gains in the HD group, the Wilcoxon signed-rank test showed a significant decrease at weeks 3-6 compared to week 2, and at weeks 5 and 6 compared to week 3.

Table 4: Statistical analysis of the comparison of the mean weekly body weight gains for the groups between the weeks of the experimental period.

Groups	Week (X)	Mean	± SD	Week (Y)	Mean difference (X –Y)	P-value
Control*	2	3	6	3	2	0.254^NS
				4	-4	0.069^NS
				5	5	0.030^S
				6	-5	0.018^HS
	3	1	3	4	-6	0.004^HS
				5	2	0.289^NS
				6	-7	0.001^HS
	4	7	5	5	8	0.000^HS
				6	-1	0.567^NS
	5	-2	4	6	-9	0.000^HS
	6	8	6	-	-	-
LD*	2	7	12	3	-4	0.214^NS
				4	1	0.760^NS
				5	4	0.168^NS
				6	4	0.160^NS
	3	10	7	4	5	0.123^NS
				5	8	0.010^HS
				6	8	0.010^HS
	4	6	5	5	3	0.280^NS
				6	3	0.268^NS
	5	3	4	6	0	0.978^NS
	6	2	7	-	-	-
HD**	2	15	7	3	7	0.006^HS
				4	12	0.008^HS
				5	14	0.005^HS
				6	11	0.004^HS
	3	7	4	4	4	0.070^NS
				5	7	0.006^HS
				6	4	0.028^S
	4	3	5	5	3	0.310^NS
				6	-1	0.568^NS
	5	1	5	6	-3	0.087^NS
	6	4	4	-	-	-

*T-test, **Wilcoxon signed-rank test

HS: Highly significant ($P < 0.01$), S: Significant ($P < 0.05$), NS: Non-significant ($P \geq 0.05$)

Comparison of the mean weekly body weight gains between the groups.

Comparing the mean weekly body weight gains between the groups at each week (Table 5) showed significant differences between the groups at week 2, using the one-way ANOVA test, and at week 3, using the Kruskal-Wallis test. On the other hand, comparing the mean weekly body weight gains at week 4, using the one-way ANOVA test, and weeks 5 and 6, using the Kruskal-Wallis test, showed no significant differences between the groups.

As for the post hoc analysis at week 2, using the t-test, the mean weekly body weight gain in the HD group was significantly higher compared to the control and LD groups, while there was no significant difference between the LD group and the control. As for week 3, using the Mann-Whitney test, both LD and HD groups were significantly higher compared to the control, while the HD group was not significantly different compared to the LD group.

Table 5: Statistical analysis for the comparison of the mean weekly body weight gains between the groups for each week of the experimental period.

Week	Group	Minimum	Maximum	Mean	± SD	± SE	P value	P value against control	P value LD against HD
2*	Control	-5	14	3	6	2	0.009^HS		
	LD	-8	22	7	12	3		0.297^NS1	0.032^S1
	HD	7	24	15	7	2		0.003^HS1	
3**	Control	-5	5	1	3	1	0.001^HS		
	LD	0	22	10	7	2		0.001^HS2	0.220^NS
	HD	-1	13	7	4	1		0.002^HS2	
4*	Control	-3	14	7	5	1	0.214^NS		
	LD	-5	11	6	5	1			
	HD	-5	12	3	5	1			

5**	Control	-8	6	-2	4	1	0.082NS		
	LD	-4	11	3	4	1			
	HD	-5	12	1	5	2			
6**	Control	-1	19	8	6	2	0.083NS		
	LD	-8	11	2	7	2			
	HD	-1	12	4	4	1			

*One-way ANOVA test, **Kruskal-Wallis test
[1]T-test, [2]Mann-Whitney test
HS: Highly significant (P < 0.01), S: Significant (P < 0.05), NS: Non-significant (P ≥ 0.05)

Discussion

This study investigated the effect of ground LS seeds on the body weights and body weight gains in rats. Published studies on the effect of LS seeds on weight and weight gains in healthy humans and laboratory animals are scarce and thus, we were not able to compare most of our finding with other studies. Nevertheless, comparisons were made between the present study and other studies conducted on the effects of LS seeds on diseased animals. In addition, not all of the parameters studied here were investigated by other researchers. Furthermore, this is the first study to use 15% LS seeds mixed with the diet of rats.

It was decided to use the whole seeds instead of the separate active ingredients of the seeds since natural foods contain many different constituents that may or may not be active individually and many components may have synergistic or antagonistic effects on each other. Therefore, in many instances, it is not possible to use individual components of an active plant or seed for the same purpose as the whole plant or seed. This leads to the preference of using whole plants or seeds, as was done in this study, to get all their benefits or effects. In addition, the goal was to study the effects of the LS seeds as they are used by people in their homes. Finally, in the current study, the used amounts of LS seeds in the experimental diets did not lead to any apparent illness or toxic effects in the rats.

The findings of this study show that the mean weekly body weights for the groups were significantly different only at weeks 3 (P = 0.049) and 5 (P = 0.046). At both weeks 3 and 5, the mean weekly body weights of the HD rats were significantly higher (P = 0.027 and 0.019, respectively) than for the control group. The remaining group comparisons showed no significant differences (P ≥ 0.05). These findings disagree with previous findings [12] that showed a significant decrease in the body weights of female and male rats receiving different concentrations (4 g and 8 g) of the water suspension of LS seeds powder, by oral gavage, for 6 weeks compared to the control.

