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Evaluation of Nutritive Value of Some Citrus Pulp as Feedstuffs in Rabbit Diets

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Abstract: The present study was conducted to evaluate, determine nutrient digestibility and nutritive value of lemon pulp and orange pulp. The citrus by-products were replaced for yellow corn in the basal diet at 3 levels (20, 40 and 60%) for each by-product. A total number of 21 White New Zealand rabbits (NZW) at 8 weeks of age were individually weighed and randomly assigned individually into seven groups representing the seven experimental groups. Each group was divided into three replicates of one rabbit each. All animals were kept under the same management and hygienic conditions and were housed in metal battery cages supplied with separated feeders. Diets were offered *ad-libitum* and fresh water was available all times from automatic nipple drinkers. The experimental period lasted for 11 days. All rabbits were vaccinated against diseases and they were under veterinary control. The result showed that lemon and orange pulps are rich in CF, NDF, ADF, ADL, Hemi-cellulose and cellulose compared to yellow corn but CP and GE content for lemon and orange pulps are similarly equal compared to yellow corn. The content of vitamin C in lemon pulp and orange pulp was 0.068 g/100 g and 0.144 g/100 g compared with yellow corn 0.030 g/100 g, respectively. The anti-oxidant content of lemon pulp and orange pulp was 11.60 µl and 12.2 µl compared the yellow corn (8.29 µl) at 25 µl and 17.9 µl and 16.4 µl compared with 15.24 µl at 50 µl, respectively. The total saturated fatty acids content of lemon pulp and yellow corn was approximately equal but its content in orange pulp was higher than the yellow corn. Total unsaturated fatty acids content of lemon pulp and orange pulp were to be lower than that in yellow corn. There were insignificant differences in DM and Organic Matter (OM) digestibility among the experimental diets and control diet. The obtained results also that 40% substitution level of lemon pulp recorded the highest ($p \leq 0.05$) value for CP digestibility (84.77%) compared others substitution levels of lemon pulp and control diet. The digestibility of Crude Fiber (CF) was recorded highest ($p \leq 0.05$) value for 60% substitution level of orange pulp when compared to the control diet and other tested levels of lemon pulp and orange pulp. The Ether Extract (EE) digestibility was recorded the lowest ($p \leq 0.05$) value with 60% substitution of lemon and orange when compared to the control diet and other substitution levels of lemon pulp. The diet containing 20% substitution level of orange pulp recorded highest ($p \leq 0.05$) digestibility of NFE. While, the diet containing 60% substitution recorded lowest ($p \leq 0.05$) value of DCP when compared to control diet and other substitution levels of lemon pulp. The different substitution levels of orange pulp showed insignificant differences when compared to the control diet. The Total Digestible Nutrients (TDN) and Digestible Energy (DE) recorded insignificant difference among control diet and 20, 40 and 60% substitution levels of lemon pulp. The diet containing 20% substitution level of orange pulp was higher in TDN and DE than the control diet. The diets containing 40 and 60% substitution levels for orange pulp recorded insignificant differences when compared to the control diet. Conclusively, replacing lemon pulp at levels of 20 and 40% and orange pulp at levels of 20 and 60% for yellow corn in rabbit diets achieved best nutrients digestibility and nutritive value.

Key words: Lemon pulp, orange pulp, vitamin C, anti-oxidant, fatty acids, nutrient digestibility, nutritive value

INTRODUCTION

The corn considers main energy source in the animals and poultry diets. The available of corn depends on some factors such as import of feedstuffs and uses it in some industrial as ethanol production.

The agro-industrial processing was resulted some wastes as vegetable and fruit by-products. The fruit by-products use as energy source in animal feed (Crickenberger, 1991) and these by-products are economical and environmentally sound way for food processors to reduce waste discharges and cut waste management cost. Selling by-products can also produce additional revenue.

