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Research Article

Utilization Leaf Meal of Water Hyacinth (*Eichhornia crassipes*) as a Replacement Protein Source for Growing Awassi Lambs

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ABSTRACT

This study was carried out to determine the effects of substituting maize with water hyacinth (*Eichhornia crassipes*) (WH) leaves on feed intake, growth performance, digestibility, ruminal parameter and some carcass assessment of Awassi lambs. Twenty four lambs aged 2.5months having an average initial weight of 15.33±0.15kg were randomly distributed into four groups. These groups were given 0% (control), 5%, 10% and 20% of WH. The partial replacement of maize by WH reveals insignificant difference between all experiment diets of dry matter. However, we found that increasing WH with 0, 5, 10, and 20 percent increases (decreases) crude protein (energy) with 12% (2786),12.6% (2691),13% (2667) and 13.6 (26340), respectively. Performance data indicated that body weight gain and feed conversion ratio were significantly (P≤0.05) better in lambs fed on 10 WHR. Furthermore, increasing level of WH in diets considerably improved DM, CP, NDF and ADF digestibility in all groups in comparison with the control group. In addition to that, we found rumen liquor pH at 10 RWH, protozoal motility and activity at 20 RWH were decreased; however, ammonia and total VFA were increased significantly (P≤0.05) in all treated group comparison with control. At the end of study, after 60 days, the sheep were slaughtered and assessed. The increase WH in diet significantly (P≤0.05) improves slaughter weight, hot dressing, and longessmiss dorsi area and length. The best finding of the previously mentioned characteristics recorded at 10WHR.Our paper indicates that WH could be used to replace maize, where the best results were found at the level of 10%.

Key words: Water hyacinth leaves, Body weight, Rumine liquor, Carcass assessment, Awassi lambs

INTRODUCTION

The dearth of dietary animal protein with increasing cost of production, coupled with rapid population growth, (Ogunlade,1992). The protein and energy sources in the diet of livestock like cereals, in short supply and costs are increasing due to its use as biofuels. Replacing maize with alternative feed sources such as water hyacinth may lead to economically advantages. The water hyacinth (WH) in combination with concentrate supplements proved to be a good quality protein source for animal feeding (Omojola *et al*., 2000).

The high levels of cellulose and hemicelluloses in water hyacinth could make it a suitable energy source for ruminants (Mukherjee and Nandi, 2004). The easily digestible content cellulose is important as a starting substrate for the cellulolytic bacteria and that once the environment is created for them they will provide the ruminant with sufficient nutrients through the process of fermentation (Dolberg *et al.*,1981).

Water hyacinth (WH) is more important in humid and tropical region where feed for ruminants is scarce in rain seasons (Kibria *et al*., 1989). Water hyacinth widely differ in their chemical composition depending upon species, season and location (Shafy *et al*., 2016). The water hyacinth is characterized by low dry matter and high crude protein and ash contents (22.8% and 12.4% respectively) (Fasakin, 2002). Protein in leaves contains most essential amino acids and is particularly rich in glutamine, asparagine and leucine (Virabalin *et al*., 1993), it is rich in minerals so that,it serves as suitable economic feed (Lata and Veenapani, 2010). Concentrations of the nutrient elements (P, K, Mg, Cu, Zn, and Mn) in water hyacinths have been determined to be in the same range as in land forages where as Na, and Fe were higher and Ca was lower (Boyd,1970).

A number of studies have evaluated WH as a feed source to beef cattle (Parashar *et al*., 1999; Thu,2011), to goats (Hira *et al*., 2002). In addition, recently, several studies have been directed to substitute the high cost

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lambs meal with less expensive protein sources (Abou-Raya *et al*., 1980).

Water hyacinth is proved to have good effect in the diet of non-ruminants(pigs), where it was found that the use of concentrate can be reduced upto 6% by using water hyacinth in diet (Manh *et al*., 2002). Replacement of para grass with water hyacinth up to 60% in rabbit diets improvs feed utilisation, growth performance and economic returns (Thu and Dong , 2009).Water hyacinth in duck diets (15%) with led to give higher daily feed intake, egg laying ratio and egg quality (Jianbo *et al*., 2008).The plants is also commonly used as forage for cattles as basal feed resource or supplement to a diet consist of sugarcane, molasses and cereal straw (Hossain *et al*., 2015).