On the other hand, the current findings agree with the findings [15] on prednisolone acetate treated female and male rats orally administered with the alcoholic extract of LS seeds for 12 weeks. Researchers found a significant increase in the weekly body weight at weeks 6, 9, and 12 compared to the corresponding osteoporotic control group. Similarly, the current findings agree with the previous findings [14] that showed increased final body weight of broiler chicks that consumed a diet containing 0.75 and 1.5 % ground LS seeds for 42 days compared to the control.

Comparing the mean weekly body weights at the weeks of the experimental period for each group, the mean weekly body weights in the control group at weeks 4 to 6 were all significantly higher (P = 0.008, 0.033, and 0.006, respectively) than in the control group at week 1. On the other hand, mean weekly body weights at weeks 2 and 3 were not significantly different compared to week 1. In both the LD and HD groups, weeks 3 to 6 were all significantly higher (P = 0.040, 0.009, 0.004, and 0.001, respectively for the LD group; P = 0.018, 0.007, 0.006, and 0.002, respectively for the HD group) compared to the respective mean weekly body weights at week 1. The mean weekly body weights at week 2 in both the LD and HD groups were not significantly different from the respective mean weekly body weights at week 1.

The total mean weekly body weight gain for the HD group was significantly lower (P = 0.003) than the control, while for the LD group it was not significantly different (P ≥ 0.05) from the weekly body weight gain in the control. The mean weekly body weight gain for the HD was highest at week 2 but afterward it decreased. As for the LD group, the weight gain was the highest at week 3 and then it decreased at the remaining weeks. Both the HD and LD groups had mean weekly body weight gains that were higher than the respective gains in the control except at week 4, where the control had the highest gain. Therefore, LS seeds led to higher weight gains in the first three weeks of consumption. Afterward, the gains were reduced and were not very different from the respective gains for the control.

The above findings agree with previous findings [11] in which rats that consumed a diet containing 10% and 50% ground LS seeds for 6 weeks had significantly lower body weight gains compared to the control. On the other hand, the current findings disagree with the findings [6] that showed no significant differences in the total body weight gains of mice consuming different concentrations of the aqueous LS extract for 3 weeks compared to the control. In addition, the current findings disagree with the previous study [10] that demonstrated no significant differences in the body weight gains of female and male rats consuming a diet containing 1%, 2.5%, 5%, or 10% ground LS seeds for 14 weeks compared to the control. Finally, the current findings disagree with previous research [14] that showed increased body weight gain of broilers chicks that consumed a diet containing 0.75 and 1.5 % ground LS seeds for 42 days (6 weeks) compared to the control.

Comparing the mean weekly body weight gains between the weeks in the control group, the gain was significantly higher (P = 0.004) at week 4 compared to week 3, and at week 6 compared to weeks 2, 3, and 5 (P = 0.018, 0.001, and 0.000, respectively). On the other hand, the mean weekly body weight gain at week 5 was significantly lower compared to weeks 2 and 4 (P = 0.030 and 0.000, respectively). The mean weekly body weight gains in the LD group at both weeks 5 and 6 were significantly lower (both P = 0.010) compared to week 3. As for the HD group, the mean weekly body weight gains at weeks 3-6 were all significantly lower (P = 0.006, 0.008, 0.005, and 0.004, respectively) compared to week 2, and also at weeks 5 and 6 (P = 0.006 and 0.028, respectively) compared to week 3. The remaining comparisons between the weeks in the groups were all not significantly different.

Comparing the mean weekly body weight gains in the three groups at each week of the experimental period, only weeks 2 and 3 showed significant differences. At week 2, the mean weekly body weight gain in the HD group was significantly higher (P = 0.003 and 0.032, respectively) compared to the control and LD groups. As for week 3, both the LD and HD groups had significantly higher mean weekly body weight gains (P = 0.001 and 0.002, respectively) compared to the control, while there was no significant difference between the gains in the LD and HD groups.

In agreement with the current findings, a study [6] on mice administered an aqueous extract of ground LS seeds at different concentrations for 21 days found significant increases in the mean daily body weights and mean daily body weight gains compared to the control. Another study [14] also found increased mean daily body weight gains in broiler chicks that consumed a diet containing 0.75% and 1.5% ground LS seeds for 42 days compared to the control. These findings led the researchers to conclude that the LS seeds increased appetite in the birds, which may be due to the high content of the linolenic fatty acids and flavonoids in the seeds. These components are known to increase muscle growth leading to a higher ratio of lean body mass to fat.

On the other hand, in disagreement with the current findings, a previous study [13] found that oral administration of the aqueous LS extract to healthy rats for 15 days caused a slight reduction in body weight. The reduction in body weight was explained to be due to the decrease in feed intake. Also in agreement with the current findings is the previous study [16] that found no changes in the body weight gains in Murrah buffaloes that consumed a diet containing ground LS seeds for 5 months compared to the control.

Conclusions and Recommendations

In conclusion, it is apparent that the addition of LS seeds to the diet of rats led to increased mean body weights and body weight gains for the first three weeks with the effects being higher for the HD group. After ingesting LS seeds for three weeks, the body weight and body weight gain increases start to diminish and become almost the same as the control. Thus, one may take LS seeds for weight gain for three weeks, while if they are taken for any medicinal purposes then any gain in weight will diminish after around three weeks. It is recommended that further work be done on different concentrations of LS seeds mixed with the regular diet of animals and for a longer experimental period.

Funding sources: There were no sources of funding for this research study.

Competing interests: Both authors declare that there are no competing interests.

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