INCLUSION OF DRIED AGRO-INDUSTRIAL STRAWBERRY BY-PRODUCTS IN GROWING RABBIT DIETS

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SUMMARY

This experiment was conducted to evaluate the effect of using dried strawberry by-product (ASB) in growing rabbit diets on growth performance, nutrients digestibility coefficients, some blood parameter and relative economic efficiency. Seventy two weaned male New Zealand White rabbits at 6 weeks received diets containing 0, 25, 50 and 75% ASB as a replace of berseem hay. The growth trial lasted for 8 weeks. Results obtained could be summarized as follows: There were significant increases in body weight gain with increasing ASB levels in the diets. Whereas, feed consumption and feed conversion ratio were not significantly affected by ASB feeding. Ether extract digestibility coefficients were significantly decreased with increasing dietary level of ASB, while the digestibility coefficients of DM, OM, CP and CF were higher in treatments containing ASB, while the digestibility coefficients of OM, CP and CF were significantly higher in treatments containing ASB. Dressing percentages of rabbits were significantly higher with 75% ASB feeding compared with other treatments. Dietary ASB treatments had no significant effects on meat chemical analysis (moisture, DM and CP contents). But EE and ash contents were decreased with ASB feeding. Blood plasma concentrations of triglycerides, cholesterol, LDL, vLDL and total lipids were significantly decreased with increasing the level of ASB in rabbit diets. Feeding ASB had a significant positive effect on blood plasma antioxidant profile. Leveling up dietary ASB inclusion rate decreased MDA level and increased the TAC capacity in an incremental manner with increasing ASB of the diet. Using ASB as a feed ingredient improved the relative economic efficiency of diets. It could be concluded that ASB can be used in the growing rabbit diets with no adverse effects on performance and health status of the rabbit. Besides, ASB could reduce the cost of the diet.

Keywords: *Dried strawberry by-products, growing rabbit, performance, nutrients digestibility coefficients and blood parameters.*

INTRODUCTION

Unconventional feedstuffs can offer a solution to extraordinary feed costs without compromising the nutritional value of animal comfort. The least cost diet formula is considered a target to rabbit nutritionists for achieving the best efficiency of utilization and economy in case of animal health and production. Berseem hay is the main plant source in rabbit diets. It is expensive in comparison to other nontraditional plant fiber sourcesthat have the privilege to enhance animal health and production.Hence, many feedstuffs, especially agro-industrial by-products which are usually of no feeding value to humans can alternatively be fed at a cheaper cost to rabbits (Obun *et al*., 2010). In Egypt, a considerable amount of food industry wastes is generated by the fruit-and-vegetable industries and handling estimates up to 30% of fruit and vegetable production (Industrial Union of Egypt, 2015). Studies concerning residual sources have been augmented considerably caused by a value adding recycling interest of the agro- and food industry, and also to increase information on the specific location of active compounds and their modification during processing (Alonso *et al*., 2002 and Amro *et al*., 2002).

Several studies reported that wastes and by-products of fruits may be an abundant source of antioxidant polyphenols (Peschel *et al*., 2006 and Wijngaard *et al*., 2009). Peschel *et al*., (2006) confirmed that agro industrial and agricultural wastes contain high amounts of phenolics and suggest the antioxidant recycling of the wastes of artichoke, apple and tomato; furthermore strawberry, asparagus or red beet. Vulić *et al*. (2011) reported that strawberry fresh pomace has a high content of polyphenolics (488.12 mg/100 g fresh pomace), flavonoids (296.11 mg/100 g fresh pomace) and anthocyanins (19.48 mg/100 g fresh pomace).

Strawberry by-products (SBP) can be used as untraditional feed ingredients (Rus *et al*., 2011). Strawberry belongs to the subfamily Rosoideae of the Rosaceae family are known to have exceptionally rich secondary metabolite composition (Puupponen-Pimin *et al*., 2005; Koponen *et al*., 2007).

Strawberry leaf includes tannins, flavonoids, a small amount of ascorbic acid and essential oils.Strawberry leaves could be used as appetizer, cholesterol and blood pressure lowering(Kümeli, 2006), and have an antioxidant activity (Ka¨hko¨nen *et al*., 2001 and Vulić *et al*., 2011). Goto *et al*. (2011) found that strawberry has a glycosides' flavonoid andpossesses anti-inflammatory, antioxidant activities.