Utilisation of both wilted and ensiled of WH as a feed for sheep has been reported by (Abou-Raya *et al*., 1980). Although wilted WH has not been recommended as a sole feed for sheep, for concentrates above 50% diets (Abdelhamid and Gabr, 1991).On the other hand ,water hyacinth ensiled with rice straw, urea and molasses found to improve milk production in cattle (Chakraborty *et al*., 1991),Hence the greatest challenge today is developing water hyacinth from its menace status into an asset of national value; by seeing the plant as an opportunity instead of a problem could help solve some nutritional problems (Jafari, 2010).

Most of the raw materials currently used for animal feed products are higher plants as maize, barley soybeans, corn, oats, and wheat. Our target is to replace the protein raw material sources like maize and reduce the cost of feed production. The high cost of feeds is a major challenge facing smallholder farmers in Iraq, this study suggests that WH is a good source of leaf protein concentrate (LPC) enhance feed efficiency, improve animal health, and/or add value by improving mutton quality.

MATERIALS AND METHODS

Collection and preparation of the water hyacinth leaf meal (WHLM)

The WH was harvested manually from water surface of Tigris River, Iraq, during May, June, and July, to represent the different stages of growth, the roots were cut-off and discarded. Samples were thoroughly washed with distilled water to remove epiphytes, encrusting materials. The samples were air-dried under partial shade by spreading on clean plastic sheets for 72 h and turned over several times and then brought to the laboratory in polyethylene bags. In laboratory heated in an oven at temperatures of 100 or 105ºC for 2 hours, then ground to pass a 1 mm screen.

Analysis of chemical compositions

Diets were analyzed in duplicate for dry matter, crude protein, fat, crude fiber, neutral detergent fiber, acid detergent fiber and ash contents of diets were determined according to the standard methods of the Association of Official Agricultural Chemists (AOAC, 1990).

Experimental animals and their management

Twenty-four, lambs Awassi sheep (average body weight 15.33±0.15 kg, 2.5 month of age) were purchased from a Numaniyah Market. The age of the sheep was determined by dentition and information from the owners. The animals were vaccinated against ovine pasteurellosis and de-wormed against internal and external parasites prior to being divided into four groups. The experimental animals were kept in semi-open sheds pen. The pens were equipped with feeding and watering troughs.

Study site and experimental design

The experiment was conducted in the small farm, between July, 2016 to September, 2016. A completely randomized experimental design was used, with four treatments and six replicates for each treatment. Treatments were: **i)** Control (C), base diet 0WHR (0% of WHL + 60% maize), **ii)** 5WHR (5% of WHL + 55% maize), **iii)** 10WHR (10% of WHL + 50% maize), **iiii)** 20WHR (20% of WHL + 40% maizes). Experimental animals were allowed to adapt to experimental diets for 1weeks before the commencement of actual feeding trial. The feeding trial lasted for 60 consecutive initial and final body weights (BW) were obtained by averaging two measurements on consecutive days. Animals were fed daily of the pelleted diets.

Digestibility and feeding trials

After the feeding trial, animals were housed individually, water and commercial mineral blocks were available at all times. Each sheep was fitted with fecal collection bags for 7 days of acclimatization period following collection of feces for seven consecutive days. Total feces voided over 24 h was weighed daily for each sheep, and after thoroughly mixing,10% representative, samples were taken and kept frozen at -10°C. At the end of the collection period, samples from each sheep were mixed and dried at 60°C to a constant weight.

Rumen Fluid Collection and Examination

At the end of study, rumen liquor samples were collected two hours after effort diet using stomach tube and suction pump of each experimental treatment. About 100 ml of ruminal liquor was collected from each animal. Each sample was divided into two parts of 50 ml, first part was used for physical and microscopical examinations, second part was strained using narrow sieve pores, then centrifuged at 4000 r.p.m for 15 minutes the clear supernatant fluid was separated into clean plastic tubes and refrigerated at -20oC until biochemical analysis (Dirksen and Smith, 1987).

1- Biochemical Examination:

Rumen liquor pH was measured immediately by portable digital pH meter, ammonia levels was measured by Kjeldahl method according (AOAC, 1990) and volatile fatty acids levels was observed by Markham system, according to Warner (1964).

