American-Eurasian J. Agric. & Environ. Sci., 11 (6): 815-823, 2011
ISSN 1818-6769
© IDOSI Publications, 2011

Strawberry By-Products as a Partial Replacement of Clover Hay in Rabbit Diets

H.A.A. Omer, F.A.F. Ali and Sh. A.M. Ibrahim

Animal Production Department, National Research Centre, Dokki, Cairo, Egypt

Abstract: Total number of 60 male growing New Zealand rabbits was used to study the effect of dietary strawberry by-products (SBP) as a partial replacement at levels 25, 50, 75 and 100 % of clover hay. Rabbits were classified into five equal groups (G_1-G_5) each contained 12 rabbits. The 1st group received the basal diet contained 24% clover hay and served as control diet. The other four groups (G_2-G_5) received the basal diet with replacement (SBP) at the level of 25, 50, 75 and 100% of clover hay, respectively. The chemical composition of (SBP) was superior in ether extract, nitrogen-free extract, gross energy, digestible energy, neutral detergent fiber, acid detergent fiber and cellulose contents compared to clover hay. Clover hay contents of crude fiber, ash, non fibrous carbohydrates and hemicellulose were higher than (SBP). Rabbits received diet replaced (SBP) at the level 75% of clover hay (G_4) recorded the highest digestibility coefficients of (OM, CP and CF) and nutritive values as (TDN and DCP), while, replacement (SBP) at the level 25% of clover hay (G_2) recorded the highest digestibility coefficients of (EE and NFE). Replacement (SBP) at the levels 50, 75 and 100% of clover hay significantly ($P<0.05$) increased the final body weight, total body weight gain and average daily gain, while showed insignificant effects ($P>0.05$) on feed intake and feed conversion. Rabbits received complete replacement (SBP) at the level 100% of clover hay (G5) increased final body weight (marketing weight), total body weight gain and average daily gain by 10.25, 13.78 and 13.79%, respectively. Rabbits received diet replaced (SBP) at the level 25% of clover hay (G_2) recorded the lowest dry matter intake. The feed conversion (g intake /g gain) of DM, CP, DCP, TDN and (Kcal intake /g gain) of DE were improved with replacement (SBP) at all levels used in rabbit diets. The best feed conversion was recorded when rabbits received basal diet with replacement (SBP) at the level 25% of clover hay (G_2). Rabbits received diet complete replacement (SBP) at the level 100% of clover hay (G_5) recorded the highest value of liver weight and total giblets weight. With increasing the rate of replacement (SBP) from zero to 100% of clover hay the total revenue, net revenue, economical efficiency and relative economic efficiency were increased. It can be maintained that strawberry by-products can be used as a good instead source of clover hay in rabbit diets without any adverse effect on their performance and can be used it economically in rabbit diets formulations.

Key words: Strawberry by-products · Rabbits · Growth performance · Digestibility · Carcass characteristics · Economic evaluation

INTRODUCTION

One major limiting factor to livestock production is the high cost of conventional feedstuffs such as (soybean meal, maize, clover hay … etc). However, many feedstuffs, especially agro-industrial by-products which are usually of no feeding value to humans can alternatively be fed at cheaper cost to animals [1]. Strawberry by-products (SBP) used as untraditional feed ingredients is the sun dried whole plant of *Fragaria ananassa* belonging to the family *Rosaceae* [2]. Polyphenolic rich strawberry may provide protection from high carbohydrate/fat meal-induced increases in fibrinolytic and inflammatory factors [3]. Tiliroside contained in strawberry is a glycosidic flavonoid and possesses anti-inflammatory, antioxidant, anticarcinogenic and hepatoprotective activities [4]. Strawberry contains a moderate source of folate that reduced the risk of tissues abnormalities [5]. The hypotheses that polyphenolic as α-amylase inhibitor (resistant starch) from strawberry [3] was also quite resistant to proteolytic digestion by trypsin [6] that

Corresponding Author: H.A.A. Omer, Animal Production Department, National Research Centre, Dokki, Cairo, Egypt.

induce delayed gastric emptying [7] and has ability to produce a large amount of butyrate as important food for cells lining colon [8] which make it practically blocked by solidified digesta and the ensuing bacterial fermentation stimulated the growth of this tissue by hyperplasia and hypertrophy [9]. This work aimed to study the effect of dietary (SBP) as a partial replacement at levels 25, 50, 75 and 100 % of clover hay on rabbit's growth performance, nutrient digestibility coefficients, carcass characteristics and economical evaluation.