Thehypotheses that polyphenolic as "-amylase inhibitor(resistant starch) from strawberry (Ellis *et al*., 2011) was also quite resistant to proteolytic digestion by trypsin (Yoshikawa *et al*., 1999) thatinduce delayed gastric emptying (Wicks *et al*., 2005) and has abilityto produce a large amount of butyrate as importantfood for cells lining colon (Donohoe *et al*., 2011) which make itpractically blocked by solidified digesta and theensuing bacterial fermentation stimulated the growthof this tissue by hyperplasia and hypertrophy (Pusztai *et al*., 1995) the resistant of strawberry by-product to rabbitalpha-amylase that produce a large amount of butyratewhich provides sufficient energy for colon cells (Champ *et al*., 2003) the limit doe of polyphenol from strawberry by-product has ability to inhibit alpha-amylase that may influence different steps in starch digestion in a synergistic manner (Mc-Dougall *et al*., 2005).

It can be maintained that strawberry by-products can be used as a good feed ingredient to replace clover hay in rabbit diets without any adverse effect on their performance and could be used economically in rabbit diet formulations (Omer *et al*., 2011).

The aim of the present investigation is to assess the effect of dried agro-industrialstrawberry by-product (ASB) as a partial replacement on growth performance, digestibility coefficients, some blood parameter and economic efficiency of growing rabbits.

MATERIALS AND METHODS

The experimental work of this study was carried out at Borg-El Arab, Alexandria Governorate, Experimental Research Station, Animal Production Research Institute, Egypt.

Table (1). Feed ingredients and chemical composition of experimental diets (%DM basis).

Feed Ingredients (%)	Control	T_1	T_2	T_3
		25% ASB	50% ASB	75% ASB
Dried Agro-industrial Strawberry By-products (ASB)	0	8.25	16.5	24.75
Berseem hay	33	24.75	16.5	8.25
Soybean meal (44%CP)	17.15	17.65	18	18
Barley	20	19	18	17.65
Yellow corn	8	8	8	8
Wheat bran	15.5	16	16.65	17
Molasses	3	3	3	3
Limestone	0.95	0.95	0.95	0.95
Dicalcium - phosphate	1.6	1.6	1.6	1.6
Sodium chloride	0.3	0.3	0.3	0.3
DL-Methionine	0.2	0.2	0.2	0.2
Mineral-vitamin permix[1]	0.3	0.3	0.3	0.3
Total	100	100	100	100
Total price feed/100 Kg (LE)	230	220	210	200
Chemical composition (%DM basis)				
Dry Matter%	89.88	89.90	89.95	90.01
Organic Matter%	90.99	90.89	90.83	90.81
Crude Protein%	16.72	16.28	16.17	16.06
Crude Fiber%	13.56	13.21	13.15	13.09
Ether Extract%	2.01	1.99	1.97	1.97
N-Free Extract%	58.70	59.41	59.54	59.69
Ash%	9.01	9.11	9.17	9.19
Digestible energy (Kcal/kg DM)[2]	2510	2507	2500	2499

[1]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. B1, 1.0 g Vit. B2, 0.33g Vit. B6, 8.33 g Vit.B 5, 1.7 mg Vit. B 1,2 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.

[2]*Digestible energy (DE) was calculated according to Fekete and Gippert (1986) using the following equation: DE (kcal/ kg DM) = 4253-32.6 (CF %)-144.4 (total ash).*

Animals, housing, treatments and diets:

A total number of Seventy two of weaning male New Zealand White rabbits at 6 weeks of age and nearly equal average initial live body weight (710.57 g) were randomly assigned to four experimental treatment groups (n=18 in each) in a completely simple randomized design. Dried agro-industrial strawberry by-product (ASB) was included in diets at levels of 0, 8.25, 16.5 and 24.75 to replace 0, 25, 50 and 75 %, respectively, of the berseem hay of the diets. The experimental period lasted for 8 weeks. ASB was obtained in a wet condition with moisture content from 65-70%. The humidity of ASB was reduced by sun-drying to 9-10%. Chemical analysis of ASB meal was carried out according (AOAC, 1996).

All rabbits were kept under the same management, hygienic and environmental conditions. Rabbits were individually housed in galvanized wire cages (Dimensions of 60×40×35 cm) until marketing at 14 weeks of age under a 12:12 h light–dark cycle. All rabbits were fed pelletized feed *ad libitum*. Feed ingredients and chemical composition of experimental diets (%DM basis) are shown in Table (1). The rabbits were reared in a well-ventilated building; fresh water was automatically available all the time by stainless steel nipples fixed in each cage.