2- Microscopic examination

Protozoal activity was examined by placing one drop of fresh ruminal fluid on a pre warmed microscope slide and a cover slip was place. It was examined under low power objective of magnifying microscope. Protozoan motility was graded in four categories: ++++ Good :>10 mobile protozoa per field; +++ fair: 6-9 mobile protozoa per field; ++ subnormal:3-5 mobile protozoa per field; +

very low: <3 mobile protozoa per field (Rosenberger *et al*., 1979).

Some carcass assessment

At the end of study all animals were slaughtered, before slaughtering fastened for 24 hours, live weight was taken prior slaughtering, weight of hot carcasses and hot dressing percentages were calculated. The rib eye muscle areas and length (Longissimus dorsi) were measured.

Statistical analysis

Data were analyzed for the treatment of each trait in each period using complete randomized design (CRD). Least significant difference (LSD) among different group means at 5% level was applied Snedecor and Cochran (1971).

RESULTS

Ingredients and chemical composition of the experimental diets

The composition of the feed ingredients and chemical analysis of the experimental diets is presented in (Table 1). The partial replacement of maize by WH resulted in increased DM. However, there was no difference between all experiment diets. The 20RWH has high crude protein content (13.6%) followed by the 10 RWH (13%). As expected, the WH leaves had more crude protein and ash content than maize and a moderately high NDF content. The energy in 0RWH is higher than in treated diet 5RWH, 10RWH and 20RWH (2786, 2691, 2667 and 26340 and respectively).

Measured growth performance trial:

The growth performance trial is shown in (Table 2). There was no difference in the initial body weight at the beginning of the experiment. The final body weight, total body weight gain and weekly body weight gain, were significantly (P≤0.05) difference was recorded in 10RWH group compared other groups. However, in this study was found that body weight increased in all animals of different groups with time progress. The group 10 RWH showed significant (P≤0.05) higher values than the 0RWH group after two weeks of the study up to the end of the experiment, but no significant differences (P≤0.05) were excited among 0RWH group and 5RWH and 20RWH groups. The same trend was conducted in the total feed intake and feed conversion efficiency Table (2) showed increased with time progress as a result of body weight improvement and record 122.62±4.01, 127.36±5.4, 138.50±10.16 and 140.01±14.86 kg for the 0WHR, 5RWH, 10RWH and 20 RWH, respectively.

Feed conversion efficiency of the groups (10 RWH and 5 RWH) were better than the 0WHR and 20 RWH groups were 8.86, 9.57 and 10.29, 11.68 respectively.

Digestibility traits

Apparent digestibility of DM, CP, NDF, and ADF of treatment diets are given in (Table 3). The dry matter of the treated groups showed an improvement it's digestibility as compared to the 0WHR group and the values were 68.86, 72.72, 68.48 and 66.33% for the 5RWH, 10 RWH, 20RWH and 0WHR groups respectively.

Table 1: Ingredients and Chemical composition of experimented diets (% DM basis)

Item	Dietary treatment			
Ingredients (%)	0WHR	5WHR	10WHR	20WHR
Maize	60.0	55.0	50.0	40.0
Wheat bran	18. 5	18. 5	18. 5	18. 5
Barley	10.0	10.0	10.0	10.0
Soya bean	5.0	5.0	5.0	5.0
Sun flower cake	5.0	5.0	5.0	5.0
Water Hyacinths	0.0	5.0	10.0	20.0
$CaCo_3$	0.5	0.5	0.5	0.5
$NaCl_2$	0.5	0.5	0.5	0.5
Mineral-vitamin premix	0.5	0.5	0.5	0.5
Chemical composition g/100g				
Dry matter	89	89.3	89.2	89.04
Crude protein	12.5	12.6	13	13.6
Ether extract	5.8	5.3	5	4.6
Crud fiber	7.8	7.7	8.02	8.4
NDF	63.2	61,7	61.5	65.01
ADF	31.8	33.58	32.4	32
Ash	3.7	4.5	5.2	5.76
NFE	69.8	69.9	70.7	67.7
Metabolized energy Kcal/kg	2786	2691	2667	26340

WHR: water hyacinth replacement.

In the mean time, the crud proteins digestibility of 10RWH groups showed better digestibility than the 5RWH,20RWH and 0WHR group as they were 77.03, 75.75, 75.58 and 75.51 value respectively. High improving digestibility existed in natural degradation fiber (NDF), with using water hyacinth meal in the diet and were 68.41, 66.54, 64.07 and 62.67 for the 10RWH, 20RWH, 5RWH and control groups respectively.