The active antioxidant compounds are flavonoids, isoflavones, flavones, anthocyanins, coumarins, lignans, catechins and isocatechins. In addition, some

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compounds found in natural foods such as vitamins C and E, b-carotene and a-tocopherol are known to possess antioxidant potential (Prior 2003). Flavonoids is good for keeping human and animals healthy. Pectin is a kind for carbohydrate gel, a component of plant cell wall. And thus it has high water absorption property and can use for treating diarrhea and its viscosity has significant health benefits. Citrus peel contains flavonoids and pectin. Larrauri *et al.* (1996) reported that flavonoids which play role in reducing cholesterol because the structure of flavonoids contains numerous OH group which can supply H atoms to quench free radical, making it a strong antioxidant and anti-tumor activity meanwhile, may play a role in cancer, heart disease, circulation and Alzhemers' disease (Shahelian, 2005). Ascorbic acid is antioxidant act (Marcy *et al.*, 1989). Oluremi *et al.* (2006) reported that content of Sweet Orange Rind (SOR) for vitamin C was 3.88 mg/100 g C vs zero mg/100 g for maize.

Papadomichelakis *et al.* (2004) found that digestible energy content of sugar beet pulp, soybean hulls, wheat bran and citrus pulp was 12.52, 7.06, 11.21 and 7.23 MJ/kg DM, respectively. Besides, Hon *et al.* (2009) reported that sweet orange fruit pulp meal can be used as replacement feedstuff for maize in the ration of growing rabbits up to 20%.

The main object of present study was to evaluate the nutrient value of some citrus by-products (lemon and orange pulps) as non-conventional sources for energy in rabbits feeding.

MATERIALS AND METHODS

The experimental part of the present study was carried out in the Faculty of Agriculture, Cairo University in September 2009. The laboratory works were conducted at laboratories of The By-product Utilization Department, Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture, Egypt.

Experimental animals, management and digestion trials: The digestion trials, according to the European Reference Method of rabbit by Perenz *et al.* (1995), were divided into two periods. The first period was adaptation period and follows the second period was the collection period. The adaptation period was lasted for 7 days and the collection period lasted for 4 days. Twenty-one White New Zealand rabbits (NZW) at 8 weeks of age were used in this period and individually weighed (1383.33±50 g). The animals were randomly assigned individually into 7 groups representing 7 experimental groups. Each group was divided into 3 replicates of one rabbit each. All animals were kept under the same management and hygienic conditions and were housed in metal battery cages supplied with separated feeders. The experimental diets were offered *ad-libitum* and fresh water was available all times from automatic nipple drinkers. All rabbits were vaccinated against diseases and they were under veterinary control.

Experimental diets: The citrus by-products (lemon and orange pulps) were collected from El-Marwa Food Industrial Co., 6th October City. By-products were dried by sun until it became brittle and stored in synthetic bags tied at the open end to keep it in a dry state and ground just before the experimental diets were compounded in the course of trail.

The experimental diets and their composition analysis are presented in Table 1. The dried citrus by-products were replaced for yellow corn in the basal diet at 3 levels for each by-product (20, 40 and 60%). The experimental diets were formulated to cover the nutrients requirements of growing rabbits as recommended by NRC (1977). The diets were manufactured in form of pellets using ingredients obtained from local market at the factory of rabbitry unit of Agriculture Cairo University. Diets were offered *ad-libitum* during the experiment period. The experimental diets were isocaloric and isonitrigenous.

Analytical and chemical methods: Chemical analyses for determining moisture, CP, CF, EE, NFE and ash for the tested citrus by-products, diets and feces were done according to the methods recommended by AOAC (2000). Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL) were determined according to Van Soest *et al.* (1991). Hemicellulose and cellules were calculated as follows:

$$\text{Hemicellulose} = \text{NDF-ADF}$$

$$\text{Cellules} = \text{ADF-ADL}$$

Vitamin C determined according to Bajaj and Kaur (1981). The free radical scavenging effect of plant extracts was assessed by the solution of 2,2'diphenylpicrylhydrazyl (DPPH) radical according to decolouration of methanolic. Antioxidant activity was assayed using the DPPH radical method (Lee *et al.*, 2002). Separated the fatty acids were determined by gas liquid chromatography trace GC ultra according to AOAC (2000).