All rabbit cages were equipped with feeders and nipples. Live Body weight was determined weekly throughout the experimental period, and weight gain was calculated. Feed consumption was determined precisely and calculated as grams per rabbit per day (during the all experimental period). Unused feed from each cage was collected daily, weighed and taken into consideration for the calculation of feed consumption, accordingly, feed conversion ratio was also calculated (g feed / g gain).

Digestibility and nitrogen balance trials:

A total number of 16 male (4 males in each group) were used in carrying out the digestibility trial for determining nutrient digestibility co-efficient of the tested diets. Animals were housed individually in cages that allowed the separation of feces and urine. All rabbits were kept under the same management, hygienic and environmental conditions. The experimental diets were offered twice daily at 9 a.m. and 15 p.m. and fresh water was provided *ad libitum*. Survey of daily feed consumption was recorded. Any possible feed contamination was removed from the feces.

The trial lasted for 15 days, 8 days as a preliminary period followed by 7 days for measurements of actual feed consumption and feces output. Samples of daily feces of each rabbit were taken and oven dried at 70º C for 48h, then was ground and stored for proximate chemical analysis. Samples of feed and feces were analyzed for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF), and ash according to the classical (AOAC, 1996) methods. The nutritive value of the experimental diets as DCP and TDN value were calculated according to Cheeke (1987).

The urine of each animal was collected in a glass recipient, containing 10 ml of a 1:1 HCl: H_2O solution, to avoid bacterial production and possible losses by volatilization. The chemical composition of feces, urine and feed was determined according to the methodologies described by Silva and Queiroz (2002). The values of nitrogen consumption (NC), nitrogen excreted in feces (NF) and nitrogen excreted in urine (NU) were obtained by multiplying nitrogen levels by the amounts of feed ingested and of feces and urine excreted, respectively; from those values, retained nitrogen was calculated as RN = NC − NF − NU.

Slaughtering and carcass traits:

At the end of the experimental period (14 weeks old), five male rabbits from each group were randomly taken, fasted for 12 h, individually weighed and immediately slaughtered. Slaughter procedure and carcass analysis were carried out as described by Blasco and Ouhayoun (1996). After complete bleeding, pelt, viscera's and tail were removed then the carcass and its components were weighed as edible parts. The non edible parts including lung, spleen, stomach, large intestine, small intestine and kidney fat were also weighed as percentage of pre-slaughter weight. Dressing percentage was calculated by dividing the hot dressed carcass weight by pre-slaughter weight and expressed as a percentage according to Steven *et al*. (1981).

Blood Sampling and determination of biochemical parameters:

Blood samples of five rabbits from each dietary treatment were collected during slaughtering to determine blood measurements. Blood plasma total protein, albumin, triglycerides, total cholesterol, LDL and HDL-cholesterol,vLDL, and total lipids were colormetrically determined using commercial kits (purchased from Bio-diagnostic, Egypt) according to the manufacturers' instructions. Plasma globulin concentration was calculated by difference was calculated. Blood plasma malondialdehyde (MDA) activity assayed using the method of Chiu *et al.*, (1976). Total antioxidant capacity (TAC) was determined according to Diamond Bio diagnostic, Egypt.

Relative Economic efficiency:

The relative economic efficiency of the experimental diets for the cost of feed required for producing one kg of body weight gain were calculated. The cost of the experimental diets was calculated according to the price of different ingredients prevailing in local market as well as the price of testing materials at the time of experimentation. Economic efficiency was calculated as a ratio between the return of weight gain and the cost of consumed feed.

Statistical Analysis:

The obtained data were statistically analyzed using SAS® Software Statistical Analysis (SAS 1999). Differences among means were tested by Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Chemical composition of ASB and berseemhay:

Chemical compositionof dried agro-industrial strawberry by-product (ASB) and berseem hayare shown in Table (2). The chemical analysis of DM and OM were higher in berseem hay compared to ASB. The chemical composition of NFE and ash in ASB was higher compared to berssem hay. On the other hand, berssem hay content of CF, CP and EE were higher than ASB. Na and K were higher in ASB were as Fe, Mn, Zn and Ca was higher in berssem hay. ASB contain higher amount of flavonoid (20.42).

Growth Performance:

Effects of experimental diets on growth performance from 6 to 14 weeks of age are presented in Table (3). Rabbits fed diets containing different levels of ASB had significantly higher body weight values compared to the control group at the end of the study.

