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EFFECT OF REPLACEMENT OF BARLEY GRAINS AND SOYBEAN MEAL BY DISTILLER'S DRIED GRAINS WITH SOLUBLES WITH OR WITHOUT SUPPLEMENTED SEAWEED IN GROWING RABBIT RATIONS ON: 4- Nutrients digestibility, nutritive values and some caecum fermentation.

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Twenty seven New Zealand White (NZW) rabbits with an average live body weight (LBW) of 2.07 kg ± 0.062 and 12 weeks old were divided into nine similar groups (3 in each). The experimental groups were fed randomly on one of the nine formulated experimental rations used. The 1st ration (R1) was used as a control, which contained: 10 % yellow corn +[10 % barley + 13.7 % soybean meal +20 % wheat bran +40 % clover hay + 3 % molasses + 1 % dicalcium phosphate + 1.2 % limestone + 0.5 % sodium chloride + 0.4 % premix + 0.2 % methionine]. The substitution was equal parts of barley and SBM by 10 % and 20 % DDGS for ration 2 (R2) and ration 3 (R3), respectively. The supplemented seaweed (SW) for these rations was at two levels. The first level was by 0.5 % seaweed of the total mixed ration for ration 4 (R4), ration 5 (R5) and ration 6 (R6). The second level was by 1.0 % seaweed of the total mixed ration for ration 7 (R7), ration 8 (R8) and ration 9 (R9). All rations were in pelleted form and nearly isonitrogenous and isocaloric.

The results of the present study revealed that the dry matter intake was increased ($P < 0.05$) when feeding on R8 (10 % DDGS + 1 % SW) (128.91 g/h/d) and R6 (20 % DDGS + 0.5 % SW) (126.67 g/h/d) than the other rations. The highest TDNI (g/h/d) ($P < 0.05$) values were obtained in groups fed on R6 (20 % DDGS + 0.5 % SW) or R8 (10 % DDGS + 1.0 % SW) being 90.18 and 91.40, respectively. The DEI (kcal/h/d) had also, the same trend as TDNI, but DEI increased ($P < 0.05$) with feeding on R3 *than feeding the other experimental diets, while the lowest value was observed with feeding on R1.*

The digestible crude protein intake to digestible energy (g/Mcal) value was higher ($P < 0.05$) with feeding in R4 (42.51) than the other rations, but feeding on R1, R5, R8 and R9 increased significantly ($P < 0.05$) the DCPI / DEI (g/Mcal) (41.19, 41.95, 41.01 and 41.21, respectively) than feeding on R2 or R3 or R7 (40.32, 38.38 and 39.61 g/Mcal, respectively).

The DCFI / DEI (g/Mcal) value was higher ($P < 0.05$) with feeding on R3 (22.46) than the other rations, while the other rations were ranged from 15.30 to 18.92 (g/Mcal).

The DEEI / DEI (g/Mcal) value was higher ($P < 0.05$) with feeding on R3 (14.28) than the other rations, but feeding on R6, R8 and R9 (13.41, 13.25 and 13.89, respectively) were higher than feeding on R1, R2, R4, R5, and R7 (6.70, 9.62, 8.78, 10.86 and 7.96, respectively).

The DNFEI / DEI (g/Mcal) values were decreased ($P < 0.05$) with feeding on DDGS with or without SW. The highest values were observed with feeding on R1, R4 and R7 (155.84, 148.46 and 154.65, respectively), while the lowest values were with feeding on R3, R6 and R9 (135.06, 138.39 and 138.89, respectively).

Caecal pH varied between 5.61 and 6.28. The pH values were not significantly affected by the feeding programme. Ammonia – N concentration was increased ($P<0.05$) with increasing the level of supplemented SW in the rations. The mean values were (9.96, 13.06 and 17.12 mg/100 ml) for (0.0, 0.5 and 1.0 % SW, respectively).

Keywords: Distiller dried grain with soluble, Digestibility, Rabbits, Caecum fermentation.

In the last 20 years, rabbit production has become an increasingly intensive system, such that productivity is now equivalent to that obtained in other intensively farmed species. The importance of nutrition has increased significantly as feed cost, pathological conditions associated with energy and nutrient deficiencies and considerations of product quality have become limiting factors to economic output from a unit. The rabbit is unique. It requires a high daily nutrient and energy intake but, because it is an herbivore, it also needs a diet with a high concentration of fiber to ensure optimum performance and, in addition, to minimize the incidence of digestive disorders (McNitt *et al*., 1996).

High starch diets are often incompletely digested in the rabbit small intestine due to rapid transit time (McNitt *et al*., 1996). Incomplete digestion of starch prior to the large intestine results in the availability of starch for microbial fermentation (Stevens and Hume, 1995). Excess starch in the gut results in an extremely rapid fermentation with possible spilling of energy leading to low Y_{atp}. For example, Oba and Allan (2003) showed that, as the rate of starch digestion increased, the Y_{atp} was reduced from 60g of microbial N/kg starch digested to approximately 30 g microbial N/kg starch digested. The rapid digestion of starch could lead to a much lower microbial cell yield in starch fermentation in the caecum of concentrate-fed as compared to forage-fed rabbits.

Distiller's dried grains with solubles (DDGS) are a valuable feed ingredient which is a co-product of dry mill ethanol production from grains. In ethanol production, the starch is fermented to obtain ethyl alcohol, but the remaining components of the grain kernel (endosperm, germ) preserve much of the original nutritional value of the grain including energy, protein and phosphorus (Bremer *et al*., 2005). For ruminants, this palatable, low starch product offers a high level of bypass protein, B vitamins and highly digestible fiber.

Aga *et al*. (2000) used a calcified seaweed as a buffer in continuous culture of rumen contents. The chemical composition of an ordinary seaweed as from *Ascophyllum nodosum*, immediately characterizes the material as of low energy content. According to the analytical data, the value of seaweed meal must primarily be sought in its content of vitamins and mineral, among which β-carotene, tocopherols, some B vitamins, iodine, zinc and potassium are the more important (Scott, 1990). The rational way of using seaweed meal in rations would be to let this component supply the above active substances according to the analytical data and to add the factors to obtain a balanced diet. Sykes (2009) reported that seaweed is totally natural multi-mineral supplement. Seaweed contains all mineral and trace elements an animal requires for a normal healthy life.