MATERIALS AND METHODS

A total number of sixty male New Zealand White rabbits aged 5 weeks with an average body weight of 585 ± 4.08 g, were divided into five equal groups each twelve animals. The basal experimental diet was formulated and pelleted to cover the nutrient requirements of rabbits according to N.R.C [10] as shown in (Table 1). Strawberry by-products (SBP) were collected from the unit of food industrial in Agriculture Benha Secondary School, Benha City, Al-Kaluobia Governorate, Egypt. Strawberry by-products was left to sun-drying and kept in clean bags until to using in ration formulations. The feeding period was extended for 56 days and the experimental groups were classified as follow:

- Group 1 basal diet contained 24% clover hay and served as control diet (G_1).
- Group 2 basal diet with replacement (SBP) at the level 25% of clover hay (G_2).
- Group 3 basal diet with replacement (SBP) at the level 50% of clover hay (G_3.
- Group 4 basal diet with replacement (SBP) at the level 75% of clover hay (G_4).
- Group 5 basal diet with replacement (SBP) at the level 100% of clover hay (G_5).

Rabbits individually housed in galvanized wire cages (30 x 35 x 40 cm). Stainless steel nipples for drinking and feeders allowing recording individual feed intake for each rabbit were supplied for each cage. Feed and water were offered *ad libitum.* Rabbits of all groups were kept under the same managerial conditions and were individually weighed and feed consumption was individually recorded weekly during the experimental period. At the end of the experimental period, all rabbits were used in digestibility trials over period of 7 days to determine the nutrient digestibility coefficients and nutritive values of the tested diets. Feces were daily collected quantitatively. Feed intake of experimental rations and weight of feces were daily recorded. Representative samples of feces was dried at 60°C for 48 hrs, ground and stored for later chemical analysis.

Table 1: Composition (kg/ton) of the experimental diets

	Experimental diets				
Item	G_1	G_2	G_3	G_4	G_5
Yellow corn	230	230	230	230	230
Barley grains	50	50	50	50	50
Wheat bran	270	270	270	270	270
Soybean meal 44% CP	180	180	180	180	180
Clover hay	240	180	120	60	-
Strawberry by-product	-	60	120	180	240
Di-Calciun phosphate	10	10	10	10	10
Lime stone	10	10	10	10	10
Sodium chloride	5	5	5	5	5
Vit. And Min. mixture*	3	3	3	3	3
DL-Methionine	1	1	1	1	1
Anti fungal agent	1	1	1	1	1
Price, L.E/Ton	2126	2057	1988	1919	1850

* Vit. and Min. mixture: Each kilogram of Vit. and Min. mixture contains: 2000.000 IU Vit. A, 150.000 IU Vita. D, 8.33 g Vit. E, 0.33 g Vit. K, 0.33 g Vit. B_1, 1.0 g Vit. B_2, 0.33g Vit. B_6, 8.33 g Vit.B_5 1.7 mg Vit. B_{12} 3.33 g Pantothenic acid, 33 mg Biotin, 0.83g Folic acid, 200 g Choline chloride, 11.7 g Zn, 12.5 g Fe, 16.6 mg Se, 16.6 mg Co, 66.7 g Mg and 5 g Mn.

LE = Egyptian pound equals 0.18 American dollars approximately.

G_1: Rabbits received control diet that contained 24% clover hay.

G_2: Rabbits received diet that replaced 25% of clover hay in basal diet with sun dried strawberry by-products (SBP).

G_3: Rabbits received diet that replaced 50% of clover hay in basal diet with sun dried strawberry by-products (SBP).

G_2: Rabbits received diet that replaced 75% of clover hay in basal diet with sun dried strawberry by-products (SBP).

G_2: Rabbits received complete replacement (100%) of clover hay in basal diet with sun dried strawberry by-products (SBP).

Six representative rabbits from each treatment were randomly chosen and fasted for 12 hours before slaughtering according to Blasco *et al.* [11] to determine the carcass measurements. Edible offal's (Giblets) included heart, liver, testes, kidneys, spleen and lungs were removed and individually weighed. Full and empty weights of digestive tract were recorded and digestive tract contents were calculated by differences between full and empty digestive tract. Weights of giblets and external offal's were calculated as percentages of slaughter weight (SW). Hot carcass was weighed and divided into fore, middle and hind parts. The 9, 10 and 11^{th} ribs were frozen in polyethylene bags for later chemical analysis. The best ribs of samples were dried at 60°C for 24 hrs. The air-dried samples were analyzed for DM, EE and ash according to A.O.A.C. [12] methods, while CP percentage was determined by difference as recommended by O'Mary *et al.* [13]. Chemical analysis of tested materials, experimental rations and feces were analyzed according to A.O.A.C [12]. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were also determined in the experimental rations according to Goering and Van Soest [14]. Hemicellulose was calculated as the difference between NDF and ADF, while cellulose was calculated as the difference between ADF and ADL. Gross energy (kilo calories per kilogram DM) was calculated according to Blaxter [15], where, each g of crude protein (CP) = 5.65 kcal, each g of ether extract (EE) = 9.40 kcal and each g crude fiber (CF) and nitrogen-free extract (NFE) = 4.15 kcal. Digestible energy (DE) was calculated according to Fekete and Gippert [16] using the following equation: DE (kcal/ kg DM) = 4253-32.6 (CF %)-144.4 (total ash). Non fibrous carbohydrates (NFC) were calculated according to [17] using the following equation:

$$NFC = 100-\{CP + EE + Ash + NDF\}.$$

Diets were offered pelleted and diameter of the pellets was 4 mm. Economical efficiency of experimental diets was calculated according to the local market price of ingredients and rabbit live body weight as following:

Net revenue = Total revenue-Total feed cost

Economical efficiency (%) = Net revenue/ total feed cost %

Statistical Analysis: Collected data were subjected to statistical analysis as one way analysis of variance using the general linear model procedure of SPSS [18]. Duncan's Multiple Range Test [19] was used to separate means when the dietary treatment effect was significant.

RESULTS AND DISCUSSION

Chemical Analysis and Cell Wall Constituents of the Tested Materials and the Experimental Diets: Chemical analysis and cell wall constituents of the tested materials and the experimental diets are presented in Table 2. The chemical composition of (SBP) was superior in ether extract, nitrogen-free extract, gross energy, digestible energy, neutral detergent fiber, acid detergent fiber and cellulose contents compared to clover hay. Dry matter, organic matter and crude protein contents were in the same range for both (SBP) and clover hay. Clover hay contents of crude fiber, ash, non fibrous carbohydrates and hemicellulose were higher than (SBP). In contrast, essential nutrient and beneficial phytochemicals in strawberry seem to have relevant biological activity on general health [20]. The experimental diets were iso caloric and iso nitrogenous. Protein contents for the five tested rations (G_1-G_5) were ranged from 18.23 to 18.58%. On the other hand the digestible energy values were ranged from 2536 to 2550 (kcal/ kg DM) for all diets. All parameters determined of chemical analysis were similar for the different experimental diets regardless the phytochemicals content of (SBP) used.

Nutrient Digestibility and Nutritive Values of the Experimental Diets: Digestibility coefficients and nutritive values (%) of the experimental diets are shown in Table 3. Dietary treatments had no significant effects on dry matter digestibility coefficients. Rabbits received basal diet with replacement (SBP) at the level 75% (G_4) recorded the highest digestibility coefficients of (OM, CP and CF) and nutritive values as (TDN and DCP). These results may be due to the resistant of (SBP) to rabbit alpha-amylase that produce a large amount of butyrate which provides sufficient energy for colon cells [21]. The (SBP) replacement at the level 25% of clover hay (G_2) recorded the highest digestibility coefficients of (EE and NFE). These results may be due to the limit doe of polyphenol from (SBP) has ability to inhibit alpha-amylase that may influence different steps in starch digestion in a synergistic manner [22].

Growth Performance of the Experimental Groups: Growth performances of the experimental groups are presented in Table 4. Dietary (SBP) treatments significantly ($P<0.05$) increased the final body weight, total body weight gain and average daily gain, while showed insignificant effects ($P>0.05$) on feed intake and feed conversion. These significant results may be due to the antioxidant activity and phenolic content in (SBP) as well as with the capacity

Table 2: Chemical analysis and cell wall constituents (%) of the tested materials and the experimental diets

	Tested materials		Experimental diets				
Item	Clover hay	Strawberry by-products	G_1	G_2	G_3	G_4	G_5
Chemical analysis (%)							
Dry matter	90.17	89.32	92.58	92.72	92.48	92.77	92.82
Chemical analysis on DM basis							
Organic matter (OM)	87.71	88.58	90.22	90.25	90.34	90.38	90.32
Crude protein (CP)	15.19	14.42	18.23	18.58	18.31	18.46	18.25
Crude fiber (CF)	25.04	12.91	9.26	9.32	9.87	9.62	9.6
Ether extract (EE)	1.52	3.19	1.43	1.47	1.41	1.44	1.47
Nitrogen-free extract (NFE)	45.96	58.06	61.3	60.88	60.75	60.86	61
Ash	12.29	11.42	9.78	9.75	9.66	9.62	9.68
Gross energy (Kcal/kg DM)1	3948	4060	4092	4102	4099	4103	4099
Digestible energy (Kcal/kg DM)2	1662	2183	2539	2541	2536	2550	2542
Non fibrous carbohydrates (NFC)3	45.87	43.56	37.16	36.67	36.94	36.67	36.65
Cell wall constituents							
Neutral detergent fiber (NDF)	25.13	27.41	33.4	33.53	33.68	33.81	33.95
Acid detergent fiber (ADF)	19.87	22.33	18	18.14	18.28	18.43	18.58
Acid detergent lignin (ADL)	6.13	6.36	5.34	5.35	5.37	5.38	5.4
Hemicellulose	5.26	5.08	15.4	15.39	15.4	15.38	15.37
Cellulose	13.74	15.97	12.66	12.79	12.91	13.05	13.18

[1]Gross energy (kilo calories per kilogram DM) was calculated according to Blaxter [15], where, each g of crude protein (CP) = 5.65 kcal, each g of ether extract (EE) = 9.40 kcal and each g crude fiber (CF) and nitrogen-free extract (NFE) = 4.15 kcal.