Table (2). Chemical analysis of Dried Agro-industrial Strawberry by-product and Berseem hay.

Item	Dried Strawberry By-product(ASB)	Berseem hay
Chemical analysis, (%)		
Dry matter (DM)	93.18	95.12
Chemical analysis on DM basis		
Organic matter (OM)	80.68	89.59
Crude protein (CP)	7.38	10.64
Crude fiber (CF)	11.65	38.54
Ether extract (EE)	0.89	1.03
Nitrogen-free extract (NFE)	60.76	39.38
Ash	19.32	10.41
Gross energy (Kcal/kg DM)[1]	3506	3932
Digestible energy (Kcal/kg DM)[2]	1083.40	1493.39
Non fibrous carbohydrates (NFC)[3]	40.12	22.03
Cell wall constituents		
Neutral detergent fiber (NDF)	32.29	55.89
Acid detergent fiber (ADF)	24.19	43.27
Acid detergent lignin (ADL)	15.78	37.19
Hemicellulose	8.1	12.62
Cellulose	8.41	6.08
Fe (ppm)	242.88	471.2
Mn (ppm)	17.987	31.94
Zn (ppm)	19.02	30.38
Na (ppm)	2777	19211
Ca (ppm)	7075	8564
K (ppm)	20114	10890
Flavonoid on dry matter, mg/ 100gm	20.42	ND*

[2]Digestible energy (DE) was calculated according to Fekete and Gippert 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. using the following equation: NFC = 100-{CP + EE + Ash + NDF}.*
Hemicellulose = NDF-ADF.
Cellulose = ADF-ADL.

The improvement in final body weight were 3.6, 3.1 and 4.3 % for rabbits receiving 25, 50 and 75% ASB, respectively compared to control rabbits. There were no significant differences in live body weight gain during each of the studied intervals except for the period 8-10 weeks of age where feeding 75% ASB resulted in the highest weight gain compared to other treatments, while there were significant improve in total BWG in ASB containing diets compared with control group.

The reported improvements in final live body weight with the increase in dietary ASB could be partially attributed to the significant improvements in CP and CF digestibility coefficients (table 4). Also, the improvement in body weight and body weight gain may be due to antioxidant activity and phenolic content in ASB (Alvarez-Suarez *et al*., 2011). Strawberry contains sulfur volatiles (Du, 2011), which is the main component of the biochemical structure of the amino acids such as cysteine, methionine, taurine and glutathione (McGrath and Raines, 2011). All these bioactive compounds could result in further enhancement of growth performance of the rabbit.

Feed consumption was affected ($p<0.05$) by experimental treatments (ASB) at 8-10 weeks and 12-14 week of age. Rabbits supplied with 50 % ASB in their diet had a pronounced decrease ($p<0.05$) in feed consumption by 9.3 % compared to the control diet at 8-10 week of age. On the other hand, the same treatment resulted in a significant increase in feed consumption during 12-14 weeks of age followed by those groups fed 25% ASB in their diets, compared to 75% ASB feeding or the control rabbits.

Feed conversion ratios were significantly improved by including different levels of ASB in the diets during 10-12 week of the study. The improvements in feed conversion ratio ranged between 8.2-8.3% of the groups fed 25, 50 and 75 % ASB substituted for berseem hay. The best significant total FCR was for the treatment with 75% ASB feeding compared to the control group. These results may attribute to the effect of resistance starch in strawberry by-product which suitable to improve the caecum fiber digestion by eliminating the hazard microorganisms (Duan and Zhao, 2009).

Table (3). Means of growth performance of growing rabbits fed diets contain different levels of ASB substitution with berseem hay.