Very little research has been conducted to evaluate the feeding value of DDGS for rabbits (Villamida *et al*., 1989). Rabbits fed the DDGS diet had the highest level of protein digestibility (70.1 %) compared to rabbits fed the wheat bran (66.6 %) and corn gluten fed (61.4 %) diets. These results suggest that DDGS is suitable ingredient for rabbit diets and provides more digestible energy, ADF and protein.

Therefore, the objective of this study was to evaluate the effect of partially or totally substituting of barley and partially of soybean meal by DDGS with or without seaweed supplementation on nutrients digestibility, nutritive values and some caecum liquor parameters.

MATERIALS AND METHODS

The experimental field of the present study was carried out at the Experimental Station of the Poultry Production Department, while, the chemical analyses were run at the Laboratory of the Animal Production Department, Faculty of Agriculture, Mansoura University, Mansoura, Egypt.

Experimental animals:

Twenty seven NZW rabbits with an average live body weight (LBW) of 2.07 kg ± 0.062 and 12 weeks of age were divided into nine similar groups (3 in each). The rabbits were housed in separate metal cages with the following dimensions (50x50x45cm) for length, width and height, respectively.

Nine digestibility trials were conducted to determine the digestibility coefficients and feeding values, as well as caecum fermentation of the tested rations.

Treatments and design:

The experimental groups were fed randomly on one of the nine formulated experimental rations used. The experimental rations were designed to gradually substitute barley grains and soybean meal (equal parts) by distiller dried grains with soluble (DDGS) at the rate of 10 and 20 % of the total mixed rations. Ration 1 (R1) contains 10 % barley and 13.7 % SBM (control), and substituting the equal parts of barley and SBM by 10 % and 20 % DDGS for ration 2 (R2) and ration 3 (R3), respectively. The supplemented seaweed for these rations was at two levels of the wheat bran. The first level was by 0.5 % seaweed of the total mixed ration for ration 4 (R4), ration 5 (R5) and ration 6 (R6). The second level was by 1.0 % seaweed of the total mixed ration for ration 7 (R7), ration 8 (R8) and ration 9 (R9). All rations were offered in pelleted form and nearly isonitrogenous and isocaloric.

Seaweed (Ascophyllum nodosum):

The seaweed from *Ascophyllum nodosum* has been obtained from the local market. Baardseth (1970) reported that kelp meal contains, as well as, 18 amino acids, 60 mineral and trace elements. Kelp meal rich in N, carbohydrates and also contains considerable amounts of β-carotene (the precursor of vitamin A), as well as, Vit. E, D, K and some B vitamins. The typical analysis of seaweed was as a follows:

Average (%):			
Moisture	12.0 %	Fat	2.0 %
Crude protein	6.0 %	Carbohydrates	52.0 %
Crude fiber	6.0 %	Total	100 %
Ash	22.0 %		
Minerals:			
Calcium (Ca)	1.0 – 3.0 %	Magnesium (Mg)	0.5 – 1.0 %
Cobalt (Co)	1 – 10 ppm	Manganese (Mn)	0.5 ppm
Copper (Cu)	4 – 15 ppm	Sodium (Na)	2.4 – 4.0 %
Iron (Fe)	0.015 0.10 %	Sulfur (S)	2.0 – 2.3 %
Iodine (I)	0.015 – 0.08 %	Selenium (Se)	3 – 4 ppm
Potassium (K)	2.0 – 3.0 %	Zinc (Zn)	35 – 100 ppm
Vitamins:			
Biotin	0.1 – 0.4 ppm	Riboflavin	5 – 10 ppm
Carotene	30 – 60 ppm	Thiamin	1 – 5 ppm
Folic acid	0.1 – 0.5 ppm	Tocopherols	150 – 300 ppm
Niacin	10 – 30 ppm		
Amino acids (g / 100 g CP - N):			
Alanine	5.3	Glycine	5.0
Arginine	8.0	Lysine	4.9
Aspartic A.	6.9	Methionine	0.7
Glutamic A.	10.0		

Baardseth (1970).

Experimental rations:

The Experimental rations were formulated to provide adequate energy and protein for growing rabbits. Nine Experimental rations were formulated to be more than 16 % protein according to the (NRC, 1977) recommendations. The constituents of the experimental rations, their percentages and the calculated chemical constituents for CP and CF are presented in Table 1.

Digestibility trials:

Rabbits were housed individually in metabolic cages. All rabbits were given their daily feed allowances at 10 am *ad libitum*. Drinking water was available at all times. Feces were collected quantitatively for 5 days. The feed intake (*ad libitum*) and the total fecal output were recorded for each separate group for a 5 days. Composite samples of each ration were taken for analysis at the beginning of experimental period. A composite sample for each separate group was also made from the daily feces voided. It was firstly dried at 60˚C overnight, and then finally dried at 105˚C for 3 hours (hrs).

Table 1. Formulation of the experimental rations offered to the experimental rabbits.

Items	R1	R2	R3	R4	R5	R6	R7	R8	R9
DDGS	**0 %**	**10**	**20**	**0 %**	**10**	**20**	**0 %**	**10**	**20**
SW		**0 %**			**0.5 %**			**1 %**	
Yellow corn	10	10	10	10	10	10	10	10	10
Barley	10	5	0	10	5	0	10	5	0
Soybean	13.7	8.7	3.7	13.7	8.7	3.7	13.7	8.7	3.7
DDGS*	0	10	20	0	10	20	0	10	20
Wheat bran	20	20	20	19.5	19.5	19.5	19	19	19
Clover hay	40	40	40	40	40	40	40	40	40
Seaweed (SW)	0	0	0	0.5	0.5	0.5	1	1	1
Molasses	3	3	3	3	3	3	3	3	3
Calcium di phosphate	1	1	1	1	1	1	1	1	1
Limestone	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Sodium chloride	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Premix	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Methionine	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

DDGS: Distiller dried grains with solubles.

