

IMPACT OF PARTIAL REPLACEMENT OF ALFALFA HAY WITH PRICKLY PEAR PEELS (PPPS) ON PRODUCTIVE PERFORMANCE OF RABBITS.

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SUMMARY

Forty New Zealand white rabbits (NZW) male rabbits weighed 500±6 g were used in the present study to determine the effect of using residues prickly pear peels of a source of dietary feedstuffs on productive performance, digestibility, some blood constituents and Economic efficiency of rabbit. The animals were divided into four experimental groups of 10 rabbits each. The experimental diets replacing hay with prickly pear peels (ppps) at portion (0.0, ,25, 50 and 75%) respectively. Results obtained could be summarized as follow: The final live body weight, total weight gain and performance index were significantly ($p < 0.05$) affected by experimental treatment groups. The highest ($p < 0.05$) values of live body weight, total weight gain and performance index were recorded by rabbits fed 75 % (ppps) Inclusion (1986.5g, 1489g and 73.30 %) followed by received Inclusion level 50 % (ppps) (1946.97g, 1416.37g and 68.31 %), respectively compared with the 25 % (ppps) (1836.97g, 1339.37g and 59.45 %) or control (1778.75g, 1283.45g and 53.74 %),respectively. Feed intake (g), protein intake, and digestible energy intake were significantly ($p < 0.05$) decreased with increasing (ppps) levels. Rabbits fed (ppps) (75%) diet recorded a significant better feed conversion ratio (FCR) value followed by those of 50 %, 25 and control respectively. Digestibility coefficient and nutritive values (DM, CP, CF, TDN and DE) were significantly improved for rabbits fed diet contained (ppps) compared to those fed the control diet. Cecal PH value and NH_3 -N concentrations were higher ($p < 0.05$) in the control group than those of the treatment groups. Concentration of TVFAS was lower in control whereas the highest was obtained by treatment 75 % of (ppps) ($p < 0.05$). Also inclusion of tested material significantly ($p < 0.05$) increased dressing percentage and carcass weight. Plasma concentrations of total proteins, albumin and globulin were increased ($p < 0.05$) whereas ALT, AST, total lipids, total cholesterol, HDL and LDL were decreased ($p < 0.05$) by treatments of (ppps). The best Economical efficiency and relative economical efficiency values were recorded with rabbits fed 75 % (ppps) inclusion followed by rabbits received 50 % and 25 % treatment of (ppps) respectively it could be concluded that replacing hay with prickly pear peels (ppps) at portion (25, 50 and 75%) into diets recorded the beneficial growth performance, nutrients digestibility, and the best Economical efficiency of NZW Rabbits.

Keywords: *NZW rabbits, prickly pear peels, performance, digestibility.*

INTRODUCTION

In Egypt, the reduction in local feedstuff recourses is considered as the main constrains for improving and developing animal production. Many problems confront the development of livestock one of which is shortage feedstuff and high cost of concentrate feed mixture. Therefore, it is believed that inclusion of some agricultural by products to replace a part of the concentrate diet for animal become on obligation (El-Ashry *et al.*, 2001; Deraz and Ismail, 2001 and Bassuny *et al.*, 2003). Increasing animal protein production in Egypt was depend upon the possibility of exploring and utilizing all possible and available resources of agriculture CO₂ products in animal feeding (El-Shinnawy and Eassawy, 2016). The processing of many fruits results in accumulation of large quantities of by – products. Proper utilization of these by – products could reduce waste disposal problems and serve as a potential new source of fats and protein for use in food and feed (Kamel and Kakuda, 2002).

In Egypt, the total area annually cultivated with prickly pear (pp) was about 14100 feddans producing about 28400 tons, fruits which calculated about 13420 tons of peels (Anon ymous, 2008). Fruits of (pp) are recognized as an important source of vitamins for local people. The vegetable stems and fruits of pp are useful for a variety of purposes including food (fresh fruit, paste, jam, salads and refreshing drinks)

fodder (auxiliary, feed for cattle, sheep and goats) and medicinal (antidiuretic agent) and for. Industrial products such as alcohol, pectin and oils (Lakshminarayana, 1980).

Cactus opuntia cladodes or cactus or *opuntia prickly cladodes* (pads) (COC) are known for its medicinal properties such as an auxiliary treatment for obesity and gastrointestinal or cardiovascular disorders. Also, the extracts of this material decrease level of cholesterol, triglyceride and serum glucose (Kaur, *et al.*, 2012). The information about the usage of COC as forage source for growing rabbits is very rare in the literature. For instance, COC accumulate after processing of prickly pear that can cause environmental pollution. Prickly pears have fundamental economic importance in many desert areas especially in north Sinai, which are produced in abundant quantities. Cactus is a desertification plant and a highly palatable to wild and domesticated rabbits (Hoffman *et al.*, 1993 and Ruiz-Feria, 1996). Its secondary compounds had antimicrobial effects by acting against bacteria, protozoa and fungi. Phenolic compounds are the main active components (Burt, 2004 and Zeedan (2015).

The *opuntia* species *cladodes* serve as a source of varied number of phytoconstituents mainly sugar, phenolics and pigments. *Opuntia prickly cladodes* (pads) are an important source of several nutritional substances like pectin, mucilage and minerals. The pads, also known as *cladodes* are an excellent source of proteins including essential amino acids, high malic acid contents and good source of vitamin A, vitamin E, vitamin C, flavonoid fraction, carotenoids, chlorophylls and phenolic constituents. Several studies have reported that high levels of amino acids especially proline, taurine and serine can also be found in prickly pads (Stintzing and Carle, 2005; Feugang *et al.*, 2006, Cardador-Martinez *et al.*, 2011 and Badr *et al.*, 2017).

Cactus opuntia cladodes are rich in potassium followed by calcium and magnesium, whereas other elements are in typical range (Batista *et al.*, 2003 Ben Salem *et al.*, 2005, and Badr *et al.*, (2017).