Items	ASB				SEM	significance
	Control zero	T_1 (25%)	T_2 (50%)	T_3 (75%)		
Live Body weight, g						
at 6 week	690.56	716.72	715.89	719.11	13.73	NS
at 8 week	1115.28	1137.22	1129.61	1141.67	29.56	NS
at 10 week	1551.44	1581.89	1562.94	1620.50	31.53	NS
at 12 week	1964.59^{b}	2017.61^{ab}	2012.47^{ab}	2053.33^{a}	23.60	*
at 14 week	2322.33^{b}	2405.18^{a}	2393.18^{a}	2421.12^{a}	23.08	*
Body weight gain, g						
6-8 week	424.72	420.50	413.72	422.56	25.23	NS
8-10 week	436.17^{b}	444.67^{ab}	428.24^{b}	478.83^{a}	13.36	*
10-12 week	402.47	437.18	449.35	432.83	17.27	NS
12-14 week	347.80	380.59	380.71	376.47	17.78	NS
Total BWG, g	1628.73^{b}	1686.59^{ab}	1678.12^{ab}	1705.88^{a}	0.88	*
Feed Consumption, g						
6-8 week	512.77	476.12	477.77	455.52	14.54	NS
8-10 week	825.46^{a}	829.38^{a}	755.22^{b}	809.14^{a}	10.30	*
10-12 week	1209.48	1198.47	1245.16	1178.59	35.52	NS
12-14 week	1247.31^{b}	1338.48^{ab}	1375.38^{a}	1272.29^{b}	33.14	*
Total FI, g	3810.43	3841.48	3861.05	3754.51	1.46	NS
Feed conversion ratio, (g feed / g gain) %						
6-8 week	1.27	1.19	1.21	1.18	0.06	NS
8-10 week	1.92^{a}	1.89^{a}	1.79^{ab}	1.70^{b}	0.05	*
10-12 week	3.01^{a}	2.79^{b}	2.78^{b}	2.78^{b}	0.07	*
12-14 week	3.63	3.62	3.66	3.50	0.13	NS
FCR	2.34^{a}	2.28^{ab}	2.31^{ab}	2.21^{b}	0.05	*
Duration period, 56 days						

**a, b, c and d: Means in the same row having different superscripts differ significantly (P<0.05).*
NS not significance.

Also, these significant results may be due to the antioxidant activity and phenolic content in strawberry by-products as well as with the capacity of promoting the action of antioxidant enzymes (Alvarez-Suarez et al., 2011), while the insignificant effect on feed consumption may be due to the unpleasant smell of butyric acid which configured as a result of resistant starch (Champ*et al*., 2003). These results may be due to the sulfur volatiles in strawberry (Du *et al*., 2011), which is a main component of the biochemical structure of the amino acids such as cysteine, methionine, taurine and glutathione (McGrath and Raines, 2011). In this respect, Omer *et al.* (2011) reported that rabbits received a basal diet with replacement strawberry by-products at the level 100% of clover hay increased the final body weight, total body weight gain and average daily gain by 10.25, 13.78 and 13.79%, respectively.

Nutrient digestibilitycoefficients and nutritive values of the experimental diets:

Digestibility coefficients and nutritive values of the experimental diets are shown in Table (4). Dietary treatments had no significant effects on dry matter (DM) and nitrogen free extract (NFE) digestibility coefficients.

Table (4).Nutrient digestibility coefficients and nutritive values of growing rabbits fed diets containing different levels of ASB.

Item	Treatments				SEM	Sign.
	Control zero	T_1 25%	T_2 50%	T_3 75%		
DM	67.70	67.87	65.94	68.25	1.62	NS
OM	74.28^{b}	74.99^{b}	77.85^{a}	74.56^{b}	1.71	*
CP	76.03^{b}	76.69^{b}	80.78^{a}	79.33^{a}	2.19	*
CF	42.69^{c}	55.64^{b}	60.72^{a}	61.57^{a}	1.11	*
EE	65.42^{a}	59.69^{b}	55.45^{b}	52.99^{b}	2.32	*
NFE	81.57	81.31	80.09	79.28	1.34	NS
Nutritive value (%DM)						
DCP	13.97^{b}	14.11^{b}	15.20^{a}	14.30^{ab}	0.71	**
TDN	53.11^{b}	55.10^{a}	56.00^{a}	53.90^{b}	1.79	*
N-balance						
N-intake (IN, g/day)	3.38	3.37	3.26	3.15	0.19	NS
Faecal-N (FN, g/day)	1.03^{a}	0.99^{ab}	0.97^{ab}	0.79^{b}	0.21	**
Urinary-N (UN, g/day)	0.99^{a}	0.98^{a}	0.87^{ab}	0.77^{b}	0.11	*
Digestible N (DN, g/d)	2.35	2.38	2.29	2.36	1.13	NS
Retained N(RN, g/d)	1.36^{b}	1.40^{b}	1.42^{b}	1.59^{a}	0.09	*
DN/IN (%)	69.53^{b}	70.62^{b}	70.25^{b}	74.92^{a}	1.70	*
RN/IN (%)	40.24^{b}	41.54^{b}	62.01^{b}	50.48^{a}	1.16	*
RN/DN (%)	57.87^{b}	58.82^{b}	55.61^{b}	67.37^{a}	0.79	*

DN = IN-FN. RN = IN-FN-UN.
DN/IN (%) = the efficiency of intake N converted into digestible N.
RN/IN (%) = the efficiency of intake N converted into retained N.
RN/DN (%) = the efficiency of digestible N converted into digestible N.
NS not-significance.