[2]Digestible energy (DE) was calculated according to Fekete and Gippert [16] using the following equation:

DE (kcal/ kg DM) = 4253-32.6 (CF %)-144.4 (total ash).

[3] Non fibrous carbohydrates (NFC), calculated according to Calsamiglia *et al.* [17] using the following equation:

NFC = 100-{CP + EE + Ash + NDF}.

Hemicellulose = NDF-ADF.

Cellulose = ADF-ADL.

G_1: Rabbits received control diet that contained 24% clover hay.

G_2: Rabbits received diet that replaced 25% of clover hay in basal diet with sun dried strawberry by-products (SBP).

G_3: Rabbits received diet that replaced 50% of clover hay in basal diet with sun dried strawberry by-products (SBP).

G_2: Rabbits received diet that replaced 75% of clover hay in basal diet with sun dried strawberry by-products (SBP).

G_2: Rabbits received complete replacement (100%) of clover hay in basal diet with sun dried strawberry by-products (SBP).

Table 3: Digestibility coefficients and nutritive values (%) of the experimental diets

	Experimental diets					
Item	G_1	G_2	G_3	G_4	G_5	SEM
Digestibility:						
Dry matter (DM)	81.63	79.66	81.12	83.56	79.4	0.66
Organic matter(OM)	75.29^{b}	77.09^{ab}	75.58^{b}	77.61^{a}	75.91^{ab}	0.32
Crude protein (CP)	76.78^{b}	76.99^{b}	78.05^{ab}	80.59^{a}	77.77^{ab}	0.56
Crude fiber (CF)	41.00^{c}	54.23^{b}	57.97^{b}	65.20^{a}	57.21^{b}	2.21
Ether extract (EE)	50.74^{b}	66.58^{a}	48.51^{b}	48.07^{b}	49.42^{b}	2.23
Nitrogen-free extract (NFE)	80.60^{a}	80.88^{a}	78.33^{b}	79.37^{ab}	78.93^{ab}	0.36
Nutritive values:						
Total digestible nutrient (TDN)	68.84^{c}	70.80^{ab}	69.14^{bc}	71.01^{a}	69.47^{abc}	0.31
Digestible crude protein (DCP)	14.00^{b}	14.30^{ab}	14.29^{ab}	14.88^{a}	14.19^{b}	0.11

a, b and c: Means in the same row having different superscripts differ significantly ($P<0.05$).

SEM, standard error of the mean

G_1: Rabbits received control diet that contained 24% clover hay.

G_2: Rabbits received diet that replaced 25% of clover hay in basal diet with sun dried strawberry by-products (SBP).

G_3: Rabbits received diet that replaced 50% of clover hay in basal diet with sun dried strawberry by-products (SBP).

G_2: Rabbits received diet that replaced 75% of clover hay in basal diet with sun dried strawberry by-products (SBP).

G_2: Rabbits received complete replacement (100%) of clover hay in basal diet with sun dried strawberry by-products (SBP).

Table 4: Growth performance of the experimental groups

	Experimental diets					
Item	G_1	G_2	G_3	G_4	G_5	SEM
Initial weight, g	587	580	590	584	586	4.08
Final weight, g	2321[d]	2339[d]	2383[c]	2454[b]	2559[a]	12.32
Body weight gain, g	1734[d]	1759[d]	1793[c]	1870[b]	1973[a]	12.24
Duration period, day	56 days					
Average daily gain, g	30.96[d]	31.41[d]	32.02[c]	33.39[b]	35.23[a]	0.22
Feed intake as:						
Dry matter, g/h/d (DMI)	111.4	92.90	98.20	101.2	105.7	3.62
Crude protein , g/h/d (CPI)	20.31	17.26	17.98	18.68	19.29	0.66
Digestible crude protein, g/h/d (DCPI)	15.60	13.28	14.03	15.06	15.00	0.52
Total digestible nutrient, g/h/d (TDNI)	76.69	65.77	67.90	71.86	73.43	2.51
Digestible energy, kcal/h/d (DEI)	283	236	249	258	269	9.21
Feed conversion (g intake/ g gain) of						
Dry matter	3.60	2.96	3.07	3.03	3.00	0.11
Crude protein	0.66	0.55	0.56	0.56	0.55	0.02
Digestible crude protein	0.50	0.42	0.44	0.45	0.43	0.02
Total digestible nutrient	2.48	2.09	2.12	2.15	2.08	0.08
Digestible energy *(Kcal intake /g gain)*	9.14	7.51	7.78	7.73	7.64	0.29

a, b, c and d: Means in the same row having different superscripts differ significantly (P<0.05)

SEM, standard error of the mean.