More recently, the antioxidant properties of the most frequent cactus pear betalains (betanin and indicaxanthin) have been revealed, anti-hyperglycemia and regulator of blood cholesterol (Tesoriere *et al.*, 2005 and Stintzing *et al.*, 2005). Kaur, *et al.* (2012) indicated that the plants of the Cactaceae family contain flavonol 3-O-glycosides (quercetin, kaempferol, and isorhamnetin), dihydroflavonols, flavonones, and flavanols. *Opuntia cladodes* are an excellent energy source, rich in nonfibrous carbohydrates and presents high dry matter digestibility coefficient (Wanderley *et al.*, 2002) and Costa *et al.* (2012). Demonstrated that increasing levels of cactus pear in the diet of these sheep favours a high digestibility of nutrients and improves the quality of forage. Louacini, *et al.* (2012) showed that the regulatory effect on blood glucose and hypolipidemic in both humans and animals.

Peels and seeds are the waste products of the pp fruits processing in dustiest ppp make about 50% of the whole fruit weight and is subsequently the major by-product while, seed constitute about 10-15% of the edible pulp and are usually discarded as waste after extraction of the pulp. Stintzing *et al.* (2000) indicated that the oil processed from the seeds constitutes 7-15% of the whole seed weight and is characterized by high degree of insaturation where in linoleic acid is the major fatty acid (57-77.1%).

The fruits have a thick peel enclosing a delicately flavored very seedy pulp. There are few reports in literatures about the utilization of the peels of PP fruits. Badr *et al.* (2017) cleared that PPPs is a source of protein (4.75%), carbohydrates (59.25%), calcium (2.04%), iron (80.35%), zinc (37.49mg/kg), copper (1.92mg/kg), phosphorous (0.9%), mannan (7.76%), beta-glucan (27.25%) and B-carotene (141.4ug/100g). PPPs content of hemicellulose, cellulose and lignin were 0.5, 10.92% and 1.2%, respectively. Amino acid profile ensured the existence of fifteen amino acids of which seven were essentials: leucine (0.22%), valine (0.19%), lysine (0.11%), phenylalanine (0.14%), threonine (0.14%), isoleucine (0.15%) and histidine (0.09%). The remaining amino acids were aspartic acid (0.28%), arginine (0.15%), alanine (0.19%), proline (0.23%), glutamic acid (0.32%), glycine (0.18%) and serine (0.14%). So, the chemical composition indicated that PPPs is rich (on dry matter basis) in its content especially in readily digestible carbohydrate that it is may serve as a good source of fermentable ME. Although it has been used as an animal feed its value especially for farm animals, has received little research attention. One of the major needs within the PP industry is the development of new processed PP products as well as the fruit by products. These new functional components from prickly pear peel open new possibilities for adding value to a very ancient, but not sufficiently known, crop of the arid and semi-arid regions. The expansion of the PP cultivation in arid and semi-arid areas could be of interest for stimulating bioindustries in developing countries (Terrazas *et al.*, 2002).

The objective of this experiment was to examine the effects of replacing hay with prickly pear peels (ppps) contained diets on production, performance, nutrient digestibility coefficients, blood constituents and economic efficiency of growing rabbits.

MATERIALS AND METHODS

The present study was carried out in the rabbit try farm of poultry production Department, faculty of Agriculture, Elsharkia, zkazik University and Regional center for food and feed (RCFF), Agric.Res. Center (ARC), Ministry of Agric., Giza, Egypt. This work designed to study the influence of replacing hay with prickly pear peels (ppps) at portion (25, 50 and 75%) at different levels on growth performance, digestibility, and economic evaluation of growing New Zealand white rabbits.

Preparation of the dried powder of PPPs and feed ingredients:

The prickly pear peels (PPPs) were collected from local market of Giza Governorate during summer season (August 2016). The peels were dried by spreading in direct sun after being chopped (about 3cm length). The peels were shuffled upside-down and mixed well every day until its moisture content regressed to about 20%. Complete drying was done by using an oven at 55C for 8h., the dried peels and feed ingredients were grounded in a blender for 5min and packed in polyethylene bags until analysis.

Chemical analysis:

Representative samples of feed ingredients and experimental rations were taken for proximate analysis according to the procedures of AOAC (2002).

Fiber fraction analysis:

Natural detergent fiber (NDF), Acid detergent fiber (ADF) and acid detergent lignin (ADL) contents of feed ingredients and experimental rations were determined by analysis of fiber fraction according to **Van Soest *et.al.* (1991)**. Cellulose (CEL) and hemicellulose (HEM.) content were calculated respectively, by subtracting ADL from ADF and ADF from NDF.

Experimental animals:-

Forty weaned New Zealand White rabbits (NZW) of male rabbits aged 35 days and weighed 500+6 on average were equally and randomly divided into four groups (10 in each one).

Feeding and drinking management:-

Feed and water were offered adlibitum throughout the experimental period from 5 to 14 weeks of age. All rabbits were nearly equal in live body weight at the beginning of the experiment. All nutrients, essential amino acids, minerals and vitamins in the experimental diets were adjusted according to the rabbit requirements of NRC (1977). All the experimental animals were healthy and clinically free from internal and external parasites and were kept under the same management and hygienic conditions. Table (1) shows the composition and calculated analysis of the experimental diets. The first group was fed adlibitum, throughout experiment period from 5 to 14 weeks of age, a pelleted diet and kept untreated and served as a control. While the other groups (second, third and fourth) were fed with pellet replaced with levels of hay 25, 50 or 75% dried prickly pear peels (PPP), respectively.

Growth performance:-

Rabbits were weighed in the morning before receiving feed or water and feed intake was recorded biweekly during the experimental period. Body weight gain (BWG) was calculated by subtracting the initial live body weights from final ones of each growth period. Feed conversion ratio (FCR) was obtained by dividing the amount of total feed intake (TFI) on the corresponding weight gain. Also, performance index (PI) was calculated according to **North (1981)**. Average protein and digestible energy intakes were calculated by multiplying feed intake by percent of protein and digestible energy contents of experimental diets.

Digestibility trial:-

The collection period lasted for 5 days. Feed intake was measured and feces output was collected daily. Hair and scattered feed were separated or taken out of the feces. The collected feces for rabbits of each treatment was pooled together, and dried at 60 C till constant weight. The dried feces for the successive five days was left few hours to get equilibrium with the atmosphere and then ground, well mixed and stored in screw-top glass jars for chemical analysis. Chemical analysis was carried out for diets and feces according to methods of AOAC (2002). The values of total digestible nutrients (TDN) and digestible crude protein (DCP) were calculated according to the classic formula (Cheeke *et al.*, 1982). DE (kcal/kg DM) = 4253-32.6 (CF %) 144.4 (Ash %), according to Fekete and Gippert (1986).