Premix: A vitamin - mineral mixture was obtained from Misr Feed Additive Co.. Contents each 1.5 kg of the Premix were Vit A, 12000000 IU; Vit D_3, 2200000 IU; Vit E, 10 gm; Vit K_3, 2000 mg; Vit B_1, 1000 mg; Vit B_2, 5000 mg; Vit B_6, 1500 mg; Vit B_{12}, 10 mg; Nicotnic, 30000 mg; Pantothenic, 10000 mg; Folic acid, 1000 mg; Biotin, 50 mg; Ca Co_3: add to 1.5 kg; Manganese, 60 gm; Zin, 50 gm; Iron, 30 gm; Copper, 4 g; Iodin, 1 gm; Selenium, 0.10 gm; and Cobalt, 0.10 gm. The inclusion rate was 4 Kg / ton of feed to cover the requirements of growing rabbits according to NRC (1977) recommendations.

Chemical analysis and procedures:

The official methods of the AOAC (1990) were used for the convential nutritive analysis using triplicate samples of 1 – 2 g and results were found to be consistent. Feed and feces samples were analyzed for DM, OM, nitrogen (N), CF, EE, and ash. The factor 6.25 was used for calculating crude protein. Nitrogen free extract % was obtained from the following equation:

[NFE % = 100 – (Moisture % + Ash % + CP % + EE % + CF %)].

Samples of the experimental rations and feces were analyzed according to Goering and Van Soest (1970) to determine neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) by using Tecator Fibretic System.

Calculation of the digestion coefficients, total digestible nutrients (TDN), digestible energy (DE) and metabolizable energy (ME):

The procedure and conversion factors for TDN followed by McDonald *et al.* (1973); while DE (kcal / kg DM) was calculated from the following equation: [DE (kcal/kgDM) = (5.28 × DCP) + (9.51 × DEE) + (4.20 × DCF) + (4.20 × DNFE)], (Schiemann *et al.,* 1972); and ME (kcal / Kg) was calculated from the following equation: [ME (kcal/Kg) = (37 × CP) + (81 × EE) + (35.5 × NFE)] (Pauzenga, 1985).

Parameters related to fermentation in the caecum:

Caecum fluid samples were collected from all rabbits of each experimental trial. About 20 ml of caecum fluid was collected at 8 hours post-feeding. The samples were filtered through two layers of surgical gauze and were used for determining the following parameters:

pH:

The caecum pH was determined immediately using HANNA instruments (HI) 98128 pH meter.

Total VFA:

After acidification of samples of caecum liquor using 2 ml concentrated ortho-phosphoric acid and 0.1 N Hydrochloric acid, the VFAs were steam-distilled from a known volume of sample using the micro-Kjeldahl apparatus. Distillation rate was adjusted so that 100 ml distillate was collected within 7 to 10 minutes. The concentration of VFA was calculated by the knowledge of the amount of 0.01 N NaOH to neutralize the VFA in the distillate (Abou Akkada and EL-Shazly, 1964).

Ammonia-N (NH_3-N):

The concentration of NH_3-N was determined according to the method of Conway and O'Malley (1942). Ammonia-N is released under alkaline conditions from the outer chambers of the Conway plate, absorbed by the boric acid in the center well and then titrated after 4–6 hours using 0.01 N-sulphuric acids.

***Statistical analysis*:**

The statistical analysis was carried out using the General Linear Model Program (GLM) of SAS (2000). The obtained data were analyzed using factorial analysis (3x3) of variance according to the following model:

$$Y_{ijk} = \mu + T_i + L_j + TL_{ij} + e_{ijk}$$

Where; Y i j k = Observation of the tested factor, µ = Overall mean, T_i = The effect of treatment (DDGS), i=0, 10 and 20 %, L_j=The effect of levels (seaweed), j = 0, 0.5 and 1 %, TL_{ij} = The interaction between treatment and level effects and e i j k = Error.

Differences among means were subjected to Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Chemical composition of the experimental rations:

Table (2) shows the actual analysis of the experimental rations. The results were ranged for: CP (18.74 to 19.80 %), CF (15.11 to 16.24 %), EE (3.08 to 6.10 %), NFE (47.22 to 52.05 %), Ca (1.47 to 1.49 %), P (0.71 to 0.77), NDF (32.42 to 35.43 %), ADF (17.48 to 19.62 %), hemicellulose (14.39 to 15.95 %) and cellulose (13.07 to 15.69 %). These chemical nutrients were suitable for formulation of growing rabbit's rations as recommended by Gidenne, (1992) and De Blas *et al*. (1995). They reported dietary level of CP (16.3 to 19.8 %), CF (14 to 18 %), EE (5.5 %), NDF (27 to 42 %), ADF (16 to 21 %), Ca (1.15 %) and P (0.60 %). However, they reported that there is a lack of research on mineral and vitamins. There is some evidence to indicate that rabbits at least, benefit from an additional 30 mg carotene / kg diet even when vit. A is plentiful supply (Tobin, 1996).

Table 2. Chemical composition of the experimental rations.

Items	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**
DDGS	**0 %**	**10 %**	**20 %**	**0 %**	**10 %**	**20 %**	**0 %**	**10 %**	**20 %**
SW		**0 %**			**0.5 %**			**1 %**	
DM	92.58	91.84	92.17	92.04	92.11	92.46	92.43	92.08	92.50
Composition of DM %:									
OM	88.24	88.69	87.75	87.90	88.86	88.78	89.35	88.55	88.23
CP	19.36	18.90	18.74	18.98	19.30	19.80	18.85	19.31	19.40
CF	15.11	15.59	15.69	16.24	15.66	15.42	15.35	15.55	15.52
EE	3.08	4.49	6.10	3.54	4.45	5.66	3.10	4.96	5.40
NFE	50.69	49.71	47.22	49.14	49.45	47.89	52.05	48.73	47.91
Ash	11.76	11.31	12.25	12.10	11.14	11.22	10.65	11.45	11.77
Ca	1.47	1.48	1.47	1.49	1.48	1.47	1.48	1.48	1.47
P	0.71	0.74	0.77	0.71	0.74	0.76	0.71	0.74	0.77
Ca / P	2.08	2.00	1.92	2.08	2.00	1.93	2.08	2.00	1.93
Fiber fractions %:									
NDF	32.42	34.29	35.43	33.14	34.22	34.93	33.15	33.85	35.22
ADF	17.64	19.02	19.48	17.48	19.09	19.44	18.24	19.46	19.62
Hemicellulose	14.78	15.27	15.95	15.66	15.13	15.50	14.91	14.39	15.60
Cellulose	13.07	14.24	15.25	14.15	15.46	15.69	14.22	14.85	15.19
ADL	4.57	4.78	4.23	3.33	3.62	3.75	4.02	4.61	4.43
NFC*	33.38	31.01	27.49	32.23	30.89	28.38	34.24	30.43	28.20
NFC/NDF	1.03	0.90	0.78	0.97	0.90	0.81	1.03	0.90	0.80
Cellulose /ADF	0.74	0.75	0.78	0.81	0.81	0.81	0.78	0.76	0.77
Cellulose /NDF	0.40	0.42	0.43	0.43	0.45	0.45	0.43	0.44	0.43
NFC/Hemicellulose	2.26	2.03	1.72	2.06	2.04	1.83	2.30	2.12	1.81

