Sun-Dried Bovine Rumen Content (SDRC) as an Ingredient of a Ration for White Leghorn Layers

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Abstract: Due to increasing price of conventional feeds, alternative locally available non-conventional feed ingredient is required for layers' production. Rumen contents are abundantly available as slaughterhouse by-product and mainly considered as waste material creating environmental pollution. Therefore, a study was conducted for 90 days to evaluate effects of sun-dried rumen content (SDRC) inclusion in layer rations on egg laying performance, egg quality parameters, fertility, and hatchability, chick quality and blood parameters. Treatment diets contained T1, T2, T3, and T4 at 0, 5, 10, and 15 percent SDRC, respectively. On chemical analysis, the rumen content contained 11.18% crude protein, 1.22% ether extract, 22.99% crude fibre, 21.54% ash and 1099.32 cal/kg of DM of metabolizable energy. The daily DM intake value increased ($P < 0.05$) with the increase in level of rumen content. The bird fed with 10 percent SDRC diet had a high DM intake. The weight gain and egg production of the laying hens reduced significantly ($P < 0.05$) as the level of rumen content increased. The average egg weight increased significantly ($P < 0.05$) with the increase in the level of rumen content. The feed to gain ratio increased as the level of rumen content increased in the diet. The hen fed T2 (5 percent SDRC) had the best feed to gain ratio. Most external and internal egg quality parameters, especially yolk color, were improved when the diet contained sun-dried rumen content (SDRC). Fertility, hatchability, early and mid embryonic mortality showed no significant differences among treatments. However, chick quality parameters increased ($P < 0.05$) with the increase in the level of rumen content. Mortality rate was not influenced by treatments. All blood parameters studied were within the normal range. It is concluded that under the condition of this experiment, diets up to 10% SDRC in the ration did not affect DMI, daily weight gain, egg production performances and blood parameters in white leghorn layers.

Keywords: White leghorns; SDRC; Egg mass; Egg quality; Fertility; Hatchability

1. Introduction

Feeding, which constitutes up to 70% of the total cost, is a major factor limiting poultry production in most developing countries. Poultry are most often dependent on cereal such as maize grain, which is stable food for human beings. Prices of these cereal crops are usually high and increases invariably. There is, therefore a need to explore, identify and utilize cheaper non-conventional alternative ingredients which attracts less competition. If properly processed and harnessed, one of such non-conventional feed source could be rumen content which is a waste material from abattoir and slaughter houses. Sun-dried rumen content (SDRC), a potential alternative feed source obtained from the rumen of ruminant animals consists of fermented and non-fermented dietary feeds that passed various stages of digestion in the rumen (Adeniji and Balogun, 2002). Rumen content contains the end products of microbiales metabolic activities such as microbial protein, amino acids, vitamins, volatile fatty acids (VFA) and contains no anti-nutritional factors (Okpanachi *et al*., 2010). It is fairly rich in crude protein (10-25 %) (Javanovic and Cuperloric, 1977). But, high percent of fibre content (25 %) has limited its use in poultry nutrition (Ricci, 1977). Rasyid *et al.* (1981) reported that an addition of 10% rumen content to broiler chicken feed did not affect its performance. Accordingly, its utilization as animal feed will increase the flexibility of ration formulation and reduce environmental pollution. Several relevant trials have been conducted on the suitability of dried rumen contents as feedstuff for livestock and fish such as rabbit (Okpanachi *et al*., 2010), broiler chickens (Colette *et al.,* 2013), Catfish (Agbabiaka *et al*., 2011), Nile Tilapia (Abdel-Hakim *et al*., 2008), feedlot Lambs (Salinas-Chavira *et al*., 2007) and Cattle (Cherdthong *et al*., 2014; Rios *et al*., 2010). There is currently no research based information on the use of rumen content for production of layers in Ethiopia. Therefore, this study was aimed at establishing the optimum inclusion level of sun-dried rumen content as feed ingredient in layers and on the subsequent laying performance of the hens.

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2.Material and Methods

2.1. Ingredients and Experimental Rations

The experiment was conducted on the main campus of Haramaya University's Poultry Farm. The feed ingredients used in the formulation of the different experimental rations in this study were rumen contents, maize grain, wheat short (WS), soybean meal (SBM), salt, vitamin premix, dicalcium phosphate and limestone. The rumen content was collected fresh from the abattoir of Haramaya University and sun dried for 3-4 days depending on the intensity of the sun. The remaining feed ingredients were purchased from the surrounding market. All the ingredients except wheat short, vitamin premix and dicalcium phosphate were hammer milled to pass through 5 mm sieve size and stored until required for chemical analysis and formulation of the experimental rations. The ingredients were then mixed based on their chemical composition to prepare the compound experimental rations. The four treatment rations used in this study were formulated on an isocaloric and isonitrogenous basis in such a way to consist 2800-2900 kcal ME per kg DM and 16-17% CP for layers (NRC, 1994).