Table (1) Composition and calculated analysis of the experimental diets

Ingredient %	Prickly pear peel			
	Control	25%	50%	75%
Alfalfa hay	32	24	16	8
Soy bean seed, meal (44%)	7.5	7.5	7.5	7.5
Prickly pear peels	0	8	16	24
Corn Gluten meal	5	5.4	5.9	6.4
Yellow corn	12.15	11.05	9	7
Calcium phosphate dibasic	0.5	0.5	0.5	0.5
Sun flower oil	1.39	1.29	1.29	1.29
Molasses	3	3	3	3
Wheat bran	24.33	25.03	26.33	27.5
Salt	0.5	0.5	0.5	0.5
Premix	0.3	0.3	0.3	0.3
Limes tone	1.25	1.35	1.6	1.9
L-lysine Hcl	0.05	0.05	0.05	0.05
DL Methionine	0.33	0.33	0.33	0.33
Total	100	100	100	100
Calculated analysis**				
DE, Kcal/kg	2529	2534	2537	2539
Crude protein (CP)	16.63	16.42	16.29	16.15
Ether extract (EE)	3.93	3.94	4.03	4.13
NFE	58.24	59.81	61.18	62.95
Ca%	1.11	1.03	1.01	1.01
Total P%	0.62	0.6	0.6	0.59
Lys %	0.701	0.63	0.62	0.59
Meth %	0.6058	0.59	0.58	0.58
CF%	14	12.4	10.7	9.09

* Each 3 kg of vit and Min in Premix contain: 6000000IU vit A, 900000 IU vit D3 40000mg vit E, 2000mg vit K, 2000mg vit.B1, 4000mg vit B2, 2000mg vit B6, 10mg vit B12, 50000mg Niacin, 10000 mg pantothenic acid, 50mg Biotin, 3000mg Folic acid, 250000 mg choline, 50000mg Zn, 8500mg Mn, 50000mg Fe, 50000mg Cu, 200mg I, 100mg Se and 100mg Co.

** According to NRC (1977).

Cecum samples:-

Samples of cecum content were individually taken from rabbits of each group and cecum contents were obtained after slaughtering and filtrated to estimate PH and cecum micro flora. Cecum ammonia-nitrogen determination was carried out as soon as possible using the steam distillation method described by Ahmed (1976). Cecum total volatile fatty acids (VFAs) content was measured according to AOAC (1995).

Carcass characteristics:-

At the end of the experimental period (14weeks of age), a total number of 20 rabbits (five rabbits from each group) were randomly taken for slaughter. Assigned rabbits were fasted for 16 hours before slaughtering and individually weighed as pre-slaughter weight. Animals were slaughtered by cutting the jugular veins of the neck, when complete bleeding was achieved, slaughter weight was recorded. After skinning, the carcass was opened down and all entrails were removed and the empty carcass, heart, liver, kidneys and spleen were separately weighed, each of them was proportioned to the live pre-slaughter weight. Dressing percentage was calculated according to Steven *et al.* (1981).

Biochemical parameters:-

Blood samples were taken at the time of slaughter and then centrifugated at 3000 r.p.m. for 20 minutes to obtain plasma and kept at -20 C until analysis. Blood plasma was assigned for determination of total protein, albumin, urea – N, cholesterol, Low Density Lipoprotein (LDL~cholesterol), High Density Lipoprotein (HDL~cholesterol), Triglyceride and liver function (aspartate aminotransferase “AST” and alanine aminotransferase “ALT”). Non-coagulated blood was tested shortly after collection for estimating blood pictures. White and red blood cells were counted according to Feldman *et al.* (2000).

Statistical analysis:-

Data were analyzed according to the statistical analysis system user guide, (SAS 1998). Separating among means was carried out by using Duncan multiple test, (Duncan, 1955).

RESULTS AND DISCUSSION

The chemical composition of prickly pear peels (PPPs) and Alfalfa hay

The chemical compositions of feed Ingredients are presented in Table (2). The results showed that the chemical composition of alfalfa hay were within the corresponding ranges reported by El-Shinnawy *et al* (2011) and Badr *et al.* (2017). The data for chemical composition of PPPs were in agreement with those obtained by (Gregory and Felker, 1992; Felker, 1995; Lopez *et al.*, 2001; El-said *et al.* 2011 and Badr *et al.*, 2017).

Table (2): The chemical analysis of prickly pear peels and Alfalfa hay

Item	OM	CP	EE	CF	NFE	NDF	ADF	ADL	ASH	DE*
Prickly pear peels	89.37	6.50	3.76	8.9	69.31	14.82	11.06	2.70	11.53	2298
Alfalfa dehydrated meal	81.20	13.3	2.33	33.33	41.24	62.2	44.4	11.27	9.8	1751

$DE^*(Kcal / kg DM) = 4253 - 32.6 (CF \%) - 144.4 (Ash \%)$, according to Faceted and Gippert (1986).

It showed that PPPs had lower content of CP (6.50), CF (8.9), NDF (14.82), ADF (11.06) and ADL (2.7%) while, it had higher values of NFE (69.31) EE (3.76) and DE (2298) when compared with Alfalfa hay. This results reported by (Dekock, 1980; Flachowsky and Yami, 1985; and Hanselka and Paschal, 1990). The NDF content of PPPs obtained in this study is higher than that reported by Amare *et al.* (2009). Badr *et al.* (2017) reported that it contains 4.75% CP, carbohydrates 59.25%, fiber 3.15% fat 3.55% and Ash 11.00%.

Chemical analysis of the rations:-

All experimental rations were iso-caloric and iso-nitrogenous approximately (**Table 1**). The chemical analysis of different experimental rations was in the same range approximately for CP, EE, CF, NFE and DE contents. The percentages of crude protein ranged from 16.15 to 16.63% ether extract content was ranged from 3.93 to 4.13% crude fiber content 9.09 to 14% nitrogen free extract content was ranged from 58.24 to 62.95 and digestible energy ranged from 2529 to 2539 kcal/kg for the four tested rations. The variation in chemical composition may be related to differ in source of roughage incorporated in rations formulation.