G_1: Rabbits received control diet that contained 24% clover hay.

G_2: Rabbits received diet that replaced 25% of clover hay in basal diet with sun dried strawberry by-products (SBP).

G_3: Rabbits received diet that replaced 50% of clover hay in basal diet with sun dried strawberry by-products (SBP).

G_2: Rabbits received diet that replaced 75% of clover hay in basal diet with sun dried strawberry by-products (SBP).

G_2: Rabbits received complete replacement (100%) of clover hay in basal diet with sun dried strawberry by-products (SBP).

of promoting the action of antioxidant enzymes [20], while the insignificant effect on feed intake may be due to the unpleasant smell of butyric acid which configured as a result of resistant starch [21]. Rabbits received basal diet with replacement (SBP) at the level 100% of clover hay (G5) increased the final body weight, total body weight gain and average daily gain by 10.25, 13.78 and 13.79%, respectively. These results may be due to the sulfur volatiles in strawberry [23], which is a main component of the biochemical structure of the amino acids such as cysteine, methionine, taurine and glutathione [24]. Dietary (SBP) treatments insignificant (P>0.05) decreased feed intakes of (DM, CP, DCP, TDN and DE) compared to control diets contained clover hay. Rabbits received basal diet with replacement (SBP) at the level 25% of clover hay (G_2) recorded the lowest dry matter intake. These results may be due to the strawberry aroma which is very complex, certain compounds have been described as main contributors, i.e. furanones, aldehydes, alcohols, sulfur compounds and particularly methyl and ethyl esters [25].

Feed conversion (g intake /g gain) of DM, CP, DCP, TDN and (kcal intake /g gain) of DE were improved when (SBP) used as a partial substitute of clover hay in rabbit diets. The best feed conversion was recorded by the rabbits received basal diet with replacement (SBP) at the level 25% of clover hay (G_2). These results may attribute to the effect of resistance starch in (SBP) which suitable to improve the caecum fiber digestion by eliminates the hazard microorganisms [26].

Carcass Characteristics of the Experimental Groups: Effect of dietary treatments on dressing percentages, carcass cuts and chemical analysis of the 9, 10 and 11th ribs are shown in Table 5. Dietary (SBP) treatments had no significant (P>0.05) effects on digestive tract weight (full, empty and content); empty body weight; carcass weight; dressing percentages; carcass cuts (fore and middle parts) and chemical analysis of the 9,10 and 11th ribs (DM, CP, EE and ash contents). Data in Table 6 showed that dietary treatments had no significant effects on external offal's and internal offal's except for liver weight and total giblets weight. Rabbits received basal diet with replacement (SBP) at the level 100% of clover hay recorded the highest value of liver weight and total giblets weight. These results may be due to the tiliroside contained in strawberry which inhibits obesity-induced hepatic and muscular triglyceride accumulation [4].

Table 5: Effect of dietary treatments on dressing percentages, carcass cuts and chemical analysis of the 9, 10 and 11th ribs

	Experimental diets					
Item	G_1	G_2	G_3	G_4	G_5	SEM
Slaughter weight (SW), g	2360	2363	2380	2370	2375	7.96
Digestive tract weight, g						
Full	378	383	370	350	333	10.96
Empty	177	180	174	164	156	5.06
Content	201	203	196	186	177	5.91
Empty body weight (EBW), g	2159	2160	2184	2184	2198	9.90
Edible offal's, g (Giblets)	129^{ab}	126^{ab}	129^{ab}	119^{b}	139^{a}	3.01
Carcass weight (CW)	1293	1301	1347	1358	1363	15.68
Carcass weight (CW)*	1422	1427	1476	1477	1502	15.7
Dressing percentages (DP)%						
DP1	54.79	55.06	56.6	57.3	57.39	0.57
DP2	59.89	60.23	61.68	62.18	62.01	0.49
DP3	65.86	66.06	67.58	67.63	68.33	0.46
Carcass cuts						
Fore part						
weight, g	439	465	481	461	471	6.69
% of CW	33.95	35.74	35.71	33.95	34.56	0.36
Middle part						
weight, g	278	296	275	295	298	5.70
% of CW	21.50	22.75	20.42	21.72	21.86	0.38
Hind part						
weight, g	576	540	591	602	594	9.74
% of CW	44.55^{a}	41.51^{b}	43.87^{ab}	44.33^{a}	43.58^{ab}	0.41
Chemical analysis of the 9,10 and 11th ribs						
Dry matter	31.34	32.44	31.36	31.98	32.01	0.36
Chemical composition on DM basis						
CP	65.43	66.13	66.43	66.54	66.81	0.90
EE	26.14	25.52	25.36	25.18	25.00	0.99
Ash	8.43	8.35	8.21	8.28	8.19	0.13

a and b: Means in the same row having different superscripts differ significantly ($P<0.05$).