The same trend was conducted in the digestibility of natural degradation fiber (NDF) was also improved with using water hyacinth meal in the diet as in NDF compared with control and were 34.56,35.93,34.64 and 32.78 % for the 5RWH, 10RWH, 20RWH and control, groups respectively.

Ruminal parameters

In the present study, replacing maize with water hyacinth in diet analysis of rumen liquor revealed that pH decreased in all groups inclusion water hyacinth in diet, but 10RWH diet decreased more rapidly and significantly (P≤0.05), whereas not significantly in 5WHR and 20WHR groups compared with 0WHR group. Increasing levels of WH in diets compared with maize (20%), reduced significant (P≤0.05) mean ruminal NH3-N concentration.

Total VFA concentration in rumen fluid was significantly (P≤0.05) higher in 10RWH compared to other groups and averaged 11.09±0.19 mmol/100cc (Table 4).

The protozoal motility and activities were found to be reduced Increasing levels of water hyacinths in diets compared with maize (20%).

Carcass assessment

The carcass dressing percentage was 49.46, 50.90, and 49.42% for diets that had 5,10 and 20% WH inclusion, respectively. It can be seen that as the amount of WH inclusion in the diet increases, the carcass dressing also increases. (Table 5). The carcass dressing was significantly (P<0.05) higher for 10RWH group compared 5RWH,20RWH and 0WHR group, whereas difference

Table 2: Body weight, gain, total feed intake and feed conversion efficiency (%) of experimented diet of Awassi lambs

Period weekly	0WH	5WHR	10WHR	20WHR	LSD
	Mean± S.E.	Mean± S.E.	Mean± S.E.	Mean± S.E.	
1st (Initial body weight)	17.78± 0.34 a	18.03±0.27 a	17.61±0. a	18.13±0.17 a	0.42
2 week from study	19.90±0.40 b	20.11±0.15 b	20.41±0.13 a	20.08±0.23 b	0.29
4 week from study	22.75±0.26 b	23.51±0.20 a	24.25±0.20 a	23.71±0.20 a	0.59
6 week from study	26.03±0.33 c	27.06±0.23 b	28.51±0.16 a	26.31±0.29 c	0.30
(final body weight)	29.70±0.27 d	31.33±0.32 b	33.05±0.13 a	30.21±0.21 c	0.28
Total wt. gain (kg)	11.91 ±0.30 c	13.30±0.32 b	15.63 ±0.32 a	11.98 ±0.11 c	0.43
Total feed intake (kg)	122.62±4.01 d	127.36±5.4 c	138.5±10.16 b	140.01±14.86 a	0.853
Feed conversion efficiency %	10.29%	9.57%	8.86%	11.68%	

*The different lowercase letters refer to significant differences between different treated groups at (P<0.05).

Table 3: Apparent digestibility coefficients of nutrients of experimental diets

Period weekly	0WHR	5WHR	10WHR	20WHR	
	Mean± S.E.	Mean± S.E.	Mean± S.E.	Mean± S.E.	LSD
Dry mater	66.33±0.88 c	68.86±1.18 b	72.72±0.75 a	68.48±0.67 b	1.02
Crud Protein	75.51±1.73 a	75.75±0.97 a	77.03±1.56 a	75.58±1.15 a	1.58
NDF	62.76±1.23 d	64.07±1.44 c	68.41±1.31 a	66.54±1.26 b	1.5
ADF	32.78±0.71 c	34.56±0.67 b	35.93±0.73 a	34.64±0.46 b	0.73

Table 4: Ruminal fermentation parameters of Awassi lambs fed experimented diets.

Variables	Dietary treatment				LSD
	0WHR	5WHR	10WHR	20WHR	
pH Value	6.21± 0.10 a	6.06±0.06 a	5.80±0.04 b	6.18±0.06 a	0.25
NH3-N concentration (mg/100ml)	10.63±0.40c	11.26±0.18b	11.75±0.11a	9.70±0.26 d	0.26
Total of VFA (mmol/100cc)	10.48±0.20 b	10.44±0.31 b	11.09±0.19 a	10.15 ±0.16 c	0.30
Protozoan motility	++++	++++	++++	+++	

Table 5: Carcass characteristics of Awassi lambs fed experimented diets.