- Non fibrous carbohydrates%= OM%- (CP%+NDF%+EE%), Calsamiglia *et al*.(1995).

Vitamin E is usually provided at 40 to 70 mg/kg diet, Mn (0.25%), K (0.9%), Na (0.3%), Zn (60 mg/kg), I (1.1mg/kg) and Cu (10 mg/kg) (Moughan *et al*., 1988). The non fiber carbohydrate (NFC) ranged from 27.49 to 34.24 % in the present experimental rations. Wheeler, (2003) reported that, the NFC levels in the total ration dry matter should not fall bellow 20 to 25 % nor go above 40 to 45 %. Rations formulated for 35 to 37 % (DM basis) should avoid metabolic disturbances related to feeding high levels of starches in grains.

Generally, the NFE and NFC % were decreased as the proportion of DDGS increased in the rations, while the NDF; ADF and cellulose (%) were increased with increasing DDGS in the rations. The EE also was increased with increasing DDGS in the rations as shown in Table 2.

The characterization of experimental rations for growing rabbits showed that the NFC: NDF ratios were decreased with increasing the DDGS in the rations and the values were ranged from 0.78 to 1.03 % as shown in Table 2.

Froseth *et al*. (1985) reported the mean starch, EE, NDF and ADF % for barley were 53.1, 2.2, 18.1 and 6.6, respectively. Dudley-Cash (2001) reported the composition of some soybean meals were in average 0.5 and 13 % for EE and NDF, respectively. The average NDF and NFC % for DDGS were 42.0 and 16.4, respectively, while the EE % was about 10.7 (Pedersen *et al*., 2007). These results were in agreement with the present chemical composition of the tested rations when barley and SBM were substituted by DDGS. So, increasing DDGS% in the rations led to increasing the NDF and EE % and decreasing NFC % of the total mixed rations.

Poor *et al*. (1993) investigated the effect of the ratio of starch to NDF. These workers reported that a starch: NDF ratio of at least 1 will allow acceptable performance. The impairment observed in rabbits fed the highest levels of fiber might be explained by higher fermentation losses in the ceacum together with an insufficient of glucose from the gut to meet the requirements. The negative effects of high starch concentrations in the diet were related to an increase in mortality through diarrhea (De Blas *et al*., 1995).

Effect of supplemented SW or feeding DDGS and their interactions on dry matter intake, nutrient digestibility and feeding values:

Table (3) showed that the DMI (g/h/d) increased ($P<0.05$) with increasing the SW in the rations. The apparent digestibility of CP increased ($P < 0.05$) with supplemented 0.5 % SW than 0.0 %, while the CP digestibility tended to decrease with supplemented 1.0 % SW but without significant effect between 0.0 % SW and 0.5 % SW. The EE digestibility increased ($P<0.05$) with supplemented 0.5 or

1.0 % SW than the 0.0 % SW. The apparent digestibility of CF decreased (P<0.05) with supplemented SW than no supplemented ration. The NDF, ADF and cellulose tended to decrease also, but without significant effects. The values of TDNI (g/h/d) were higher (P<0.05) with supplemented 0.5 % SW or 1.0 % SW (84.55 and 85.91, respectively) than no supplemented SW (79.39 g/h/d). The DCPI (g/h/d) values were also increased (P<0.05) with supplemented 0.5 SW % or 1.0 % SW (15.34 and 15.35, respectively) than no supplemented SW (13.91 g/h/d). The digested energy intake (DEI) (kcal/h/d) was increased (P < 0.05) with supplemented 0.5 % or 1.0 % SW (371.93 and 377.67, respectively) than no supplemented SW (348.65 Kcal/h/d). Durand and Kawashima (1980) reported that macro. and micro elements affect the process that proceeds in animal's organism in different ways and through their presence in the digestive tract.

Thus for example, cellulose degradation is accelerated by the following elements: P, Mg, Ca, K, Na, Fe, Zn, Mn, Co, and Mo, whereas the fermentations may be increased by Mn, Co, and Zn. On the other hand anti bacterial activity of seaweed was found against 10 of 11 organisms tested *in vitro*. Activity against both Gram-positive and Gram-negative types was observed from an extract of *Ascophyllum nodosum* (Behrends *et al*., 2000). So, Zahid Phool *et al*. (1995) reported that supplemented of seaweed may improve the nutritive quality of diet in terms of fat and protein contents.

Table (3) also, showed that the DMI (g/h/d) was increased (P < 0.05) with feeding on 10 % and 20 % DDGS in the ration (120.61 and 121.02, respectively) than feeding on 0.0 % DDGS ration (114.36). The apparent digestibility of CP was higher (P<0.05) with feeding on 10 % DDGS than feeding on 20 % DDGS, while there was no significant effect between 0.0 % DDGS and 10 % DDGS or between 0.0 % DDGS and 20 % DDGS rations. The CF, NDF, ADF and cellulose digestibility were increased (P<0.05) with increasing DDGS % in the rations. The NFE digestibility was higher (P<0.05) with feeding on 0.0 % or 10 % DDGS than feeding on 20 % DDGS. The values of TDN %, TDNI (g/h/d), DCPI (g/h/d), DE (kcal / kg DM), DEI (kcal/h/d) and MEI (kcal/h/d) were increased (P<0.05) with feeding on 10 % and 20 % DDGS rations than 0.0 % DDGS ration. The DCPI / DEI (g/M cal) was increased (P<0.05) with feeding on 0.0 % DDGS or 10 % DDGS (41.11 and 40.86, respectively) than feeding on 20 % DDGS (39.90).