Growth performance:-

Results in Table (3) shows that the final live body weight, total body weight gain and performance index were significantly ($P < 0.05$) affected by experimental treatments. The highest ($P < 0.05$) values of live body weight, total body weight gain and performance index were recorded by rabbits of treatment 75% PPPs (1986.5g, 1489g and 73.30%) followed by those of 50% PPPs (1946.97 g, 1446.37g and 68.31%) respectively compared with the other experimental treatments. While the lowest ($P < 0.05$) live body weight, total body weight gain and performance index were recorded the control group (1778.75g, 1283.45g and 53.74%) respectively. These results are in agreement with results of Atti, *et al.* (2009) and Aguilar-yanez *et al* (2011). Ruiz-feria *et al* (1998) reported that fed rabbits leucaena inclusion had the poorest performance, whereas the opposite was true with diet of 10% cactus, growth traits was improved Gebremariam *et al* (2006) concluded that inclusion of cactus in the experimental diet or other comparable diets to up to 50% on DM basis for sheep fed tefstraw promotes weight gain without causing digestive disturbances. Abu shamalah (2007). Reported that the average final body weights of the growing rabbit age 56 days fed 20% and 40% cactus opuntia cladodes (COC) were relatively similar to the average final body weights of control. Taddesse, *et al.* (2014) reported that supplemented spineless cactus goats (150g/head/dcactus) had higher final BW and mean daily BW gain as compared to the control.

Improvement growth performance may be attributed to mode of action of PPP including the maintaining a beneficial microbial population and improving digestion. The increased live weight gain in rabbits fed PPPs diets can be explained by the associative effects of high soluble carbohydrates contained the cactus. Also cactus is a desertification plant and a highly palatable to wild and domesticated rabbits. Prickly pear peels (ppp) are an important source of several nutritional substances like pectin, mucilage and minerals. The prickly pear peels (ppp) also known as an excellent source of proteins including essential amino acids, high malic acid contents and good source of vitamin, flavonoid fraction, carotenoids and phenolic constituents. Several studies have reported that high levels of amino acids especially proline, valine, serine and proline can also be found in prickly pear (Stintzing and Carle, 2005; Feugang *et al.*, 2006, Cardador Martinez *et al.*, 2011 and Badr *et al.*, 2017). General cladodes are rich in pectin, mucilage and minerals, whereas the fruits are good sources of vitamins, amino acids and betalains (Habibi *et al.*, 2005). Cowan, (1999) reported that plant derived products contain a great diversity of photochemical such as phenolic acids, flavonoids and tannins. These increments in live body weight and body weight gain may be attributed to increasing digestion of all nutrients (Table 3), decreasing PH, NH₃-N mmol/L. concentration and the increasing of VFA in the cecum, according improving the nutrients utilization may be attributed to the conversion of ammonia-N into microbial protein for the benefit of rabbits which characterized by the pseudo- rumination.

Feed intake and feed conversion:-

The data shows that there is significant effect of treatment PPPs on total feed intake (TFI), feed conversion ratio (FCR), protein intake, (PI) and digestible energy intake of rabbits (Table 4). Feed intake (g/day), protein intake, and digestible energy intake significantly ($P < 0.05$) decreased with increasing PPPs levels containing diets. Rabbits fed PPPs diet recorded significantly better FCR values. Prickly pear peels (PPP) improved the feed digestibility and utilization of ammonia and (PPP) constituted of like minerals, sugars, organic acid, amino acids, lipids, terpenes, high malic acid contents, good source of vitamin A, vitamin C, flavonoid, carotenoids, chlorophylls and phenolic constituents. The decrease of feed intake in rabbit fed PPPs could be explained by the in nutrient supply such as minerals and water soluble vitamins could accelerate nutrients metabolism and increase energy digestibility. Also, PPPs can improve the condition of the intestines and enhances the overage daily weight gain and digestibility. These results are in agreement with finding of Gebremariam, *et al.*, (2006), Einkamerer (2008), Einkamerer, *et al.*, (2009), Menezes, *et al.*, (2010) and Badr Azza (2017) in sheep, Mendez- Liorente *et al.*, (2008) and Aguilar. Yanez, *et al.*, (2011) in lambs.

Table (3): Effect of dietary PPP levels on growth performance of growing rabbits

Parameters	Treatments	Zero	1	2	3	L.S.D
Initial live body weight		495.3 ^a	497.6 ^a	500.6 ^a	497.5 ^a	N.S
Final live body weight		1778.75 ^b	1836.97 ^b	1946.97 ^a	1986.5 ^a	75.4751
Total weight gain		1283.42 ^b	1339.37 ^b	1446.37 ^a	1489 ^a	80.1467
Average weight gain		22.91 ^b	23.92 ^b	25.28 ^a	26.58 ^a	1.4277
Feed intake (FI)		4248 ^a	4150 ^b	4120 ^b	4040 ^c	69.0262
Feed conversion ratio(FCR)		3.31 ^a	3.09 ^b	2.85 ^c	2.71 ^c	0.20888
Performance index		53.74 ^c	59.45 ^c	68.31 ^b	73.30 ^a	5.8118
Protein intake(PI)		706.44 ^a	684.03 ^b	671.14 ^c	652.45 ^d	11.0152
Protein efficiency ratio (PER)		1.82 ^d	1.96 ^c	2.16 ^b	2.28 ^a	0.12513
Digestible energy index		10743.19 ^a	10516.1 ^b	10452.44 ^b	10257.56 ^c	174.9400
Efficiency of energy utilization		8.37 ^a	7.85 ^b	7.23 ^c	6.88 ^c	0.53113
No. of dead Rabbits		1	1	-	-	

a, b, c and d Means in the same row bearing different superscripts are significantly different.

* $P \leq 0.05$, NS: not significant. $IPI = (\text{Body weight (kg)} / \text{Feed conversion}) \times 100$.

Abu Shammalah (2007) reported that average feed intake, g/day in rabbits fed *Opuntia* cladodes (COC) were 87.60, 63.80, 53.00 and 34.60 gm. for control, 20%, 40% and 60% respectively. Zeedan *et al.* (2015) reported that feed intake (g/day), protein intake, and digestible energy intake were significantly ($P < 0.05$) decreased with increasing cladodes *Opuntia* cladodes (COC) in fed rabbits. The increase prickly pear peels (PPP) level significantly ($P < 0.05$) improved feed conversion compared to control diet (Table 3).