2.2. Management of Experimental Hens

The existing concrete floor type poultry experiment house of Haramaya University poultry farm was used for the experiment. Pens, watering, feeding troughs and laying nests of the experimental house were properly cleaned, disinfected and sprayed before the placement of the experimental animals. The pens had the dimension of 2.5 * 2m with a stocking density of 3 hens per m^2. The floor of each pen was covered with saw-dust litter. The experimental hens were obtained from Haramaya University's poultry farm. Hens with no defects, uniform in size, and the same age were selected from a flock of hens in growers' house. A total of 204 hens of five months of age comprising 180 females and 24 males of White Leghorn breed were used for the study. The animals were given leg band numbers. These hens were weighed and randomly distributed into four treatments. The hens were acclimatized to the four treatment rations for 7 days and then fed for 90 days (experiment duration). All health precautions and disease control measures were taken throughout the study period according to the procedure followed by the poultry farm. Feed was measured and provided to the animals every day. The daily feed offer was divided into two equal parts and given to experimental hens in a group per pen at 08:30 and 14:30 hours *ad libitum* throughout the experimental period. Feed refusals were collected, weighed and recorded every next morning at 07:30 hours. The feeding and watering troughs were cleaned every morning before the daily meal is offered. Clean, fresh water was available to the animals every time. The hens were weighed individually at the beginning and at the end of the experiment in group using sensitive balance.

2.3. Experimental Design and Treatments

The design of the experiment was a completely randomized design (CRD) with 4 dietary treatments each with three replications. A total of 180 point of lay white leghorn hens (15 per pen) were randomly distributed to the 12 pens, each pen having 2 males of the same breed and age. The control diet was layers ration prepared without sun dried rumen content. The treatment ration to be used was formulated as indicated in Table 1.

2.4. Chemical Analysis

Except for dicalcium phosphate, salt, vitamin premix and limestone, representative samples feed ingredients used in the experiment were taken and analyzed before formulating the actual dietary treatments. The results of the analysis were used to formulate the ration. Samples were taken from each treatment ration bulked over the experimental period and sub sampled for chemical analysis at the end of the experiment. Thus, the total samples analyzed were 5 feed ingredients and 4 treatment rations. Dry matter (DM), ether extract (EE), crude fiber (CF) and ash were analyzed according to AOAC (1990). Nitrogen (N) content was determined by Kjeldahl method and crude protein (CP) was calculated as Nx6.25. Calcium (Ca) and total phosphorous (P) were determined by atomic absorption spectrometry (FAO, 1980). All the chemical analysis were analyzed in nutrition laboratory at Haramaya University. Metabolisable energy (ME) of the experimental diets was determined by indirect method according to Wiseman (1987) as follows:

$$ME\ (Kcal/kg\ DM) = 3951 + 54.4\ EE - 88.7\ CF - 40.8\ Ash \quad (1)$$

2.5. Measurements and Observations

Feed intake: The hens in each replicate were group fed, feeding being *ad libitum* for the entire length of the experiment. A weighed amount of feed was offered twice a day. Refusal was collected daily before offering fresh feed and weighed after removing external contaminants by visual inspection and hand picking. The feed offered and refused were recorded for each replicate and multiplied by respective DM contents. The amounts of feed consumed were determined as the difference between the feed offered and refused on DM basis. Similarly, the daily CP and ME intakes were calculated from the feed offered and refused and the differences were multiplied by the respective CP and ME concentrations.

Body weight measurement: The experimental hens were weighed individually on the first day of the commencement of the experiment and at the end of the experiment using sensitive balance. Average body weight gain for each replicate was computed by subtracting the initial weight from the final weight and dividing by the number of experimental days. The pen means were used for data analysis.

Egg production parameters: Egg number and egg weight were recorded daily to calculate percent egg production and egg mass. Eggs were collected three times a day from each pen at 1000, 1400 and 1800 hours. The sum of the three collections along with the number of hens alive on each day were recorded and summarized at the end of the period. Rate of lay for each treatment expressed as the average percentage hen-day egg production (HDEP) and hen-housed egg production (HHEP) were computed by taking the average values from each replicate following the method of Hunton (1995) as:

$$\% \text{ HDEP} = \frac{\text{Number of eggs collected per day}}{\text{Number of hens present that day}} * 100 \quad (2)$$

$$\% \text{ HHEP} = \frac{\text{Sum of daily egg counts}}{\text{No. of hens' originally housed}} * 100 \quad (3)$$

Egg weight and egg mass: Eggs collected daily was weighed immediately after collection for each replicate in the treatment. The average weight of daily collected eggs from each replicates was calculated as weight of all eggs divided by the number of eggs laid. After mean weight had been determined, the following formula was used to calculate the egg mass on daily bases (North, 1984).