Variables	Dietary treatment				LSD
	0WHR	5WHR	10WHR	20WHR	
Live body wt.	28.76 ±0.36 d	30.11±0.68 b	31.80±0.48 a	29.08±0.24 c	0.62
Slaughter wt.	26.70±1.1 c	28.76±1.2 b	29.33±1.3 a	27.36±0.8 b	0.53
Hot dressing%	48.03 ±0.12 c	49.46±0.19 b	50.90±0.14 a	49.42±0.16 b	0.256
longissimus dorsi length (cm)	13.73±0.25 d	14.93±0.2 b	15.73±0.25 a	14.51±0.31 c	0.41
Eye muscle area (mm)	381.3 ±3.6 c	387.6±1.9 b	404.1±1.9 a	389.1±2.0 b	7.71

*The different lowercase letters refer to significant differences between different treated groups at (P<0.05).

between (5RWH and 20RWH) was non-significant. Slaughter weight had a significant influence (P<0.005) on the weight of the carcass.

longissimus dorsi muscle length and eye muscle area of the 10RWH was significantly (P<0.05) longer than other groups, while 5RWH and 20RWH groups recorded better values than the 0WHR group and were (13.73 cm, 381.3mm), (14.93cm, 387.6mm) (15.73cn, 404.1mm) and (14.51cn, 389.1mm) for the 0WHR, 5RWH, 10RWH and 20RWH groups respectively.

DISCUSSION

The results of the proximate analysis of the experiment diet showed that the leaves meal exhibited a considerable potential as an aquafeed ingredient can be used as dietary protein source (NRC 2007). The CP contents of experimental diets were approximately similar. Sindhu *et al.* (2017) indicated that high protein content in the leaves and rapid growth have made WH potential for use as fodder for cows, goats, pigs, ducks, etc. Hossain *et al.* (2015) also reported that WH contains moderate crude protein content (10.5%) It can also assist farmers by ensuring sustainable production with the lowest cost diets for cattle.

It can be seen that as the amount of WH increased in the diet, the DM, CP NDF ADF also increased. Water hyacinth contains high amount of cellulose and hemi cellulose which acts as an energy source for ruminants (Mukherjee and Nandi 2004).The value of crude fibre was calculated as 7.8-8.4% present in the experimental diets. Fibre is the most common variable to predict the energy content of the substrate and also lies a close relation between the chemical composition and the substrate digestibility rate which correlates with the structural arrangements and linkage type between the components control the fermentation process (Rodrigues *et al.*, 2002).

The ash content on dry matter basis ranged 11.2%. Macro and micro mineral contents of WH from all the different water sources is within the recommended requirements for grazing animals (NRC, 1981). This is an indication that WH will supply the mineral requirements for animals.

Huang *et al.* (2013) investigated the effect of adding 30% of water hyacinth slag and wheat bran mixed silage on the growth performance of goats. Abdelhamid and Gabr (1991) stated that wilted water hyacinth replaced up to 50% of the concentrates in complete diets, and Islam *et al.* (2009) also reported that 50% wilted water hyacinth supplemented diets resulted in significantly higher CP in diets.

The increase in live body weight of all lambs after two weeks of the study up to the end of the experiment, indicated that those animals were at growth stage, this result is in consistency with previous explanation of (Ramzi, 2010).

In this experiment, the increased DMI was already expected due to the increased weight of animals. However, there was an interaction between diet and time for DMI. The partial replacement of maize by WH resulted in increased DMI ($P \leq 0.05$). In the other way, Tag EI-Din (1992) Sheep growth rate did not decrease when water hyacinth dry powder replaced 30% legume straw.

The lowest average total gains and feed intake recorded in animals base diet (0WHR) (Table 2). This might be due to the low intake of diet which could be associated with its high energy of diet, this increase in DMI occurred to compensate reduction in dietary energy concentration as WH was included in the diets. According to NRC (2007), the energy concentration in maize is higher than in WH (3.9 and 3.0Mcal of ME kg-1 of DM, respectively). Which differs from.

de Vasconcelos *et al*. (2016) reported that DM, OM, CP, and NDF intakes were linearly reduced with the replacement of Tifton-85 hay with WH hay. Aregheore and Cawa (2000) also reported that more than 25% fresh water hyacinth in the feed reduces intake.Substitution of concentrate mix with 50WHL and 75WHL resulted in higher ($P \leq 0.001$) total DM,OM, and CP intake than 100WHL.