Significant differences among administration were found for the FCR, it was noted that the best FCR (2.71, 2.85) was recorded for rabbits fed with 75% and 50% respectively followed by those treated 25% (3.09 this finding is very consistent with those reported by Abu Shammalah (2007) who reported that average feed conversion ratios in rabbits fed the control diet c, either 20%, 40% or 60% were 3.33, 3.01, 2.85 and 3.25 respectively. Zeedan *et al.* (2015) reported that rabbits fed cactus *Opuntia cladodes* (COC) 30% diet recorded a significant better FCR value followed by those of 20 and 10% tested material respectively.

These improvements in FCR and lower feed intake may be attributed to PPPs inclusion decreases $\text{NH}_3\text{-N}$ (Table 5) and increases digestion of all nutrients (Table 5). In the present experiment, improved FCR with PPPs inclusion may be due to improve their crude protein digestibility and improve nutrient utilization of flavonoids and phenolic acids contained PPPs. Also the improvement of FCR of PPPs level may be due to a beneficial microbial environment in the gut which might have enhanced digestion, absorption and utilization of nutrients. Also the improvement of FCR may be due to the antioxidant, antibacterial, antimicrobial and anti-inflammatory activity as well as nutrient utilization depended on the presence of flavonoids and phenolic acids (Ennouri, *et al.*, 2014, Cawan, 1999) and Badr *et al.*, 2017).

Mortality rate:-

Results indicated that there is no dead for experimental groups fed 50% and 75% (PPPs) inclusion (Table 3). It may be due to immune system compared to the control group. The decrease in mortality may be due to the decrease in PH and $\text{NH}_3\text{-N}$, in the cecum which leading to decrease the diarrhea. Also, to the antibacterial, antimicrobial and anti-inflammatory activity effect of PPPs and improving nutrient utilization due to the presence of flavonoids and phenolic acids, (Ennouri, *et al.*, 2014) and (Cawan, 1999) reported that prickly pear products contain a great diversity of phytochemicals such as phenolic acids, flavonoids and tannins, Badr *et al.* (2017) found that numerous health related effects such as antibacterial, antigenic, antiproliferative, antithrombotic and vasodilatory activities. Increasing globulin concentration with increased PPPs inclusion explains the decrease in the mortality.

Digestibility and nutritive value:-

Table (4) Shows that the digestibility of all nutrients were significantly ($P < 0.05$) increased by increase PPPs inclusion. These results are in agreement with Einkamerer (2008), Costa, *et al.*, (2012 and Menezes *et al.* (2010). Gregory and Felker (1992) reported that prickly pear cactus has high dry matter digestibility and also to be highly palatable to wild and domesticated rabbits. Zeeman (2005) reported that digestibility of most chemical constituents significantly increased ($P < 0.05$) in line with increased *Opuntia* inclusion and the low fiber content of *Opuntia* is positively correlated with DM digestibility. Ben salem *et al.* (1996) concluded that the apparent DM digestibility increases with addition of *Opuntia cladodes* due to its higher easily digestible carbohydrate content. Also, Zeeman (2005) found that ascribed the higher digestibility to the fact that *Opuntia cladodes* contain higher levels of easily digestible carbohydrates. The highest digestibility was observed in the treatment of 75% PPPs followed by the diet of 50% PPPs, 25% PPPs, respectively. Despite the low nutritive quality of the spineless cactus, it conferred a better digestibility, given the high fermentative capacity of its carbohydrates (Misra *et al.*, 2006). Digestible organic matter is important for ruminal microbial protein synthesis as an energy source. This difference may be due to the high content of non-structural carbohydrates (NSC) found in cactus. Tegegne, *et al.* (2005) found that the high concentration of soluble carbohydrates in cactus facilitates the incorporation of nitrogen into microbial protein, which is the main source of metabolizable protein for the host animal. The highest digestibility of all nutrients in treated groups can be discussed from the point that PPPs contains minerals (Mg, Ca, K, Na, Cu, Zn, Mn, P and Fe), amino acid, high malic acid contents, vitamin A, vitamin E, vitamin C, flavonoid, carotenoids, phenolic constituents, which may be associated with improvement in digestibility of all nutrients (Stintzing and Carle, 2005, Habibi *et al.*, 2005, Feugang *et al.*, 2006, Abu Shammalah, 2007, Cardador-Martinez *et al.*, 2011, Cordova-Torres *et al.*, 2015 and Badr *et al.* 2017).

The compounds with antimicrobial effect maintained the health of the digestive tract and improved both digestion and absorption. Consequently, the improving in the nutrients digestibility, for treated groups may be reflected a better growth performance as shown in Table (3). Apportion of the increase in digestibility may have resulted from the reduction of intake that occurred. It is well documented that digestibility of the diet increases with decreasing intake (NRC, 1977 and Zeedan *et al.* (2017).

In this study, the results showed that the use of PPPs improved digestibility of nutrients and absorption this reaction can lead to increase feed utilization and improve performance.

Table (4): Digestibility coefficient of the experimental rations

Parameter	Treatment	Control	25%	50%	75%	L.S.D
Digestion coefficient %						
DM		65.22c	65.82bc	66.53b	67.74a	1.1067
CP		65.48c	66.50bc	67.23ab	68.28a	1.1639
EE		67.92c	68.43c	69.23b	69.95a	0.7197
CF		46.27d	48.43c	51.51b	53.75a	0.8123
NFE		69.90d	72.44c	75.62b	77.98a	1.2013
NDF		43.28d	44.64c	45.87b	47.94a	0.7581
ADF		41.01d	43.43c	44.69b	45.90a	0.9849
ADL		33.86d	35.86c	37.59b	38.35a	0.5768
Nutritive values						
TDN %		61.38d	62.42c	64.52b	66.48a	0.7981
DCP %		10.88a	10.92a	10.95a	11.02a	*N.S
DE** (Kcl /Kg)		2719.43d	2765.35c	2858.23b	2945.36a	35.3584

a, b and means in the same row bearing different superscripts are significantly different.