Average egg mass = % Hen-day egg production * Average Egg weight in gram (4)

Feed conversion ratio: Feed conversion ratio per replicate was determined as a ratio of the total weight of feed consumed on DM basis and egg mass according to the following formula.

$$\text{FCR} = \frac{\text{Mean dry matter intake (g/hen/d)}}{\text{Average egg mass (g/hen/d)}} \quad (5)$$

Egg quality measurements: Internal egg quality parameters were measured for each replicate. For internal quality egg measurement, eggs were randomly picked and weighed once every week from each replicate. The weighed eggs were broken on a flat tray to measure shell weight, shell thickness, albumen height, haugh unit, albumen weight, yolk weight, yolk color, yolk diameter, yolk height and yolk index. The measurements were done by taking five eggs per replicate and a total of 15 fresh eggs per treatment were used for quality analysis.

Procedures followed to determine egg quality parameters were as shown below:
Eggs were broken on flat mirror and the different components were taken for internal and external quality parameters analysis. After breaking eggs, egg membrane was carefully removed from the shells and shell thickness was measured using micrometer gauge. The measurements were taken from three sites; the top (pointed part), bottom (round part) and the middle of the egg. Finally, the average of the three measurements was taken as shell thickness of each egg. Egg shell weight was measured using sensitive balance with 0.01g sensitivity. The albumen of the broken egg was carefully separated from the yolk. Tripod micrometer was used to measure the albumen height. Albumen quality was evaluated by calculating Haugh unit (HU). Haugh unit was determined according to the formula suggested by Standelman and Cotterill (1986).

$$HU = 100 \log (H + 7.57 - 1.7W^{0.37}) \quad (6)$$

Where: HU = Haugh unit; H= albumen height (mm); W= egg weight (g)

Albumen weight was calculated as the difference between the weight of the whole egg, and the weight of yolk and egg shell. The proportion of the albumen to egg weight was calculated by using the following formula.

$$\text{Albumen \%} = \frac{\text{Albumen weight (g)}}{\text{Weight of whole egg (g)}} * 100 \quad (7)$$

After the separation of the yolk and albumen, the quality of yolk was determined by taking the weight, diameter, height and its color. Yolk diameter was measured using graduated caliper. The yolk height of the broken egg was measured directly (without removing it from the albumen) using tripod micrometer and recorded to the nearest 0.1mm. Yolk weight was determined by using sensitive balance. After taking all the necessary measurements, first yolk membrane was removed; the yolk was stirred thoroughly to mix all parts. Then sample was taken on a piece of white paper and yolk color was determined by comparing the yolk sample with Roche color fan measurement strips which consists of a series of 1-15 colored plastic strips with one rated as very pale yellow to 15 representing a deep intense reddish orange color. Yolk quality was expressed also in terms of yolk index. It was determined as the ratio between yolk height and diameter according to the formula;

$$\text{Yolk Index} = \frac{\text{Yolk Height (mm)}}{\text{Yolk Diameter (mm)}} * 100 \quad (8)$$

Percentage of yolk to egg weight was determined by the following formula:

$$\% \text{ of yolk} = \frac{\text{Yolk weight (g)}}{\text{Weight of whole egg (g)}} * 100 \quad (9)$$

Fertility and hatchability: Medium size eggs and normal shape were selected by visual inspection for incubation. Before the commencement of incubation, the eggs collected from different treatments and their respective replicates were selected, weighed, coded and stored for not more than 5 days at a temperature of 10°C to l2°C. A total of 180 eggs (45 eggs from each treatment and 15 from each replicate) were incubated for fertility and hatchability estimation. Incubation was carried out between 8th to 11th weeks of the experiment period. Eggs were transferred to hatchery unit after 18th day of incubation. During incubation period, eggs were

candled to identify fertile and non fertile eggs and embryo mortality. Candling was conducted three times, at 9th, 14th, and 18th day of incubation. Those eggs that appeared relatively opaque were considered fertile and those that appeared clear were considered non-fertile. To confirm its clearness, break out analysis was done for the eggs identified as infertile. Chicks were hatched out after 21st day of incubation. The hatched chicks were then counted and weighed. The average percentage fertility per pen was calculated by dividing the total number of eggs found to be fertile at candling with total number of eggs set and multiplied by 100.

$$\% \text{ of fertility} = \frac{\text{Total fertile eggs}}{\text{Total eggs set}} * 100 \quad (10)$$

Hatchability as a percentage of fertile eggs was calculated by dividing the number of chicks hatched by the number of fertile eggs.

$$\% \text{ of hatchability on FEB} = \frac{\text{Number of chicks hatched}}{\text{Total fertile eggs}} * 100 \quad (11)$$