Distiller's dried grains with soluble (DDGS) are quite variable in nutritional content (Widyaratne and Zijlstra, 2007). Although the DDGS contains a significant amount of CF, it also contains 10 – 12 % fat (Whitney *et al*., 1999). Because fat has high efficiency of conversion of the ME into retained energy and supplies essential fatty acids, the activity of these acids in animal body is reflected mainly in the activity of eicosanoids (Known as tissue hormones) (Corl *et al*., 2003).

Table (4) shows that the dry matter intake was increased (P < 0.05) when feeding on R8 (10% DDGS+1% SW) (128.91 g/h/d) and R6 (20% DDGS+ 0.5% SW) (126.67 g/h/d) than the other rations, while feeding on R3 (20% DDGS+0.0%SW) (119.39 g/h/d), R5 (0.0 % DDGS+0.5 %SW) (118.37 g/h/d), R7 (0.0% DDGS+1% SW) (119.70 g/h/d) and R9 (20% DDGS+1%SW) (117.02 g/h/d) where higher (P<0.05) in DMI than feeding on R1 (control) (107.39 g/h/d), R2 (10 % DDGS) (114.56 g/h/d) and R4 (0.0 % DDGS+0.5 % SW) (115.97 g/h/d).

A guide to typical daily feed intake for complete compound feeds for adult at maintenance is around 112 g (30 –35 g DM / kg BW) (Santoma *et al*., 1989). The growing rabbit adjust its feed intake according to the energy concentration of the feeds offered to it where the proteins and other dietary components are balanced.

The energy needed for organic synthesizing is usually supplied by carbohydrates and to a lesser extent by fats. Where there is an excess of proteins, these also help to supply energy after deamination (Lebas, 1989). The CP digestibility was higher (P < 0.05) when feeding on R4 (67.73 %) than the other rations, while feeding on R2, R5, R8 and R9 rations where similar in CP digestibility (66.0, 66.60, 66.28 and 65.83 %, respectively) and higher (P < 0.05) than feeding on R1, R3, R6 and R7 rations (63.63, 63.63, 63.33 and 64.68 %, respectively).

These results showed that the CP digestibility was higher with rations which were around 0.90 NFC: NDF ratio. The lower protein digestion of animal fed the low NFC: NDF diet was not strictly correlated with the activity of proteases, since the total activity of trypsin and chymotrypsin were significantly lower for low NFC: NDF diet (Gidenne *et al*., 2007). The lack of correlation between enzymes activities and whole tract digestion could also be due to the caecal microbial activity that attenuates the differences in intestinal digestion.

The tendency in the last decade to increase the dietary fiber level and reduce the starch to avoid digestive problems has favored increased inclusion levels of alfalfa hay and cereal by-products, resulting in higher dietary protein levels than recommended (> 15 %) (Xiccato *et al*., 2006). However, taking into account the low fermentability of the fiber (30 % of digestibility for NDF components) and the high content of endogenous substances in the nitrogen residues (about 65 %), both components may equally contribute to resident intestinal micro biota maintenance.

On the other hand, the CF digestibility was higher ($P < 0.05$) when feeding on R3 (20 % DDGS) (44.48 %) than feeding on the other rations, while feeding on R2 (10 % DDGS), R5 (10 % DDGS + 0.5 % SW) and R6 (20 % DDGS + 0.5 % SW) where higher ($P < 0.05$) in CF digestibility than feeding on R1 (0.0 % DDGS), R4 (0.0 % DDGS + 0.5 % SW), R7 (0.0 % DDGS + 1.0 % SW), R8 (10 % DDGS + 1.0 % SW) and R9 (20 % DDGS + 1.0 % SW).

The ADF digestibility had the same trends as CF digestibility, but the ADF digestibility was increased ($P < 0.05$) with feeding on R8 or R9 than feeding on R1, R4 and R7.

Hemicelluloses digestibility was higher ($P < 0.05$) with feeding on R2, R3 and R9 than feeding on the others, but hemicelluloses digestibility increased ($P < 0.05$) when feeding on R1, R5 and R7 than feeding on R4, R6 and R8.

Cellulose digestibilities were similar to CF digestibility. The highest value ($P < 0.05$) (45.10 %) was with feeding on R3 (20 % DDGS) than feeding on the other rations, while the lowest value was observed when feeding on R1 (0.0 % DDGS) (24.55 %).

Generally, the presented results showed that the CF, ADF and cellulose digestibiliteis were increased with feeding on R3 (20 % DDGS) than feeding on the other rations, but hemicellulose digestibility was increased with feeding on R2, R3 and R9 than the others. Feed composition such as a dietary fiber, interacts with the digestive health of the young animal (Montagne *et al*., 2003) and particularly of the growing rabbit after weaning (Gidenne, 2003). The ceacal microbial activity developed mainly during the 2 weeks after weaning (Gidenne *et al*., 2002). Gidenne *et al*. (2007) reported that no significant interaction among age and group effect was detected for the concentration in bacterial fibrolytic enzymes. Whatever age, the pectinolytic activity was prevalent and was higher than xylanolytic (about two folds) or cellulolytic ones (about 4–5 folds). The level of fibrolytic enzymes was already high at 25 days of age and between weaning and 42 days old the cellulase activity increased strongly (+60 %).

The TDNI (g/h/d) was the highest ($P < 0.05$) with feeding on R6 (20% DDGS+0.5%SW) or R8 (10% DDGS+1.0%SW) being 90.18 and 91.40, respectively than the other rations. The DEI (kcal/h/d) had also, the same trend as TDNI, but DEI increased ($P<0.05$) with feeding on R3 than feeding on R2 or R4 or R5 or R7 and R9, while the lowest value was observed with feeding on R1.

The DCP % results were higher ($P < 0.05$) with feeding on all rations except with feeding on R3, which was the lowest value (11.92 %). The DCP % for the other ration ranged from 12.19 to 12.86 %.