*: $P \leq 0.05$, NS: not significant.

**DE (kcal / kg) = TDN \times 44.3.

Cecum traits:-

The cecum PH, ammonia-N concentrations and total VFN concentrations (mmol/L) of cecum contents are presented in Table (5). Cecum PH value is one of the most important factors, which effect microbial fermentation in the cecum and influences their functions concerning the values of caecal PH, there were significant ($P < 0.05$) lower PH and $\text{NH}_3\text{-N}$ with increasing PPPs. The lowest acidity was recorded for rabbits treatment fed 75% PPPs inclusion. The increasing PPPs resulted in more fermentation in the caecal, thus reduced caecal PH as a result of increasing volatile fatty acids production.

Table (5): Effect of prickly pear peels (ppps) levels on Cecal fermentation activity of growing rabbits

Item	Control	25 %	50 %	75 %	L.S.D
Cecum PH	6.85 ^a	6.53 ^b	6.15 ^c	5.67 ^d	0.29889
$\text{NH}_3\text{-N}$ (Memel/L)	20.16 ^a	19.30 ^a	17.72 ^b	16.61 ^c	0.99420
Total VFA(Memel/L)	49.94 ^d	46.50 ^c	62.28 ^b	65.73 ^a	2.97257

Table (6): Effect of prickly pear peels levels on some carcass traits of growing rabbits

Item	control	25 %	50 %	75 %	L.S.D
Pre. Slaughter weight(g)	1798.75 ^b	1856.97 ^b	1976.97 ^a	1996.5 ^a	75.47513
Carcass weight (g)	828.66 ^b	876.12 ^b	964.80 ^a	1057.47 ^a	71.139171
Dressing weight (g)	891.08 ^b	952.63 ^b	1055.35 ^a	1156.3 ^a	71.46524
Dressing %	49.54 ^b	51.30 ^b	53.38 ^a	57.91 ^a	1.867127
Total giblets weight %	3.47 ^d	4.12 ^c	4.58 ^b	4.95 ^a	0.30794
Heart	0.45 ^a	0.46 ^a	0.46 ^a	0.47 ^a	NS*
Liver	2.01 ^d	2.33 ^c	2.67 ^b	2.95 ^a	2.72983
Kidney	1.01 ^c	1.33 ^c	1.45 ^b	1.53 ^a	1.038740
Chemical analysis of carcass meat on DM basis %					
	Control	25 %	50 %	75 %	L.S.D
Moisture %	7.18 ^a	7.13 ^a	7.21 ^a	7.52 ^a	NS
CP %	19.19 ^c	20.12 ^b	20.22 ^b	21.05 ^a	0.714468
EE %	2.96 ^a	3.05 ^a	2.70 ^b	2.23 ^c	0.257015
Ash %	1.79 ^a	1.62 ^{ab}	1.51 ^b	1.43 ^b	0.241855

a, b, c and d Means in the same row bearing different superscripts are significantly different.

* $P \leq 0.05$, NS: not significant.

These results are in agreement with those reported by Bisop, *et al.* (2007), Mendez. Liorente, *et al.* (2008) in sheep, Vieira, *et al.* (2008) in goats and Zeedan, *et al.* (2015) found that cecal PH value and

NH₃-N concentration were higher (P<0.05) in the control group than those fed with 30,20 and 10% *Cactus Opuntia cladodes* (COC).

On the other hand, Misra, *et al.* (2006) found that ruminal NH₃-N was not significantly different between lambs fed 0, 10 and 20% cactus *Opuntia cladodes* (COC) but were higher than 30 and 40%. High cactus *Opuntia* (COC) inclusion significantly increased (P<0.05) the concentration of total VFA compared to control. The used of PPPs that is probably the most interest to rabbit's producers is as an antimicrobial and antioxidants Zeedan, *et al.* (2015) (The flavonoids, phenolic components play a significant role in the free radical scavenging capacity of cactus *Opuntia cladodes* (COC) (Abu Shammalah 2007 and Cardador-Martinez *et al.*, 2011). The increased total VFA may be attributed to the effect of decreasing PH and NH₃-N increased the digestible protein and TDN with high PPPs level (Table 4). The decreased cecum PH, the decreased ammonia-N concentration and the higher VFA concentration suggest active microbial synthesis existed in the cecum. Also, decreasing NH₃-N concentration may be attributed to the conversion of ammonia-N into microbial protein for the benefit of rabbits which characterized by the pseudo-rumination and improvement in digestion of nutrient in Table (4). (Zeedan *et al.*, 2015). On the other hand, Ben salem and Smith (2008) reported that the high content of sugars in cactus pear did not affect ruminal fermentation in sheep.

Carcass characteristics and chemical composition:-

Results in Table (6) show that significant variation between dietary treatments of PPPs for all carcass characteristics. Rabbits fed 75% PPPs had the highest value all carcass characteristics than other rabbit's treatments groups. The increase in carcass traits for treated groups may be mainly related to the increase in growth performance and digestibility. These results are agreement with (Zeedan *et al.*, 2015) who found that rabbits received 30% cactus *Opuntia cladodes* (COC) had the highest value all carcass characteristics than other rabbit's treatments groups. Mahouachi, *et al.*, (2012). Ruiz. Feria *et al.*, (1998) who evaluated that rabbits fed *Leucaena* had the poorest performance, but when fed 10% level cactus, growth and carcass traits were improved. Abu Shammalah (2007) found that the carcass weight, kidneys, spleen and liver of rabbits significant effect (P<0.05) with cactus supplementation. On the other hand Attie *et al.*, (2006) showed that the carcass weight of goat kids decreased significantly (P<0.05) with cactus supplementation.

Generally, the increase in carcass traits in treated groups can be discussed from the point that PPPs contains minerals (Mg, Ca, K, Na, Cu, Zn, Mn, P and Fe), amino acid, high malic acid contents, vitamin A, vitamin E, vitamin C, flavonoid, carotenoids, phenolic constituents, which may be associated with improvement in digestibility of all nutrients (Stintzing and Carle, 2005, Feugang *et al.*, 2006, Abu Shammalah, 2007, Cardador-Martinez *et al.*, 2011, Cordova-Torres *et al.*, 2015) and Zeedan *et al.*, 2015.