Where: FAB= fertile egg basis

2.6. Breakout Analysis

Breakout analysis was done to identify stages of embryo mortality of the incubated eggs. Eggs failed to hatch was removed from the hatchery tray, placed on egg flats and the exterior of the egg were examined first for piping and location of the air cell. The shell was cracked at the large end, over the air cell, and a hole opened in the shell and membranes to observe the interior of the egg. When the egg appeared to be infertile or contains a very early dead embryo, germinal disc was observed. When the embryo was relatively small, the egg was broken into a dish for further examination. Eggs with late stage embryos were observed for piping into the air cell, and then opened from large end to small end without disturbing the position of the embryo. According to Butcher (2009), the stages of embryo development were classified into early, mid, and late. Early embryonic development signs characterized by eye development, but without limb buds. The mid embryonic development signs characterized by limb development. The presence of feather in the embryo indicates late embryo development. In addition to this, live piped and dead piped identification was also done. Eventually, embryonic mortality of fertile eggs as early, mid, late, pip alive and pip dead was analyzed using logistic regression.

Chick quality: The quality of chicks was measured by visual observation, weighing and measuring the length of the chicks. Based on the quality standard stated by North (1984), chicks that are not malformed, with no unhealed navels, not dehydrated, physically active, stand up well and look lively were recorded good quality chicks. The visual observation was conducted by the researcher and experts of poultry farm. In order to measure the weight and length, one day old chicks were selected randomly from each replicate and their average was taken. The weight was taken using a sensitive balance and the length was measured by stretching the chick on the table and taking the length from the tip of the beak to tip of the middle toe using a ruler.

$$\text{Chick quality}^{\beta} = \frac{\text{Total No. of quality chicks}}{\text{Total No. of hatched chicks}} * 100 \quad (12)$$

$^{\beta}$= visual observation

Blood parameters: Blood samples on the first day before starting the experiment and at the end of the experiments were obtained from 4 randomly selected hens from each pen for all treatments. Blood samples were taken by inserting a sterile needle into the wing vein and extracting 1 ml of blood. The samples were then placed inside test tubes containing EDTA, properly shaken to mix with the EDTA to prevent coagulation. The blood samples were taken to the laboratory for analysis. Red blood cells (RBC) and white blood cells (WBC) were counted by Neubauer's improved haemocytometer. Packed Cell Volume (PCV) was calculated using the standard formula described by Dacie and Lewis (1991).

2.7. Data Analysis

Data on body weight, feed intake, egg production, feed conversion efficiency, egg mass, fertility, hatchability, egg quality and chick quality were subjected to statistical analysis using SAS version 9.1.3 (2002) with one-way ANOVA. The least significance difference (LSD) test was employed for separating means on when the F-tests were found to be significant. The following model was used for the analysis:-

$$Y_{ij} = \mu + T_i + e_{ij} \quad (13)$$

Where: Y_{ij} = the j observation taken under i treatment; μ = overall mean; T_i = treatment effect; e_{ij} = error term

Data on the early embryo mortality, mid embryo mortality, late embryo mortality, live pipped and dead pipped were analyzed by logistic regression.

3.Results and Discussion

3.1. Laboratory Analysis of Feed Ingredients and Treatments

The results of the laboratory analysis of the different feed ingredients used and the four experimental diets are shown in Tables 1 and 2, respectively. From the results, it could be seen that ruminal contents were lower in DM, CP, CF, ME and ether extract (Table 1) than the values given by Agbabiaka *et al.* (2011) and Colette *et al.* (2013). This may be due to vegetation diversity and selectivity of pasture by different ruminants in different locations. This result is consistent with the proposition that the composition of the rumen content is influenced by the pre-slaughter feeding regimen and the length of the holding period between feeding and slaughter (Abouheif *et al.*, 1999). Variation could also be due to the chemical

composition of the type of pasture grazed by the slaughtered animal and species differences (Dairo *et al.,* 2005). The CP value (11.18%) of the rumen contents obtained in our experiment was within the ranges (10-25%) as reported by Javanovic and Cuperloric (1977). The crude fiber content increased linearly with the increasing levels of rumen content (SDRC) in the diets. This could be attributed to the fibrous nature of the SDRC compared to other feed ingredients in the diets. The CF values obtained in the treatment diets were within a range (6 to 10%) that was reported to be optimum for poultry (NRC, 1994). Corroborating this result, Deaton *et al.* (1977) showed that diets with a CF content as high as 8.07% did not affect layer performance.

Table 1. Chemical composition of feed ingredients used to formulate the experimental rations[1].

Nutrient	Maize grain	SDRC	Wheat short	NSC	SBM
DM (%)	88.59	85.36	87.75	90.87	92.54
CP (% DM)	6.86	11.18	13.93	32.34	36.36
CF (% DM)	1.85	22.99	7.96	19.40	2.60
EE (% DM)	5.35	1.22	4.20	10.03	11.42
Ash (% DM)	2.20	21.54	4.96	8.14	6.49
ME (kcal/kg of DM)	3988.55	1099.32	3271.06	2443.74	4076.836
Calcium (% of DM)	0.03	0.20	0.25	0.38	0.56
Phosphorus (% of DM)	0.25	0.45	0.51	0.95	0.61

Note: [1]SDRC = sun dried rumen content; NSC = noug seed cake; SBM = soybean meal. DM = dry matter; CP = crude protein; EE = ether extract; CF = crude fiber; Ca= calcium; P= phosphorus; ME =metabolizable energy.