Rabbits received diets 50% ASB recorded significantly the highest digestibility coefficients of organic matter (OM) and nutritive values as total digestible nutrient (TDN) or digestible crude protein (DCP) when compared with the rest treatments or control diets. The highest digestibility coefficients of crude protein (CP) and crude fiber (CF) were recorded for the rabbits that fed on diets containing 50 and 75% ASB when compared with a control group or with that containing 25% ASB in their diets. The digestibility coefficients of ether extracts (EE) significantly decreased with increasing the dietary level of ASB when compared with the control group.

The effects of the ASB on N balance are shown in Table 4. The fecal N (FN) and urinary-N (UN) were significantly decreased, while retaining N (RN), the efficiency of consumption N converted into digestible N (DN/IN) and the efficiency of consumption N converted into retained N (RN/IN) significantly increased with the 75% ASB compare to other treatments. In addition, no significant effect was observed on N consumption (IN) and the efficiency of digestion N (DN) between treatments. Increased digestibility and N-utilization may be due to positive impacts of ASB on absorption and utilization of nutrients.

The improvement in digestion coefficient and nitrogen balance when using ASB as a feed may be due to that polyphenolic from strawberry may: 1-resiste proteolytic digestion by trypsin (Yoshikawa *et al*., 1999). 2- Delayed gastric emptying (Wicks *et al*., 2005). 3- Has abilityto produce a large amount of butyrate as an importantfood for cells lining the colon (Donohoe *et al*., 2011). On the other hand, the resistant of strawberry by-product to rabbitalpha-amylase that produce a large amount of butyrate,which provides sufficient energy for colon cells (Champ *et al*., 2003) the limit doe of polyphenol from strawberry by-product has ability to inhibit alpha-amylase that may influence different steps in starch digestion in a synergistic manner (Mc-Dougall *et al*., 2005).

Carcass traits and chemical composition:

Results of carcass traits studied are shown in Table 5. Dressing, edible giblets and total edible parts percentage of rabbits fed 75% ASB diet was significantly higher than the other treatments. These results may be due to the tiliroside contained in strawberry which inhibits obesity-induced hepatic and muscular triglyceride accumulation, (Goto *et al.*, 2011). In this connection, Omer *et al*., (2011) claimed that rabbits received a basal diet with replacement dried agro-industrial strawberry by-products at the level 100% of berseem hay recorded the highest value of liver weight and total giblets weight.

The effect of dietary treatments on chemical analysis of the meat carcass is shown in Table 5. ASB treatments had no significant effects on chemical analysis of moisture, DM, and CP contents of the meat. However, ether extract and ash in the meat of the rabbits fed on different levels 25, 50 and 75 % ASB were significantly decreased when compared with the control group.

Table (5).Carcass traits and chemical analysis of the meat carcass of growing rabbits fed diets containing different levels of ASB.

Item	Treatments				SEM	Sign.
	Control zero	T_1 25%	T_2 50%	T_3 75%		
Pre-slaughter weight (g)	2232.4	2225.6	2236.4	2214.5	62.5	NS
Dressing %	57.00^{b}	58.70^{b}	61.24^{ab}	63.70^{a}	1.7	*
Edible giblets %	3.20^{b}	3.15^{b}	3.32^{ab}	3.42^{a}	0.01	*
Total edible parts %	60.20^{b}	61.85^{b}	64.56^{ab}	67.12^{a}	1.08	**
Chemical compositionof carcass %						
Moisture	71.174	71.684	72.084	73.03	0.19	NS
DM	28.826	28.316	27.916	26.97	0.17	NS
CP	22.194	23.264	23.008	22.56	0.21	NS
EE	4.072^{a}	3.162^{b}	2.066^{c}	2.026^{c}	0.14	*
Ash	1.896^{a}	1.372^{b}	1.47^{b}	1.392^{b}	0.017	*

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

NS not significance

Blood plasma biochemical values:

Effects of dietary treatments on blood plasma biochemical concentration are shown in Table 6. Data for the plasma total protein and HDL showed that there were no significant differences between the experimental groups fed diets containing 25, 50 and 75 % ASB and the control group. Albumin of the rabbits fed 50 and 75% ASB diets were significantly (P<0.05) higher than those fed 25% ASB and control diets. Plasma globulin, triglycerides, cholesterol, vLDL and total lipids were significantly lowered with ASB inclusion in the rabbit diets compared to the control rabbits.Plasma cholesterol and LDL were significantly lowered upon feeding 50 or 75% ASB compared to the control or 25% ASB feeding. Higher dietary ASB treatments decreased blood plasma analysis of cholesterol, LDL, vLDL and total lipids. These results may be due to that the leaves of strawberry contain a wide range of phenolic compound classes. This polyphenolic rich strawberry may provide protectionfrom high carbohydrate/fat meal-induced increases infibrinolytic and inflammatory factors (Ellis *et al*., 2011).

Blood plasma antioxidant constituents:

Effects of different levels of ASB on blood plasma antioxidative parameters are presented in Table 6. The blood plasma lipid peroxide (malondialdehyde (MDA) (nmol/l) levels of rabbits fed diets of 50 and 75 % ASB diets were significantly lower compared with control and 25% ASB diets. MDA level was observed to move down to the highest levels of ASB (50 and 75%), respectively. The blood plasma total antioxidant capacity (TAC) was within the range of 0.50 –3.09 mmol/l. The blood plasma TAC levels of rabbits fed ASB at any inclusion level were significantly higher compared with control rabbits. The blood plasma TAC levels were observed to move up constant with increasing dietary levels of ASB. The reduced levels of lipid peroxides following substitution with ASB may have been associated with increased antioxidant enzyme activity. Confirming to our results,Saponjac *et al.*, (2014) reported that the strawberry pomace contained higher amounts of total flavonoids and anthocyanin's, individual phenolic acids and flavonoids, among them protocatechuic acid, catechin and pelargonidin-3-glucoside (1838.31and 1646.68 per 100 g, respectively). Niki (2008) found that lipid peroxidation represents oxidative decomposition of lipids and is an indicator of oxidative stress status in tissues and cells. Kosseva (2013) reported that phenolic compounds are major contributors to the antioxidant capacity of common fruits and vegetables and their agro wastes.

Table (6). Blood plasma biochemical of growing rabbits fed diets containing ASB.

Item	Treatments				SEM	Sign.
	Control zero	T_1 25%	T_2 50%	T_3 75%		
Total protein, (g/dl)	5.93	5.55	6.06	6.01	0.17	NS
Albumin, (g/dl)	3.03^b	3.02^b	3.56^a	3.58^a	0.101	*
Globulin (g/dl)	2.90^a	2.53^b	2.50^b	2.43^b	0.109	*
Triglycerides, (mg/dl)	81.50^a	75.74^b	70.90^b	67.84^b	2.066	*
Total cholesterol, (mg/dl)	127.21^a	123.24^a	118.17^b	117.8^b	2.99	**
HDL, (mg/dl)	68.97	66.43	64.78	64.57	1.499	NS
LDL, (mg/dl)	41.94^a	41.662^a	36.21^b	35.06^b	1.057	*
vLDL, (mg/dl)	16.3^a	15.15^b	14.18^b	13.57^b	0.957	**
Total Lipid(mg/l)	346.19^a	302.69^b	256.61^b	251.02^b	17.34	**
Blood plasma antioxidant constituents						
MDA, (nmol/l)	5.34^a	5.01^a	1.90^b	1.01^c	0.065	*
TAC, (mMol/L)	0.50^d	0.83^c	1.06^b	3.09^a	0.098	*

**a, b, c and d: Means in the same row having different superscripts differ significantly (P<0.05).*
NS not significance

Economic Evaluation:

Final body weight, length of the growing period and feeding cost are generally among the most important factors involved in achievement of maximum efficiency values of meat production. The relative economic efficiency (REE) of the different formulated diets as affected by different treatments is shown in Table 7. It should be pointed that the REE values were calculated according to the prevailing market selling price of 1 kg LBW.

Table (7). Economic analysis of growing rabbits fed diets containing different levels of ASB.