SEM, standard error of the mean

* Carcass weight: included edible offal's (Liver, heart, kidneys, spleen, testes and lungs).

DP [1]: Dressing percentages calculated as (carcass weight / slaughter weight).

DP [2]: Dressing percentages calculated as (carcass weight / empty body weight).

DP [3]: Dressing percentages calculated as (carcass weight + edible offal's / empty body weight)

EBW: Empty body weight = Slaughter weight-digestive tract content.

G_1: Rabbits received control diet that contained 24% clover hay.

G_2: Rabbits received diet that replaced 25% of clover hay in basal diet with sun dried strawberry by-products (SBP).

G_3: Rabbits received diet that replaced 50% of clover hay in basal diet with sun dried strawberry by-products (SBP).

G_2: Rabbits received diet that replaced 75% of clover hay in basal diet with sun dried strawberry by-products (SBP).

G_2: Rabbits received complete replacement (100%) of clover hay in basal diet with sun dried strawberry by-products (SBP).

Economical Evaluation: The economical efficiency of dietary treatments is presented in Table 7. The profitability of using (SBP) as replacement in rabbit diets depends on upon the price of tested diets and the growth performance of rabbits fed these diets. Costing of one kg feed, (LE) was decreased by 3.25%, 6.49%, 9.74% and 12.98% for G_2, G_3, G_4 and G_5, respectively compared to control diet (G_1). Increasing the rate of replacement (SBP) from 0% to 100% of clover hay lead to increase the total revenue, net revenue, economical efficiency and relative economic efficiency. These results affected by the low price of (SBP) and the improvement of growth performance for (SBP) treatments compared to the control group. Relative economic efficiency values were 128.7, 131.7, 142.2 and 155.5% for groups G_2, G_3, G_4 and G_5 received (SBP) as replacement of clover hay by 25, 50, 75 and 100%, of clover hay, respectively compared to the control diet (G_1). On the other hand feed cost / kg LBW (LE) were decreased with increasing the level of (SBP) replacements of clover hay.

Table 6: Effect of dietary treatments on external and internal offal's (Giblets)

Item		Experimental diets G_1	G_2	G_3	G_4	G_5	SEM
Slaughter weight (SW), g		2360	2363	2380	2370	2375	7.96
External offal's:							
Head	weight, g	150	148	149	153	155	2.35
	% of SW	6.36	6.26	6.26	6.46	6.53	0.10
Fur, legs ears and blood	weight, g	410	405	385	390	385	7.22
	% of SW	17.37	17.14	16.18	16.46	16.21	0.32
	Total weight, g	560	553	534	543	540	6.61
	% of SW	23.73	23.40	22.44	22.92	22.74	0.30
Internal offal's (Giblets):							
Liver	weight, g	81.00^{ab}	75.00^{ab}	80.00^{ab}	68.00^{b}	89.00^{a}	3.19
	% of SW	3.43	3.17	3.36	2.87	3.75	0.14
Heart	weight, g	9.50	9.00	8.50	9.50	9.50	0.24
	% of SW	0.40	0.38	0.36	0.40	0.40	0.009
Kidneys	weight, g	15.50	16.50	17.50	17.50	17.00	0.48
	% of SW	0.66	0.70	0.73	0.74	0.72	0.02
Spleen	weight, g	1.75	1.50	1.50	1.50	1.25	0.11
	% of SW	0.07	0.06	0.06	0.06	0.05	0.005
Testes	weight, g	8.75	8.75	9.25	9.00	9.00	0.25
	% of SW	0.37	0.37	0.39	0.38	0.38	0.01
Lungs	weight, g	12.50	15.25	12.25	13.50	13.25	0.57
	% of SW	0.53	0.65	0.51	0.57	0.56	0.02
Total giblets	weight, g	129^{ab}	126^{ab}	129^{ab}	119^{b}	139^{a}	3.01
	% of SW	5.46	5.33	5.41	5.02	5.86	0.13

a and b: Means in the same row having different superscripts differ significantly ($P<0.05$).
SEM, standard error of the mean
G_1: Rabbits received control diet that contained 24% clover hay.
G_2: Rabbits received diet that replaced 25% of clover hay in basal diet with sun dried strawberry by-products (SBP).
G_3: Rabbits received diet that replaced 50% of clover hay in basal diet with sun dried strawberry by-products (SBP).
G_2: Rabbits received diet that replaced 75% of clover hay in basal diet with sun dried strawberry by-products (SBP).
G_2: Rabbits received complete replacement (100%) of clover hay in basal diet with sun dried strawberry by-products (SBP).