On the other hand, the control diet had the highest metabolizable energy level which may have resulted from the variation in the ingredients used in the other diets. The low metabolizable energy values of SDRC containing diets could be due to the lower energy value of SDRC (1099.32 kcal/kg of DM) in the ration (Table 2).

Table 2. Proportion of ingredients used in formulating the layers ration and chemical composition of the treatment ration.

Item[1]	Treatment[2]			
Ingredient (%)	T1	T2	T3	T4
Maize grain	46	45	42	40
SDRC	0	5	10	15
Wheat short	16	13	14	12
NSC	24	23	20	19
SBM	5	5	5	5
Vitamin premix	0.8	0.8	0.8	0.8
Salt	0.5	0.5	0.5	0.5
Limestone	7	7	7	7
Dicalcium phosphate	0.7	0.7	0.7	0.7
Total	100	100	100	100
Nutrient content				
DM (%)	90.73	90.26	90.34	89.86
CP (% DM)	17.84	16.55	16.18	16.09
CF (% DM)	6.44	7.86	9.53	9.32
EE (% DM)	9.09	9.24	7.99	7.65
Ash (% DM)	11.82	13.94	13.70	13.88
Ca (% DM)	3.88	3.81	3.24	3.31
P (% DM)	0.40	0.37	0.43	0.42
ME (kcal/kg of DM)	3244.15	3187.40	2981.10	2974.45

Note: DM = dry matter; CP = crude protein; EE = ether extract; CF = crude fiber; P = phosphorous; Ca = calcium; ME = metabolizable energy.
[1]SDRC = Sun dried rumen content; NSC = noug seed cake; SBM = soybean meal..
[2]T1 = Diet containing 0% SDRC; T2 = diet containing 5% SDRC; T3 = diet containing 10% SDRC; T4 = diet containing 15% SDRC.

The crude protein and metabolisable energy contents of the rations slightly decreased with the increasing levels of SDRC (Table 2). However, the CP and ME levels were within the ranges of the recommended levels of 16-18% and 2500-3300 kcal/kg, respectively for white leghorn layers (Tadel1e, 1997 and Leeson and Summers, 2001). Generally, the four treatment rations used in the current study were nearly comparable in their CP and ME contents.

Dry matter intake: The DM intake of layers is presented in Table 3. The dietary treatments had significant ($P < 0.05$) effect on the DM intake of the laying hens. The DM intake values obtained increased ($P < 0.05$) with the increase in the level of rumen content in the diets. DM intake was significantly lower in the control diet-fed groups as compared to the rumen content-fed group, which might be due to better utilization of nutrients in the former. In our experiment, the rumen content diets were readily accepted by the laying hens at the first offer which showed there was no palatability problem with the SDRC diets.

The increase in average DM intakes of the hens as SDRC increased in the diets may be attributed to the dilution of nutrients by the dietary fiber thereby reducing the nutrient composition and consequently the energy. Hens must, therefore, eat more to meet their energy requirement to sustain rapid growth and development, hence the increased DM intake. This observation is in agreement with the findings of Juvanovic *et al.* (1977) who reported that rumen content containing diets induced more feed intake as compared to the control diet. Similar results were found by Esonu *et al.* (2006) who reported higher feed consumption in groups fed with diet containing rumen content than the control. Consistent with the results Adeniji (2008) also reported that rumen content containing diet induced more feed intake than the control treatment. However, our results disagree with the findings of Abouheif *et al.* (1999), who observed a decrease in DM intake in rumen content based diet groups as compared to other diets.

Table 3. Dry matter intake, BW change, and egg laying performances of hens fed on a ration containing sun dried rumen contents at different levels.

	Treatment[1]					
Parameter	T1	T2	T3	T4	SEM	SL
DM intake (g/hen per day)	81.47b	83.87ab	86.40a	84.19ab	1.01	*
CP intake (g/hen per day)	14.89a	13.88b	13.98b	13.58b	0.28	*
ME intake (g/hen per day)	282.84a	267.31b	257.56bc	250.43c	7.01	*
Initial BW (g)	977.56	995.87	950.58	987.87	9.87	NS
Final BW (g)	1157.63a	1155.42a	1119.85b	1122.42b	10.24	*
BW gain (g/hen)	180.08a	159.56ab	169.27ab	134.55b	9.72	*
AD gain (g/hen)	2.00a	1.77ab	1.88ab	1.50b	0.11	*
Total egg/hen	54.93a	54.62a	49.71ab	44.87b	2.38	*
HDEP[2] (%)	61.30a	62.36a	56.59ab	50.44b	2.72	*
HHEP	61.01a	60.69a	55.24ab	49.85b	2.64	*
Egg weight (g)	46.92b	48.66a	48.88a	47.79ab	0.45	*
Egg mass (g/hen per day)	28.87a	30.40a	27.70a	24.28b	1.30	*
FE (g of egg/g of feed DM)	3.06b	2.96b	3.35b	3.88a	0.21	*
Mortality rate	2.22	8.89	8.89	4.44	1.67	NS