Feed conversation efficiency (FCE) increased 10WHR,5WHR and decreased in 20WHR might be due to the high intake of water hyacinth leaf meal, which could be associated with its high nutrient detergent fiber content in diets (Table 2). Mekuriaw *et al*. (2013) There is higher weight gain and feed conversion efficiency in 50WHL and 75WHL than 100WHL. Islam *et al*. (2009) reported that wilted water hyacinth supplementation significantly improved the protein conversion efficiency of growing bullocks. The inclusion of the WH in the diets did not promote changes in the crude protein digestibility (Table 3) because the diets were isonitrogenous and the dry matter in diets was similar between the treatments. The water hyacinth leaf protein concentrate combined with other feeds has been reported to be a good quality protein source for animal feed formulation (Adeyemi and Osubor, 2016).

There were significant effects of WHL inclusion level on DM, NDF and ADF digestibility, all of which increased when the level of WH increased to 10% but decreased when the level of water hyacinth 20%. Abdelhamid and Gabr (1991) found in vitro organic matter digestibility (IVOMD) of fresh WH was 52%, and in a previous study (Tham *et al*., 2012) we found IVOMD values for leaf varying between approximately 40 to 65%.

The result of pH value measurement in rumen fluid shows normal condition where the pH value ranges from 6.65 to 7.0 The degree of acidity of rumen fluid is influenced by the type of feed consumed and the time of measurement. Feed materials containing non-structural carbohydrates will rapidly decrease the pH of rumen fluid. Low pH values after provision of concentrates is due to the fact that it is more easily fermented, according to (Suharti *et al*., 2015). The degree of acidity of rumen fluid is the main variable of rumen fermentation because the pH value change can alter the type of fermentation (Orskov and Ryle,1988).

The increase of NH3 in rumen fluid was due to the accumulation of NH3 resulting from feed protein degradation. Aurora, (1989) that ammonia in rumen fluid is derived from the degradation of feed protein and NPN (Non-Protein Nitrogen) by proteolytic microbes.

Volatile Fatty Acids are the end product of carbohydrate or protein fermentation and are primary products in the fermentation process of monosaccharides in the rumen making it the main energy sources for ruminants. Furthermore, crude protein content in the present study was 125-136 g/kg DM. Abdelhamid and Gabr (1991) reported values ranging from 52 to 130 g/kg DM depending on location and plant part (leaf or stem).

Rumen protozoan are sensitive to changes in pH as the growth, multiplication and motility of the protozoa is dependent on hydrogen ion concentration. The protozoan motility was active in 0,5,10 due to plenty of nutrients and optimal pH.

The increase in carcass dressing of sheep fed WH is very important since it means more meat yield per animal. This increased in carcass in the treated groups could be attributed in the muscle anabolism due to effect of WH inclusion in diets which improved the body weight performance might be due to an increase in digestibility as previously indicated and mentioned. Also, body weight improvement caused an increase in carcass weight then rib eye muscle area and it's length .The effect of slaughter weight on dressing percentage was significant, probably because the animals slaughter weights for animals were reflected in hot carcass. However, some authors (Beriain *et al*., 2000) reported a decrease in dressing percentage with the increase in slaughter weight, as the lightest animals did not have fully developed digestive tracts. As might be expected, heavier animals had heavier skin with lower legs weight.

The influence of slaughter weight on those indicators was reported by Marichal *et al*. (2003) in kids of different slaughter weights.

Eleraky and Mohamed (1996) investigated the addition of water hyacinth in the basal diet did not affect the slaughter rate. Measurement of the rib-eye area in the longissimus dorsi, together with other variables such as live weight, helps to predict the amount of muscle and fat yield in the carcass (Sahin *et al*., 2008) since rib-eye area correlates highly with live weight (Fernández *et al*., 1998).

Conclusions

The potential of water hyacinth leaf as an alternative protein source with maize in formulated diets for the Awassi lambs without adverse effects and give good results in term of growth performance. Water hyacinth leaves have relatively high CP content and could be utilized as fodder for ruminant and its concentrate replacement could be economically advantageous for sheep feeding in areas with great availability of this plant. Water hyacinth leaves can safely substitute concentrate mix up to 10% and result in the optimum growth of Awassi sheep.

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