Table 7: Economical evaluation of the experimental groups

Item	Experimental diets G_1	G_2	G_3	G_4	G_5
Marketing weight, Kg	2.321	2.339	2.383	2.454	2.559
Feed consumed (as it is, kg) / rabbit,	6.737	5.611	5.947	6.11	6.378
Costing of one kg feed, (LE)[1]	2.126	2.057	1.988	1.919	1.85
Total feed cost, (LE)	14.32	11.54	11.82	11.73	11.8
Management/ Rabbit, (LE)[2]	4	4	4	4	4
Total cost, (LE)[3]	33.32	30.54	30.82	30.73	30.80
Total revenue, (LE)[4]	51.06	51.46	52.43	53.99	56.30
Net revenue	17.74	20.92	21.61	23.26	25.50
Economical efficiency[5]	0.5324	0.685	0.7012	0.7569	0.8279
Relative economic efficiency[6]	100	128.70	131.70	142.20	155.50
Feed cost / kg LBW (LE)[7]	6.17	4.93	4.96	4.78	4.61

[1] Based on prices of year 2011.
[2] Include medication, vaccines, sanitation and workers.
[3] include the feed cost of experimental rabbit which was LE 15/ rabbit + management.
[4] Body weight x price of one kg at selling which was LE 22.
[5] net revenue per unit of total cost.
[6] Assuming that the relative economic efficiency of control diet equal 100.
[7] Feed cost/kg LBW = feed intake x price of kg / Live weight.
LE = Egyptian pound equals 0.18 American dollars approximately.
G_1: Rabbits received control diet that contained 24% clover hay.
G_2: Rabbits received diet that replaced 25% of clover hay in basal diet with sun dried strawberry by-products (SBP).
G_3: Rabbits received diet that replaced 50% of clover hay in basal diet with sun dried strawberry by-products (SBP).
G_2: Rabbits received diet that replaced 75% of clover hay in basal diet with sun dried strawberry by-products (SBP).
G_2: Rabbits received complete replacement (100%) of clover hay in basal diet with sun dried strawberry by-products (SBP).

These results are in agreement with those obtained by Ibrahim *et al.* [27] who fed rabbits on two different levels of energy supplemented with herbs mixture at level of (1:1:1) of *Artemisia herba-alba*, *Matricaria recutita L.* and *Chrysanthemum coronarium.*

CONCLUSION

Under conditions of this study it can be maintained that strawberry by-products can be used as a good untraditional alternative source for clover hay in rabbit diets without any adverse effect on their performance. The feeding cost will reduce which is more than 70 percent of the total cost of production, consequently it can be considered that strawberry by-products a cheap source of ingredients can be used economically in rabbit diets formulations.