Note: [a, b]Means within a row with different superscripts differ significantly ($P < 0.05$).
*[2]T1 = diet containing 0% SDRC; T2 = diet containing 5% SDRC; T3 = diet containing 10% SDRC; T4 = diet containing 15% SDRC. *=$P > 0.05$. [2]HDEP = hen-day egg production, SL = significant level, * $P < 0.05$, NS = not significant*

Body weight gain: There were positive responses in the weight gain and final weight of hens up to 10% level of SDRC inclusion. Although, there were no significant differences between the 0 and 10% SDRC diets, significant ($P < 0.05$) differences occurred between the 0 and 15 percent SDRC diets. The slight decrease in weight gain indicated the effect of the fibrous nature of the rumen content. Sonaiya *et al.* (1989) reported that fiber causes depression in the proportion of energy digested and retained for metabolism. Awotoye (1991) also reported a gradual decrease in weight gain of experimental broiler hens when dietary level of dried rumen content increased. But our results disagree with the results of Esonu *et al.* (2006) who observed general increment in growth rate as dietary inclusion of dried rumen content increased.

Egg production: Hen-day egg production (HDEP) and hen-housed egg production (HHEP) of White leghorn hens consumed diet containing different levels of sun dried rumen content is presented in Table 3. The mean number of eggs produced per bird during the experiment period, HDEP, HHEP, and egg mass were significantly different between treatments. Total eggs produced per hen, HDEP (%), HHEP and egg mass were significantly lower ($P < 0.05$) for 15 percent SDRC diets (T4) as compared to the other treatment (Table 3). The percentage hen day egg production values obtained for T1, T2 and T3 were similar ($P > 0.05$), indicating uniformity in the laying pattern and quantity of egg laid by the hens. Better egg production parameters recorded for control diet is due to the better nutrient balance. The findings in this trial agree with the observations of Adeniji (1995) who recorded a stepwise decrease in egg production for fed diets containing high levels of a mixture of blood and rumen content. Concurrently, the intake of major nutrients like protein and energy would be adversely affected in

fed 15 percent SDRC diets (T4) (Table 3), hence the poor laying performance recorded. Layers on diets 4 performed more poorly than those fed diets 2 and 3 possibly as a result of nutrient imbalance.

Egg weight and egg mass: The effect of varying levels of SDRC in layers' ration on egg weight and egg mass is presented in Table 3. The mean egg weight seemed comparable for hens fed on SDRC containing diets, except for the eggs laid by the hens on control diet that were significantly ($P < 0.05$) smaller (46.92 g) as compared to T2 and T3. It is suggested that an inverse relationship exists between the rate of lay and egg size. This might have caused the very low egg weight from hens on the control diet which had the highest rate of lay in this study. Egg mass was significantly lower ($P < 0.05$) for hens fed 15 percent SDRC diets. Fakhraei *et al.* (2010) noted that egg mass followed the same trend as egg production, and the same trend has been seen in the present study as well.

Feed conversion ratio: The effect of including varying levels of SDRC in layers' ration on feed conversion ratio expressed as feed consumed per egg mass is presented in Table 3. Differences were observed in the efficiency with which the feeds were converted into egg. The 5 percent SDRC diet though, proved a little bit more efficient than the control although, it was not statistically better ($P > 0.05$) than the control or 10 percent SDRC diet. The 15 percent SDRC diet proved to be the least efficient. This situation is in accordance with the differences in egg production. T1 and T2 produced higher percentage of eggs; as a result, they are efficient in nutrient utilization.

Table 4. Egg quality characteristics of hens fed a ration containing sun dried rumen contents at different levels.