Fiber is a carbohydrate, but is in a form unavailable to the rabbit. It is made up of the same glucose units found in starch, just arranged so the rabbit cannot digest. Fiber although not providing nutrients, it is important part of the rabbit diet. It functions to aid in passage of materials through the rabbit gastrointestinal system and is required for the proper functioning of the caecum that separate the soluble from insoluble materials in rabbit gastrointestinal tract (Brooks, 1997).

Effects of supplemented SW or feeding DDGS and their interaction on digestible (%) of CP, CF, EE and NFE. and relationship to digestible energy intake:

Table 5 showed that, the DCP % and DEE % were increased ($P< 0.05$) with supplemented SW, while the DCF % was decreased ($P < 0.05$). The same trends were observed on DCPI, DCFI, DEEI and DNFEI (g/h/d). The DCPI / DEI (g/ Mcal) was highest ($P < 0.05$) with feeding on 0.5 % SW but DCFI / DEI was decreased ($P < 0.05$), but DEEI / DEI was increased ($P < 0.05$) and there was no significant effects on DNFEI / DEI with supplemented SW. Sykes (2009) reported that seaweed is a totally natural multi-mineral supplement. Seaweed contains all minerals and trace elements an animal requires for a normal healthy life. The improvement in nutrients digestibility in relation to the increased Zn supplementation level, was accompanied by an improvement in the nutritive value of the given diet expressed either as kcal metabolizable energy (ME) or as digestible crude protein (DCP). So, the increase of DCP may be related to the high content of Zn. Increasing the digestive ability of rabbits by elevation the level of Zn supplementation may be attributed to increasing the activity of some enzymes related to the digestion of carbohydrates, fats and protein such as amylase, lipase, trypsinogen, chemotrypsinogen and some peptidases since these enzymes are known to be Zn-dependent enzymes (Banerjee, 1988).

As shown in Table 5, the digestible CP (DCP %) was increased ($P<0.05$) with feeding on 10 % DDGS ration than feeding on 0.0 % or 20 % DDGS. The DCF % and DEE % were increased ($P < 0.05$) with increasing the level of DDGS in the ration as, while the DNFE % was decreased ($P < 0.05$). The DCPI, DCFI and DEEI (g/h/d) were increased ($P < 0.05$) with feeding on DDGS rations. The DCPI / DEI was higher ($P < 0.05$) with feeding in 0.0 % or 10 % DDGS rations than feeding on 20 % DDGS ration. The DCFI / DEI and DEEI / DEI were increased ($P < 0.05$) with increasing the level of DDGS in the rations, while the DNFE / DEI was decreased ($P < 0.05$) with increasing the level of DDGS in the rations. When providing protein, it is important to understand were is really providing amino acids, building blocks of protein. The

proteins found in feeds are broken down in the digestive system to amino acids which are then absorbed (Hillyer *et al*., 1997). The next major nutrient provided in the feed is energy. A prime source of energy are the carbohydrates found in various grain by-products included in rabbit feed. Fats can also serve as an energy source although rabbits tend to net like diets high in fats. Both carbohydrates and fats provide the fuel for cellulose function. High starch diets are often incompletely digested in rabbit small intestine due to rapid transit times (McNitt *et al*., 1996). Fiber is also a carbohydrate, but is in a form unavailable to the rabbit. It is made up of the same glucose units found in starch, just arranged so the rabbit cannot digest. Fiber, although not providing nutrients, it is an important part of the rabbit diet (Brooks, 1997).

As shown in Table 6, the DCPI (g/h/d) increased with feeding on R6 or R8 (15.89 and 16.51 g/h/d, respectively) than feeding on the other rations. The lowest value (13.21 g/h/d) was with feeding on R1. The DCFI (g/h/d) was higher ($P < 0.05$) with feeding on R3 (8.33 g/h/d) than the other rations, while the lowest value ($P < 0.05$) (4.89 g/h/d) was with feeding on R1. The DEEI (g/h/d) values were higher ($P < 0.05$) with feeding on R3, R6, R8, and R9 (5.29, 5.32, 5.33 and 5.03 g/h/d, respectively) than the other rations and the lowest value ($P < 0.05$) was with feeding on R1 (2.14 g/h/d). The DNFEI (g/h/d) values increased ($P < 0.05$) with feeding on R6, R7 and R8 (54.83, 56.97 and 56.63, respectively) than the other rations. The digestible crude protein intake to digestible energy ratio (g/Mcal) value was higher ($P < 0.05$) with feeding in R4 (42.51) than the other rations, but feeding on R1, R5, R8 and R9 were higher ($P < 0.05$) in DCPI / DEI (g/Mcal) (41.19, 41.95, 41.01 and 41.21, respectively) than the feeding on R2 or R3 or R7 (40.32, 38.38 and 39.61 g/Mcal, respectively). The DCFI / DEI (g/Mcal) value was higher ($P < 0.05$) with feeding on R3 (22.46) than the other rations, while the other rations were ranged from 15.30 to 18.92 (g/Mcal).

The DEEI / DEI (g/Mcal) values higher ($P < 0.05$) with feeding on R3 (14.28) than the other rations, but feeding on R6, R8 and R9 (13.41, 13.25 and 13.89 g/Mcal, respectively) were higher than feeding on R1, R2, R4, R5, and R7 (6.70, 9.62, 8.78, 10.86 and 7.96 g/Mcal, respectively) as shown in Table 6. The DNFEI / DEI (g/Mcal) values decreased ($P < 0.05$) with feeding on DDGS with or without SW. The highest values were observed with feeding on R1, R4 and R7 (155.84, 148.46 and 154.65 g/Mcal, respectively), while the lowest values were with feeding on R3, R6 and R9 (135.06, 138.39 and 138.89 g/Mcal, respectively).

In generally, the presented results showed that feeding on DDGS with 10 % or 20 % with or without SW (R2 and R3) led to decreased DCP % in rations while supplemented 1.0 % SW led to increase the DCP and DEE % (R8 and R9

rations). But feeding on high level of DDGS without SW led to increase DCF and DEE % (R3). There was negative effect with feeding on DDGS with or without SW on DNFE % in the experimental rations. So, the highest values were with feeding on R1 and R7. Although, the DDGS contains a significant amount of crude fiber 8 –10 %, it also contains 10 – 12 % fat (Whitney *et al*., 1999). Fats as energy carriers and sources of essential unsaturated fatty acid have attracted the attentions of nutritionists in recent years; the activity of these acids in the animal body is reflected mainly in the activity of eicosanoids (known as tissue hormones). Owing to the mechanism of their action, they can be treated as the most peripheral first messengers, which strengthen or weaken the regulatory activity of hormones and neuromediators at cellulas level (Corl *et al*., 2003). Because fat has higher efficiency of conversion of the ME into retained energy and supplies essential fatty acids, fat was often used in commercial meat rabbit production. Supplements of seaweed may improve the nutritive quality of diets and growth of small animal in terms of body weight gain as well as fats and protein contents (Zahid Phool *et al*., 1995).