REFERENCES

1. Obun, C.O., S.M. Yahaya, A.A. Kibon, O.A. Olafadehan and S.D. Alison, 2010. Evaluation of *Detarium microcarpum* pulp meal as feed ingredient in rabbits diets. EJEAF Che, 9(2): 308-314.
2. Eduard Cruz-Rus, Iradida Amaya, Jose F. Sanchez-Sevilla, Migual A. Botella and Victoriano Valpuesta, 2011. Regulation of L-ascorbic acid content in strawberry fruits. J. Exp. Bot., 62(12): 4191-201.
3. Ellis, C.L., I. Edirisinghe, T. Kappagoda and B. Burton-Freeman, 2011. Attenuation of meal-induced inflammatory and thrombotic responses in overweight men and women after 6-week daily strawberry (Fragaria) intake. A randomized placebo-controlled trial. J. Atheroscler Thromb., 18 (4): 318-327.
4. Tsuyoshi Goto, Hiroyuki Nagai, Kahori Egawa, Young-Il Kim, Sota Kato, Aki Taimatsu, Tomoya Sakamoto, Shogo Ebisu, Takahiro Hohsaka, Hiroh Miyagawa, Shigeru Murakami, Nobuyuki Takahashi and Teruo Kawada, 2011. Farnesyl pyrophosphate regulates adipocyte functions as an endogenous PPARγ agonist. Biochem. J., 438(1): 111-119.
5. Bassett, M.N. and N.C. Sammán, 2010. Folate content and retention in selected raw and processed foods. Arch Latinoam Nutr., 60(3): 298-305.
6. Yoshikawa, H., M. Kotaru, C. Tanaka, T. Ikeuchi and M. Kawabata, 1999. Characterization of kintoki bean (*Phaseolus vulgaris*) alpha-amylase inhibitor: inhibitory activities against human salivary and porcine pancreatic alpha-amylases and activity changes by proteolytic digestion. J. Nutr. Sci. Vitaminol (Tokyo), 45(6): 797-802.
7. Wicks, D., J. Wright, P. Rayment and R. Spiller, 2005. Impact of bitter taste on gastric motility. Eur. J. Gastroenterol Hepatol., 17(9): 961-965.
8. Donohoe, Dallas R., Nikhil Garge, Xinxin Zhang, Wei Sun, Thomas M. O'Connell, Maureen K. Bunger and Scott J. Bultman, 2011. The Microbiome and Butyrate Regulate Energy Metabolism and Autophagy in the Mammalian Colon. Cell Metabolism, 13(5): 517-526.
9. Pusztai, A., G. Grant, T. Duguid, D.S. Brown, W.J. Peumans, E.J. Van Damme and S. Bardocz, 1995. Inhibition of starch digestion by alpha-amylase inhibitor reduces the efficiency of utilization of dietary proteins and lipids and retards the growth of rats. J. Nutr., 125(6): 1554-1562.
10. N.R.C., 1977. National Research Council. Nutrient Requirements of Rabbits, National Academy of Science, Washington, D.C, USA.
11. Blasco, A., J. Quhayaun and G. Masoscro, 1993. Hormonization of criteria and terminology in rabbit meat research. World Rabbits Sciences, 1: 3-10.
12. A.O.A.C., 2000. Official Methods of Analysis. 17th Ed. Association of Official Analytical Chemists, Washington, D.C, USA.
13. O'Mary, C.C., L.M. Everett and A.D. Graig, 1979. Production and carcass characteristics of Angus and Charolais x Angus steers. J. Anim. Sci., 48: 239.
14. Goering, H.K. and P.J. Van Soest, 1970. Forge Fiber Analysis (Apparatus, Reagents, Procedure and Some Applications). Agric. Hand Book 379, USDA, Washington and DC., USA.
15. Blaxter, K.L., 1968. The Energy Metabolism of Ruminants. 2nd Ed. Charles Thomas Publisher, Spring Field. Illinois, U.S.A
16. Fekete, S. and T. Gippert, 1986. Digestibility and nutritive value of nineteen important feedstuffs for rabbits. J. Appl. Rabbit Res., 9(3): 103-108.
17. Calsamiglia, S., M.D. Stem and J.L. Frinkins, 1995. Effects of protein source on nitrogen metabolism in continuous culture and intestinal digestion *in vitro*. J. Anim. Sci., 73: 1819.

18. SPSS., 1998. Statistical Package for Social Sciences, Chicago, U.S.A
19. Duncan, D.B., 1955. Multiple Rang and Multiple F-Test Biometrics, 11: 1-42
20. Alvarez-Suarez, J.M., D. Dekanski, S. Ristic, N.V. Radonjic, N.D. Petronigevic, F. Giampieri, P. Astolfi, A.M. Gonzalez-Paramas, C. Santos-Buelga, S. Tulipani, J.L. Quiles, B. Mezzetti and M. Battino, 2011. Strawberry Polyphenols Attenuate Ethanol-Induced Gastric Lesions in Rats by Activation of Antioxidant Enzymes and Attenuation of MDA Increase. PLOS One, 6(10): 25878.
21. Champ, M., A.M. Langkilde, F. Brouns, B. Kettlitz and Y.L. Bail-Collet, 2003. Advances in dietary fibre characterization. 2. Consumption, chemistry, physiology and measurement of resistant starch; implications for health and food labeling. Nutr. Res. Rev., 16(2): 143-161.
22. McDougall, G.J., F. Shpiro, P. Dobson, P. Smith, A. Blake and D. Stewart, 2005. Different polyphenolic components of soft fruits inhibit alpha-amylase and alpha-glucosidase. J. Agric. Food Chem., 6(53)(7): 2760-2766.
23. Du, X., M. Song and R. Rouseff, 2011. Identification of new strawberry sulfur volatiles and changes during maturation. J. Agric. Food Chem., 59(4): 1293-1300.
24. McGrath, N.A. and R.T. Raines, 2011. Chemo selectivity in chemical biology: acyl transfer reactions with sulfur and selenium. Acc. Chem. Res., 44(9): 752-761.
25. Moreno, Fde L., G.P. Blanch, G. Flores and M.L. del Castillo, 2010. Impact of postharvest methyl jasmonate treatment on the volatile composition and flavonol content of strawberries. J. Sci. Food Agric., 90(6): 989-994.
26. Duan, J. and Y. Zhao, 2009. Antimicrobial efficiency of essential oil and freeze-thaw treatments against *Escherichia coli* O157:H7 and *Salmonella enterica* Ser. Enteritidis in strawberry juice. J. Food Sci., 74(3): 131-137.
27. Ibrahim, Sh. A.M., A.A. Abedo, H.A.A. Omer and F.A.F. Ali, 2009. Response of growing New Zealand White rabbits to diets containing different levels of energy and mixture of some medical plants. World Journal of Agricultural Science, 5(5): 544-551.