	Treatment[1]					
Parameter	T1	T2	T3	T4	SEM	SL
Sampled egg weight (g)	49.26b	50.03ab	50.88a	50.96a	0.40	*
Shell thickness (mm)	0.32	0.32	0.31	0.31	0.00	NS
Shell weight (g)	5.713ab	5.82a	5.31ab	5.17b	0.16	*
Albumen height (mm)	8.98	8.38	8.70	8.77	0.12	NS
Albumen weight (g)	28.77	29.03	28.90	29.64	0.19	NS
Haugh unit	96.72a	93.53b	94.56ab	95.23ab	0.67	*
Yolk weight (g)	14.42	14.65	14.38	14.79	0.09	NS
Yolk height (mm)	15.19	15.46	15.25	15.51	0.08	NS
Yolk diameter(cm)	38.10 b	38.83a	38.43ab	38.51ab	0.15	*
Yolk index	0.40	0.40	0.39	0.40	0.00	NS
Yolk color (RCF)[2]	1.81c	2.79b	4.80a	5.17a	0.80	*

Note: [a–c]Means within a row with different superscripts differ significantly ($P < 0.05$).
*[1]T1 = diet containing 0% SDRC; T2 = diet containing 5% SDRC; T3 = diet containing 10% SDRC; T4 = diet containing 15% SDRC, [2]RCF = Roche color fan, SL = significant level, * $P < 0.05$, NS = not significant.*

Egg quality characteristics: An increasing trend of sample egg weight was observed as the inclusion level of SDRC increased. Significantly smaller egg was laid by hens fed the control diet as compared to hens consumed 10 percents of SDRC diet. However, egg shell weight significantly differed only between hens fed with 5 percent SDRC diet and 15 percent SDRC diet, being lower in the 15 percent SDRC diet. But, egg shell thickness was not significantly affected by dietary treatments. The mean values for the shell thickness observed across the treatments in this study were similar. The similarity in these values showed that SDRC has no adverse effect on the metabolism of either calcium or phosphorous of the diets. Values observed in this study agreed with the report (0.33-0.36 mm) given by Sakunthala and Reddy (2004) for white leghorn eggs. Egg albumen weight and albumen height were not significantly affected ($P > 0.05$) by dietary treatments. However, there was significant difference ($P < 0.05$) in percentage of Haugh unit.

Haugh unit was greater ($P < 0.05$) for control diet than 5 percent SDRC diet and was similar ($P > 0.05$) among other treatments. Haugh unit determines albumen quality and the highest HU refers to good quality albumen. In this study, all treatments scored HU within the recommended range of 70-100, which is an indication of good egg quality (Lewko and Omowicz, 2009). There was no significant ($P > 0.05$) difference among dietary treatments in yolk weight, yolk height and yolk index (Table 4), despite the expected positive association between egg weight and yolk weight (Suk and Park, 2001). Yolk height and yolk index was greater ($P < 0.05$) for the diet with no SDRC but was similar ($P > 0.05$) among the SDRC containing diets. Contrary to the current result, Sekerodlu and Ebubekr (2009) reported that yolk height and yolk index increased with egg size. Therefore, the results regarding effects of nutrition on yolk index appeared to be inconclusive. There was significant ($P < 0.05$) difference among dietary treatments in yolk diameter and yolk color (RCF) (Table 4). The Roche color fan values showed higher ($P < 0.05$) yolk color score for T4 (15 percent SDRC diet) and T3 (10 percent SDRC diet) and lighter yolk color for T1 (0 percent SDRC diet). Smith (1996) reported that the color of the yolk is determined by the presence and absence of xanthophylls, some of which are precursor of vitamin A. Therefore, the color of the yolk is influenced to a

large degree by nutrition of the hens. The present result showed that as the level of SDRC increased, the intensity of yolk color increased. Xanthophyll of rumen content (mainly consists of greens) is expected to fulfill the needs for egg yolk pigment or poultry skin pigment (Wizna *et al.*, 2008).

Fertility, hatchability, chick quality and embryo mortality: Fertility, hatchability, chick quality, early, mid embryo mortality parameters and pip embryo mortality % appeared to be not negatively affected (P > 0.05) by the dietary inclusion of SDRC in the present study (Table 5). However, fertility and hatchability of eggs were actually improved in the diets containing SDRC as compared with the control diet. Correspondingly, embryo mortality also decreased as the level of SDRC increased. As documented by Hocking *et at.* (2002) poor hatching results occur when nutritionally deficient feeds are used for layers. Odunsi *et al.* (2002) also stated that inadequacy of nutrients in the breeder diets resulted in poor hatchability of fertile eggs. Thus, the present result indicated that inclusion of rumen content did altered nutrients that enhance fertility of particularly males, and hatchability of eggs.

Table 5. Fertility, hatchability, embryonic mortality, and chick quality of hens fed a ration containing sun dried rumen contents at different levels.