Effects of supplemented SW or feeding DDGS and their interaction on some caecum liquor parameters:

As shown in Table 7, supplemented 1 % SW increased ($P< 0.05$) the pH value (6.11) than the control (5.92), while there was no significant effect between supplemented 0.5 % SW (6.08) and 1 % SW or between 0.5 % SW and control ration. There was no significant effect with feeding on 0, 10 and 20% DDGS (5.92, 6.08, 6.05, respectively). There was also no significant effect on the pH values with feeding on DDGS with or without SW. The pH values ranged from 5.87 to 6.29. The sum of dietary peptic concentrations, the degree of lignifications of neutral detergent fiber (NDF) and the dietary particle size, should be controlled to commercial rabbit diet in order to optimize caecal microbial activity (Garcia *et al*., 2000). Caecal pH varied between 5.61 and 6.28. The pH or the concentration of the fermentation end products were not significantly affected by the feeding programme (Gidenne *et al*., 2007).

Ammonia – N concentration was increased ($P<0.05$) with increasing the level of supplemented SW in the rations. The mean values were (9.96, 13.06 and 17.12 mg/100 ml) for (0.0, 0.5 and 1.0 % SW, respectively). The ammonia concentration was higher ($P<0.05$) with feeding on 20 % DDGS (15.72 mg/100 ml) than the control (11.36 mg/100 ml), but there was no significant effect with feeding on 10 % DDGS (13.07 mg/100 ml) and the control or with feeding on 20 % DDGS. There was no significant effect with feeding on DDGS with or without SW on NH_3 concentration values, which were ranged from 6.53 to

Table 7. Effects of supplemented SW or feeding DDGS and their interaction on some caecum liquor parameters.

Items	SW	DDGS			Effect seaweed (SW)		
		0%	10%	20%	Mean	± SEM	*P*
pH	0% 0.50% 1%	5.89 5.92 5.96	5.87 6.08 6.29	5.99 6.08 6.08	**5.92 b** **6.08 ab** **6.11 a**	0.048	**0.037**
Effect DDGS		**5.92**	**6.08**	**6.05**	6.02	0.084	**0.281**
± SEM		0.048					
P		**0.074**					
NH3 (mg/100ml)	0% 0.50% 1%	6.53 10.27 17.28	10.74 12.61 15.88	12.61 16.34 18.21	**9.96 c** **13.07 b** **17.12 a**	0.947	**0.0002**
Effect DDGS		**11.36 b**	**13.07 ab**	**15.72 a**	13.38	1.640	**0.383**
± SEM		0.947					
P		**0.015**					
VFA (ml eq./100ml)	0% 0.50% 1%	3.93 5.62 4.98	4.62 5.57 4.40	4.57 4.23 4.45	**4.37** **5.14** **4.61**	0.253	**0.119**
Effect DDGS		**4.84**	**4.86**	**4.42**	4.71	0.438	**0.181**
± SEM		0.253					
P		**0.390**					

a, b, c: Means within the same raw with different superscripts are significantly different (P <0.05).
SEM = Standard error of means, *P* = Probability.

18.21, but the highest values were observed with feeding on 20 % DDGS with 1 % SW ration. Ammonia is the main end product of N catabolism, as well as, the main nitrogenous source for the microbial population in the caecum. Ammonia content is between 6.0 and 8.5 mg/100 ml caecal content with normal diets (Carabano *et al.*, 1988).

The present data showed that there was no significant effect on total Volatile fatty acids (VFA) values by supplemented SW or feeding on DDGS. The mean values with 0.0, 0.5 and 1.0 % SW were 4.37, 5.14 and 4.61 ml eq /100 ml, respectively, while the mean values when feeding on 0.0 %, 10 % and 20 % DDGS were 4.84, 4.86 and 4.42 ml eq/100 ml, respectively. The VFA values ranged from 3.93 to 5.62 ml eq /100 ml when feeding on DDGS with or without SW. Volatile fatty acids are end products of fermentation in the caecum providing an important source of energy for the rabbits (Bellier and Gidenne, 1996). There was no changes in the caecal VFA production in finishing rabbits (Garcia *et al.*, 1995). The VFA production results from caecal fermentation of digestible dietary fiber (Nicodemus *et al.*, 1999), or undigested nutrients (De Blas and Gidenne, 1998). The concentration of the fermentation of undigested nutrients (starch, fat and protein) is unlikely. The concentration of total VFA observed ranged from 4.3 to 8.2 mmol/100ml (Garcia *et al*., 2002).

Effects of interaction between supplemented SW or feeding DDGS on some caecum liquor parameters were not significant (Table 7).

Conclusively, agro-industrial by–products such as DDGS with or without SW could be used as new alternative source of energy in the growing rabbits rations. Distiller's dried grains with soluble (DDGS) can be used up to 20 % of the total balanced ration of growing rabbits to replace 100 % of barley grains and part of soybean meal.

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تأثير إحلال النواتج العرضية لتقطير الحبوب الجافة بالسوائل محل حبوب الشعير وكسب فول الصويا مع إضافة أو بدون إضافة الطحالب البحرية فى علائق الأرانب النامية على:-

٤ - معاملات الهضم، القيمة الغذائية وبعض قياسات سائل الأعور.

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تم اختيار ٢٧ أرنبا نيوزيلندي أبيض عمر ١٢ أسبوعا بمتوسط وزن٢،٠٧ ±٠٦٢, كجم وتم توزيعهم عشوائيا في تسع مجاميع متساوية في العدد والعمر وتغذيتها على تسع علائق تجريبية على النحو التالي: العليقه (الاولى) المقارنة تحتوى على: ١٠ % ذرة صفراء + ١٠ % شعير + ١٣،٧ % كسب فول الصويا + ٢٠ % نخالة قمح + ٤٠ % دريس برسيم + ٣ % مولاس + ١ % داى كالسيوم فوسفات + ١،٢ % حجر جيرى + ٠،٥ % ملح طعام + ٠،٤ % مخلوط معدنى وفيتامينات + ٠،٢ % مثيونين.