Items	Control	T_1	T_2	T_3
Average total weight gain/ rabbit (kg)	1.629	1.687	1.678	1.706
Total revenue/ rabbit (LE)(1)	40.73	42.18	41.95	42.65
Total feed consumed/rabbit (Kg)	3.810	3.842	3.861	3.755
Price of feeding/kg (LE)	2.30	2.20	2.10	2.00
Total cost of feed/ rabbit (LE)	8.76	8.45	8.11	7.51
Total fixed cost of/ rabbit (LE)	6	6	6	6
Total cost/ rabbit (LE)	14.76	14.45	14.11	13.51
Net revenue/ rabbit (LE(2))	25.97	27.73	27.84	29.14
Economic efficiency (EE)(3)	1.76	1.92	1.97	2.16
Relative economic efficiency (REE)	100	109.1	111.93	122.73

Total price for feeds was calculated according to the price of different ingredients available in ARE.

1- *The price was calculated due to the local market the price of one ton of ASB (LE) and price of one Kg live weight was 25 LE.*
2- *Net revenue= total revenue/rabbit- total feed cost*
3- *Economic efficiency= net revenue/ total feed coast*
4- *Relative economic efficiency of the control, assuming that the relative E1 of the control (T1)=100*

Results indicated that ASB improved slightly the net revenue and reduced the cost of producing kilogram BW as compared with control group. Data showed that 75% ASB to growing rabbit gave the best economic efficiency (2.16) followed by 50 and 25 % ASB (1.97 and 1.92), when compared to the control group (1.76), respectively. The results indicated that 25, 50 and 75% ASB as a partial replacement for berseem hay improved the REE of diets by 109.1, 111.93 and 122.73%, respectively, when compared with the control diet .(%100.00)

The results of this study are in agreement with those of Omer et al. (2011) who found that rabbits received diet complete replacement strawberry by-product at the level 100% of clover hay recorded the highest value of the total revenue, net revenue, economical efficiency and relative economic efficiency were increased. It can be maintained that ASB could be used in rabbit diets.

CONCLUSION

The results of the current study suggests that dietary supplementation of ASB at 25, 50 and 75% levels as a replacement of berseem hay had no adverse effect on growth performance, digestibility coefficient, carcass traits, blood plasma analysis and economic efficiency. It can be concluded that ASB can be used as a cheap non-traditional source in rabbit's diets at level of 75% as a replacement of berssem hay.

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إدخال مخلف تصنيع الفراولة المجفف في علائق الأرانب النامية

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يهدف هذا البحث إلي تقييم استخدام مخلف تصنيع الفراولة المجفف علي الأداء الإنتاجي وكفاءة الهضم وبعض قياسات الدم والكفاءة الاقتصادية للأرانب النامية. تمت تغذية 72 أرنبنامي متوسط عمر 6 أسابيع علي علائق تحتوى علي صفر و 25 و 50 و 75% مخلف تصنيع الفراولة المجفف بدلا من دريس البرسيم. واستمرت التجربة لمدة 8 أسابيعويمكن تلخيص النتائج علي النحو التالي:

بزيادة مخلف الفراولة الجاف في العليقة زاد معدل الوزن الناتج للجسم زيادة معنوية بينما لم يتأثر كل من متوسط الغذاء المأكول وكفاءة التحويل الغذائي باستخدام مخلف تصنيع الفراولة المجفف. انخفض معامل هضم الدهن الخام في حين زاد معامل هضم المادة العضوية والبروتين الخام والألياف الخام بصورة معنوية. النسبة المئوية للتصافي زاد في الأرانب التي غذيت علي 75% مخلف الفراولة مقارنة بالمعاملات الأخرى. لا يوجد تأثير معنوي علي التحليل الكيميائي للحم (رطوبة – مادة جافة – بروتين خام) بينما انخفضت نسبة الدهن بصورة معنوية.

انخفض كل من الجلسريدات الثلاثية والكوليستيرول و LDL و vLDL والليبيدات الكلية بصورة معنوية في بلازما الدم. مخلف الفراولة كان له تأثير معنوي ايجابي علي مضادات الأكسدة. بزيادة مستوي مخلف الفراولة الجاف في عليقة الأرانب نقص معدل MDA وزاد TAC بصورة تدريجية. أدي استخدام مخلف الفراولة إلي زيادة معدل الكفاءة الاقتصادية.

يستخلص من هذا البحث أنه يمكن استخدام مخلف تصنيع الفراولة الجاف في عليقة الأرانب بدون تأثير علي الأداء الإنتاجي والحالة الصحية للأرانب كما أنه أدى إلي خفض تكلفة العليقة.