Concerning the chemical analysis for carcass (Table 6), the results shows a significant effect was found as feeding PPPs inclusion with in crude protein (CP), ether extract (EE) and ash of meat. Zeedan *et al.*, (2015) found that results shows a significant effect was found as feeding (COC) inclusion with in crude protein (CP), ether extract (EE) and ash of meat on the other hand Mahouachi, *et al.*, (2012) reported that no significant differences were found for moisture, crude protein, and ash contents between treatment groups.

These values led to improve the meat quality and better effects to human health. Also, the increase in protein in rabbit meat can be attributed mainly to the presence of amino acids, vitamins, increase of protein digestibility as mentioned in Table (4) and trace elements of PPPs are nutritionally beneficial for improving intestinal absorption and digestion of all nutrient due the stimulus to the development proliferation and differentiation of intestinal cells and because they improve the environmental conditions for the intestinal microbial ecosystem.

Blood constituents:-

Results in Table (7) shows that there is a significant difference (P<0.05) in biochemical parameters was recorded as feeding inclusion levels of tested material. Significant differences were detected for plasma total protein, albumin and globulin. However, the increase in total protein, albumin and globulin was in a normal range as receiving 75% PPPs may be associated with improvement of crude protein digestibility as shown in Table (4) and this result is in harmony with finding of Zeedan *et al.* (2015) and Brahma, *et al.* (2012). Increase globulin concentration with increased PPPs inclusion which was observed in the present study may be an indication of increased immunity in the rabbits since the liver will be able to synthesize enough globulins for immunologic action. This explains the decrease in the mortality with increased PPPs analysis of variance shows that there is a significant effect due to dietary treatment an cholesterol, LDL, HDL and triglyceride was detected in this respect. All inclusion level of tested material

decreased cholesterol, LDL, HDL and triglyceride compared to the control diet (Zeedan *et al.*, (2015) and Wolfram, *et al.* (2002) reported that ingestion of fresh cladodes reduced cholesterol concentration.

Table (7): Effect of Prickly pear peels (PPPs) on some constituents in blood plasma of growing rabbits

Item	Control	25%	50%	75%	L.S.D
ALT	27.28 ^a	25.64 ^b	25.10 ^{bc}	24.63 ^c	0.88663
AST	39.43 ^a	38.66 ^b	38.38 ^b	37.76 ^c	0.614333
Total lipid	5.28 ^a	4.68 ^b	4.36 ^b	3.67 ^c	0.33456
LDL	25.99 ^a	25.71 ^{ab}	25.05 ^b	25.92 ^{ab}	0.83689
HDL	55.60 ^a	52.84 ^b	46.95 ^c	45.10 ^c	1.99682
Triglyceride	1.57 ^a	1.52 ^a	1.46 ^b	1.42 ^b	0.054080
Cholesterol	81.59 ^a	78.55 ^b	72.01 ^c	71.02 ^c	1.770766
Globulin	2.23 ^c	2.90 ^{bc}	3.63 ^{ab}	3.85 ^a	0.7885312
Albumin	3.54 ^a	3.59 ^a	3.84 ^a	3.89 ^a	N.S
Total protein	5.77 ^c	6.49 ^b	7.48 ^a	7.74 ^a	0.6225973
Red blood cells (N × 10 ⁶ /mm ³)	4.08 ^a	4.25 ^a	4.50 ^a	4.66 ^a	NS*
White blood cells (N × 10 ³ /mm ³)	5.56 ^a	5.60 ^a	5.63 ^a	5.93 ^a	NS*

a, b, c and d Means in the same row bearing different superscripts are significantly different.

**P ≤ 0.05, NS*: not significant*

Louacini, *et al.*, (2012) showed that the pectin of opuntia tends to reduce cholesterol by binding to bile acids and the increases of their concentrations enhance the catabolism of cholesterol. Feugang *et al.*, (2006) suggested that cactus pear reduces cholesterol levels in human blood and modify low density lipoprotein (LDL). The antioxidant properties of the most frequent cactus pear battalions (betanin and indicaxanthine) have been revealed anti-hyperglycemia and regulator of blood cholesterol (Tesoriere *et al.*, 2005, Stintzing and Carle 2005), Zeedan *et al.* (2015) and Badr *et al.*, (2017). Overall, the effects of cactus are generally attributed to the high fiber content of the cladodes. The decrease of cholesterol levels may be directly related to the influence of PPPs on lipid metabolism. Liver function as AST and ALT activity were not affected by dietary treatments with supplementing PPPs.

Values of AST and ALT were within the normal range and indicated that the animals were generally in a good nutritional status and their livers were in a normal health condition. Plasma AST and ALT (Table 7) were determined as an indicator for enzymatic activity related to the rate of protein metabolism and liver function. It was showed that significant variations ($P < 0.05$) were found for dietary treatments applied in liver functions. The protective effect of PPPs on some organs such as liver and brain may be due to its contents of some flavonoids which play a role as antioxidant against oxidative material which caused damage to such organs. These results are agreement with Stintzing and Carle (2005), Feugang *et al.* (2006), Abushammalah (2007) and Zeedan *et al.* (2015). Data in Table (7) illustrated that value of each of blood components including (red and white blood cells count) were increased in rabbits fed diet contained ppps than those of the control. The increase in WBCs in treated groups can be attributed mainly to the antibacterial functions, antimicrobial, anti-inflammatory activity and antioxidant of ppps (Ennouri *et al.*, 2014; Zeedan *et al.* 2015 and Badr *et al.*, 2017). Generally, the increase in blood constituents may be due to the role of ppp in improving all nutrient digestibility (Table 4). The improvements in the blood components of result of treatment with ppps may be due to the enhancement in the immune response (minerals and flavonoids have a role in enhancing immune system). Inclusion of the minerals composition are comprised of (Mg, Ca, K, Na, Cu, Zn, Mn, P and Fe) vitamin A, vitamin E, vitamin C, carotenoids, phenolic constituents and flavonoid (Stintzing and Carle, 2005; Feugang *et al.*, 2006; Abushammalah, 2007; Cardador-Martinez *et al.*, 2011; Cordova-Torres *et al.*, 2015 and Badr *et al.*, 2017).