وتم إحلال النواتج العرضية لتقطير الحبوب الجافة بالسوائل محل الشعير وكسب فول الصويا بنسبة ١٠ ، ٢٠ % (كل من النسبة مقسمه على كل من الشعير وكسب فول الصويا بنسب متساوية) وذلك للعلائق (الثانية والثالثة). ثم تم إضافة الطحالب البحرية لهذه العلائق بنسبة ٠،٥ % وذلك لـ لـل من العليقة الرابعة والخامسة والسادسة. كما تم إضافة الطحالب البحرية لهذه العلائق بنسبة ١ % وذلك لكل من العليقة السابعة والثامنة والتاسعة. وكانت جميع العلائق على شكل مكعبات ومتساوية في الطاقة والبروتين تقريبا. وطبقا للاحتياجات المطلوبة لتغذية الأرانب النامية.

وكانت أهم النتائج المتحصل عليها هى كما يلى:-

- زادت كمية المأكول من المادة الجافة معنويا (٠،٠٥) بالتغذية على العليقه الثامنة والعليقه السادسة (١٢٨،٩١و ١٢٦،٦٧ جم / رأس / اليوم، على التوالى) مقارنة بالتغذية على العلائق الأخرى.
- أظهرت النتائج تحسن معنويا (٠،٠٥) على المركبات الغذائية الكلية المهضومة المأكولة عند التغذية على العليقه السادسة والثامنة (٩٠،١٨و ٩١،٤ جم / رأس / اليوم، على التوالى) مقارنة بالتغذية على العلائق الأخرى ولكن تحسنت كمية الطاقة المهضومة المأكولة (كيلو كالورى / رأس / يوم) معنويا (٠،٠٥) بالتغذية على العليقة الثالثة مقارنة بالغذية على العلائق التجريبية الأخرى.
- زاد كمية المأكول من المادة الجافة معنويا (٠،٠٥) مع إضافة الطحالب البحرية للعلائق كما زاد معامل هضم البروتين بإضافة ٠،٥ % طحالب بحرية مقارنة بالعليقة الكنترول بينما

إنخفض معامل هضم البرونتين بإضافة ١% طحالب بحرية فى حين زاد معامل هضم المستخلص الأثيرى معنويا (٠،٠٥) ولكن أدت إضافة الطحالب البحرية الى إنخفاض معنوى (٠،٠٥) فى هضم الألياف مقانة بالعليقة الكنترول.

- زاد كمية المأكول من المادة الجافة معنويا (٠،٠٥) عند التغذية على ١٠ ، ٢٠ % من النواتج العرضية لتقطير الحبوب الجافة (١٢٠,٦١و١٢١,٠٢ جم / رأس / يوم على التوالى) مقارنة بالعليقة الكنترول (١١٤,٣٦ جم / رأس / يوم). بينما زاد معامل هضم البروتين معنويا (٠،٠٥) عند التغذية على ١٠ % من النواتج العرضية لتقطير الحبوب الجافة مقارنة بالتغذية على ٢٠ % منها فى حين زاد معامل هضم الألياف ومستخلص الألياف المتعادل ومستخلص الألياف الحامضية مع زيادة معدل الإحلال.
- زادت كمية المأكول من البروتين المهضوم بالنسبة للطاقة المهضومة معنويا (٠،٠٥) عند التغذية على العليقه الرابعة (٤٢،٥١ جم / ميجا كالورى) مقارنة بالتغذية على العلائق الأخرى.
- زاد كمية المأكول من الألياف المهضومة بالنسبة للطاقة المهضومة معنويا (٠،٠٥) عند التغذية على العليقه الثالثة (٢٢،٤٦ جم / ميجا كالورى) مقارنة بالتغذية على العلائق الأخرى.
- زادت كمية المأكول من الدهن المهضوم بالنسبة للطاقة المهضومة معنويا (٠،٠٥) عند التغذية على العليقه الثالثة (١٤،٢٨ جم / ميجا كالورى) مقارنة بالتغذية على العلائق الأخرى.
- زادت كمية المأكول من مستخلص خالى الازوت المهضوم بالنسبة للطاقة المهضومة معنويا (٠،٠٥) عند التغذية على العليقه الاولى، الرابعة و السابعة (١٥٥،٨٤و ١٤٨،٤٦و١٥٤،٦٥ جم / ميجا كالورى) مقارنة بالتغذية على العلائق الأخرى.
- لم تظهر فروق معنوية على قيم درجة الحموضة التى تراوحت بين ٥،٨٧ ــ ٦،٢٩ عند التغذية على العلائق المختبرة.
- زادت تركيز الامونيا فى الأعور معنويا (٠،٠٥) مع زيادة مستوى الطحالب البحرية فى العلائق وكان متوسط القيم المتحصل عليها ٩,٩٦ و ١٣,٠٦ و ١٧,١٢ مجم / ١٠٠ ملى عند اضافة (صفرو٠،٥ و ١ % طحالب بحرية، على التوالى).
- لم تظهر فروق معنوية على كمية الأحماض الدهنية الطيارة عند التغذية على العلائق المختبرة والتى تراوحت بين ٣،٩٣ و ٥،٦٢ ملليمكافئ / ١٠٠ مل سائل أعور.

التوصية: يستنتج من هذه الدراسة أنه من الممكن تغذية الأرانب النامية بعد الفطام عمر (٧ ــ ١٣ أسبوعاً) على علائق تحتوى على النواتج العرضية لتقطير الحبوب الجافة بالسوائل حتى نسبة ٢٠% من العليقة الكلية وذلك باحلالها كليا محل حبوب الشعير مع جزء من كسب فول الصويا مع اضافة او بدون اضافة الطحالب البحرية وذلك نتيجة لزيادة كمية الماكول من الالياف المهضومة والدهن المهضوم بالنسبة للطاقة الكلية المهضومة التى تناولتها الارانب.