	Treatment[1]					
Parameter	T1	T2	T3	T4	SEM	SL
Fertility (%)	95.56	90.00	94.44	97.78	1.64	NS
H on total eggs set basis (%)	63.33	73.33	72.22	78.89	3.22	NS
H on fertile egg basis (%)	66.05	82.38	76.35	80.77	3.67	NS
Early embryo mortality (%)	8.19	2.38	4.80	2.22	1.39	NS
Mid embryo mortality (%	6.99	2.22	5.91	2.22	1.24	NS
Late embryo mortality (%)	10.49a	7.38b	5.99b	4.44b	1.29	*
Pip embryo mortality (%)	2.22	4.52	4.72	2.22	0.69	NS
Chick weight (g)	30.39b	31.46ab	31.62a	32.05a	0.35	*
Chick length (cm)	14.50b	14.49b	14.63ab	14.85a	0.084	*
Chick quality Visual score	96.64ab	94.41b	100.00a	98.81a	1.23	*

Note: [a,b]Means within a row with different superscripts differ significantly (P < 0.05).
*[1]T1 = diet containing 0% SDRC; T2 = diet containing 5% SDRC; T3 = diet containing 10% SDRC;T4 = diet containing 15% SDRC, SL = significant level, * P < 0.05, NS = not significant.*

Durmus *et al.* (2004) noted increased hatchability with increasing zinc concentration in the diets of Brown parent stock layers. The study of Brown and Pentland (2007) showed that zinc helps in protecting the structure of the genetic material or the DNA chromatin in the sperm nucleus, a structure important for successful fertilization. Rumen content contains significant amount of iron, phosphorus, calcium, and is relatively rich in vitamin C (Agbabiaka *et al.*, 2012). Adesola *et al.* (2012) reported improved hatchability as a result of ascorbic acid supplementation to diets of indigenous Venda hens. However, the relatively poor hatchability and higher embryonic mortality observed in the control group might be happening due to a deficiency in critical nutrients, such as zinc, vitamin E, and so on, which are important for better hatchability (Park *et al.*, 2004; Mahmood and Al-Daraji, 2011). In the present study, the feed ingredients, as well as the formulated experimental rations, were not analyzed for such nutrients. Gabreil *et al.* (2006) reported that level of dietary protein significantly affected egg fertility and hatchability. The similarity in fertility and hatchability among treatment of the present study may be related to similarity in nutrient use or the efficiency of nutrients absorbed from the egg. Thus, the result indicated that replacing malted barley for maize up to 30% did not negatively affect fertility and hatchability.

There was significant (P < 0.05) difference among dietary treatments in chick weight; length and visual score (Table 5). As compared with the control diet, chick quality parameters were actually improved in the diets containing SDRC. Differences in chick weight observed in our study appeared to be attributable to comparable variations in egg weight. This observation is in agreement with the findings of Abiola *et al.* (2008) and Malago and Baitilwake (2009) who noted a positive correlation between egg size and chick weight at hatching.

Table 6. Blood parameters of hens fed a ration containing sun-dried rumen contents at different levels.

Parameter	Treatment[1]				SEM	SL
	T1	T2	T3	T4		
PCV (%)						
Before the experiment	29.68ab	31.83a	26.92b	28.67b	1.03	*
At the end of experiment	34.08	32.33	35.17	33.67	0.59	NS
RBC (10^6/µl)						
Before the experiment	3.32a	2.94b	3.13ab	3.29a	0.09	*
At the end of experiment	3.77ab	3.31b	3.93a	3.78ab	0.13	*
WBC(10^3/µl)						
Before the experiment	22.3a	18.65b	17.93b	18.59b	0.58	*
At the end of experiment	18.97	18.0	17.02	24.0	1.51	NS

Note: RBC = red blood cell, WBC = white blood cell, HB = haemoglobin, PCV = packed cell volume. SL = significant level
** P < 0.05, NS = not significant.*

Blood parameters: Blood analysis (Table 6) revealed that treatment had significant effect ($P < 0.05$) on red blood cells (RBC) before and after experiments. Though at the end of experiment blood analysis showed no significant effect of dietary treatments on PCV values and WBC total count, there were significant difference ($P < 0.05$) in PCV and WBC before the experiment. Generally, inclusion of SDRC to layer diets significantly improved PCV and RBC of the hens as it indicated in mean values shown before and after the experiments. The results showed that the values for all the parameters were within the normal range (Schalm *et al.*, 2010), though there were differences within treatments. Thus, dietary treatments had no negative effect on the health status of the hens. Laying hens fed high level of SDRC diets had better WBCs and RBCs. This showed that these hens have enhanced immune-competence to handle physiological stress.

4.Conclusion

Results of the present study have demonstrated that up to 10% sun-dried rumen content can be included in the diets of white leg horn layers without compromising production performance and the health status of the layers. The results implied the rumen content is a potential feedstuff for layers; it is economical and simple to practice. The SDRC is a promising feedstuff particularly during the periods of scarcity and high cost of conventional feeds. Its utilization also alleviates the problem of environmental pollution and disposal of rumen content in abattoirs.

To fully explore the potential of rumen contents as a feedstuff in layers' nutrition long-term feeding trials should be performed. In addition, the impact of different preservation methods (e.g. drying and ensiling) on the nutritional value of rumen contents needs further investigations. Moreover, the economic aspects of sun-dried rumen content feeding, which include feed costs, animal performance and carcass traits, need to be evaluated.

5.Acknowledgements

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