Economical efficiency:-

The effects of dietary treatments on economical efficiency are presented in Table (8). The greatest total revenue and economical efficiency were calculated for rabbits fed diet containing 75% PPPs followed by 50% PPPs and 25% PPPs compared with control. The relative Economical efficiency values

were 117.65, 141.58 and 159.84% for rabbits fed 25%, 50% and 75% PPPs respectively. Badr Azza *et al.* (2017), and Zeedan *et al.* (2015) Reported that the greatest total revenue and economical efficiency were calculated for rabbits fed diet containing 30% cactus *Opuntia cladodes* (COC) followed by 20% (COC) and 10% (COC) compared with control AguilarYanez *et al.* (2011) reported that the economic analysis shows that feeding sheep with dehydrated and fresh spineless cactus, net gains increase to 16.23\$ and 17.84\$, respectively while, the control was only 12.98\$ (diets with dehydrated and fresh spineless cactus, respectively).

Table (8): Economical efficiency of Rabbits fed different experimental rations

Items	control		25%		50%		75%	
	weight G	price L.E	weight g	price L.E	weight g	price L.E	Weight G	Price L.E
Initial live body weight (g)	495.3	30	497.6	30	500.6	30	497.5	30
Final live body weight (g)	1778.75		1836.97		1946.97		1986.5	
Total gain (g)	1283.45	55.19	1339.37	57.59	1446.37	62.19	1489	64.02
Feed intake of feed (g)	4248		4150		4120		4040	
Price 1kg FI (L.E)	5		4.840		4.680		4.400	
Total feed cost/Rabbit (L.E)		21.24		20.00		19.30		17.78
Cost of Kg gain/Rabbit (L.E)		16.55		14.93		13.34		11.94
Total cost / Rabbit (L.E)		51.24		50		49.30		47.78
Cost / kg BW (L.E)		28.81		26.78		25.32		24.10
Total revenue		76.49		78.99		83.72		85.42
Net revenue Rabbit (L.E)		25.25		28.99		34.42		37.64
Economic efficiency		0.493		0.580		0.698		0.788
Relative economic %		100		117.65		141.58		159.84

Economical efficiency = Net revenues / Total cost; price kg live = 43 L.E; CFM = 5000 L.E per ton; PPP= 500 L.E per ton.

CONCLUSION:

Under the conditions of this, study it could be an advantageous to using PPPs to growing rabbits without any adverse effect on health. The prickly pear peels (PPP) will have appositive influence on the health primarily aiming to improve immune status of rabbits, improve their growth performances, digestibility and nutritive value, cecum traits, carcass characteristics, some blood constituents and economical efficiency. It can be concluded that (PPP) feed as available and very low cost feed can be used as a partial feed to maintain rabbit's growth under unavoidable economical conditions and higher feed prices in Egypt. However, there is need of chemical and nutritional evaluations and more work is required for the application of PPPs in in-vivo trails for feeding ruminants.

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تأثير استبدال دريس البرسيم بقشور التين الشوكي على الأداء الإنتاجي للإرانب

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المركز الاقليمي للأغذية والاعلاف - مركز البحوث الزراعية - الجيزة

استخدمت في هذه الدراسة أربعون أرنب تيوزيلندي ابيض بمتوسط وزن 500 ± 0.6 جرام لتقييم استخدام قشر التين الشوكي كمصدر علفي على الأداء الإنتاجي، الهضم وبعض مكونات الدم والكفاءة الاقتصادية للإرانب. قسمت الارانب عشوائيا الى 4 مجموعات بكل مجموعة 10 أرانب وكانت المجاميع الغذائية عبارة عن كنترول واستبدال دريس البرسيم بنسبة 25%، 50%، 75%، من قشر التين الشوكي المجفف على التوالي. وأوضحت النتائج المتحصل عليها من هذه الدراسة: تراوحت نسبة البروتين الخام من 16.15 إلى 16.63 % في حين تراوحت الطاقة المهضومة من 2529 الى 2539 كيلو كالوري مادة جافة للعلائق الأربعة المختبرة. وزن الجسم ومعدل الزيادة ومعامل الكفاءة اعلى معنويا في المجموعات المعاملة وكانت اعلى وزن الجسم ومعدل الزيادة و معامل الكفائية في المعاملة 75% من قشر التين الشوكي المجفف (1986.5 جم - 1489 جم - 73.30 %) يليهم 50% (1946.97 جم - 1446.37 جم - 68.31 %) ثم 25% (1836.97 جم - 1339.37 جم - 59.45 %) بالمقارنة بالكنترول (1778.75 جم - 1783.45 جم - 53.74 % على التوالي. حدث تحسن معنويا في قيم معاملات هضم CP، DM، CF، NFE، NDF، ADF، ADL للعلائق المغذاة على قشر التين الشوكي المجفف مقارنة بالكنترول DE و TDN. كان الرقم الهيدروجيني في الأعور و NH₃-N أعلى في الكنترول بالمقارنة بالمجاميع الأخرى وكان تركيز TVFAs أعلى في كل المجاميع بالمقارنة بالكنترول. المجموعات المغذاة على قشر التين الشوكي كانت اعلى معنوية (P<0.05) في نسبة التصاقي ووزن الذبيحة ووزن الأجزاء المأكولة بالمقارنة بالكنترول. أنزيمات الكبد في الحدود المسموح بها في المجموعات المغذاة على قشر التين الشوكي والكنترول وبينما تزداد مكونات الدم الأخرى مثل البروتين الكلى و الالبومين و الجلوبيولين ويقل تركيز الكوليسترول و الدهون الثلاثية في المجموعات المغذاة على قشر التين الشوكي مقارنة بالكنترول. كانت تركيزات كل من كرات الدم البيضاء و كرات الدم الحمراء في البلازما أعلى في المعاملات 75% يليها 50% يليها 25% في المجموعات المغذاة علي قشر التين الشوكي بالمقارنة بالكنترول. سجلت أفضل كفاءة اقتصادية مع الارانب المقداة على 75% قشر التين الشوكي يليها الارانب المغذاة على 50% و 25% على التوالي. مما سبق يتضح ان استخدام قشر التين الشوكي كان مفيد لمعدلات النمو ومعاملات الهضم وأفضل كفاءة اقتصادية للإرانب النيوزلاندي.