The data pooled through this study were proceeded by General Linear Model of SAS® software Statistical analysis (SAS, 1999). Differences among treatments were tested using (Duncan, 1955) and differences were significant at ($p \leq 0.05$).

RESULTS AND DISCUSSION

Evaluation of citrus pulp:

Proximate analysis of lemon pulp, orange pulp and yellow corn: Data in Table 2 showed that the proximate analysis for lemon pulp, orange pulp and yellow corn.

Table 1: Composition and determined analysis of experimental diets

		Experimental diets					
		Replacement levels of citrus pulp					
		Lemon pulp			Orange pulp		
Ingredients	Control diet	20%	40%	60%	20%	40%	60%
Soybean meal (44% CP)	13.00	13.00	13.40	14.00	13.00	13.40	14.00
Barley	15.00	15.00	15.00	15.00	15.00	15.00	15.40
Yellow corn	18.00	14.40	10.80	7.20	14.40	10.80	7.20
Lemon pulp	-	3.60	7.20	10.80	-	-	-
Orange pulp	-	-	-	-	3.60	7.20	10.80
Wheat bran	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Clover hay	34.00	33.32	32.30	31.30	33.38	32.52	31.20
Corn oil	-	0.68	1.30	1.70	0.62	1.08	1.40
Di-calcium phosphate	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sodium chloride	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Vit. and min. mix*	0.30	0.30	0.30	0.30	0.30	0.30	0.30
DL-Methionine	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Sugar-cane molasses	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Chemical composition (on DM basis)							
DM%	90.91	90.05	89.87	90.11	92.00	92.28	92.00
OM%	92.87	92.82	92.86	92.88	92.37	92.57	92.63
CP%	16.75	16.50	16.24	16.00	16.52	16.29	16.05
EE%	2.26	3.30	3.97	4.68	3.27	3.60	4.10
CF%	13.05	13.81	14.56	15.32	13.50	13.96	14.40
NDF	35.21	36.66	37.47	40.97	36.29	38.44	41.22
ADF	16.93	19.38	19.56	21.11	17.39	17.51	18.49
ADL	2.25	2.73	3.19	3.51	3.03	3.23	3.34
Hemi-cellulose	18.28	17.28	17.91	19.86	18.90	20.93	22.73
Cellulose	14.68	16.65	16.37	17.60	14.36	14.28	15.15
NFE%	60.81	59.21	58.09	56.88	59.08	58.72	58.08
Ash%	7.13	7.18	7.14	7.12	7.63	7.43	7.37
DE (kcal/kg)**	2522.61	2498.14	2474.00	2449.53	2508.12	2493.31	2479.15

*Supplying each kg diet = Vit. A 12000 IU, Vit. D_3 2000 IU, Vit. E 10 mg, Vit. K_3 2 gm, Vit. B_1 1000 mg, Vit. B_2 5 mg, Vit. B_6 1.5 mg, Vit. B_{12} 10 mg, Niacin 30 mg, Pantotheni acid 10 mg, Folic acid 1 mg, Choine 250 mg, Biotin 50 mg, Copper 5 mg, Manganese 60 mg, Zinc 50 mg, Iron 30 mg, Iodine 0.3 mg Selenium 0.1 mg and Cobalt 0.1 mg.

**DE (kcal/kg) = 4.36-0.049 x [28.924 + 0.657 (CF %)] according to Cheeke (1987)

Table 2: Chemical composition of yellow corn, lemon pulp and orange pulp

Items	Yellow corn	Lemon pulp	Orange pulp
DM%	88.00	14.76	18.90
OM%	98.60	94.83	94.98
Ash%	1.40	5.17	5.02
CP%	7.70	7.04	6.40
EE%	3.80	3.60	4.76
CF%	2.30	21.03	12.60
Fiber fraction (%)			
NDF	9.00	34.23	26.21
ADF	2.20	25.47	20.35
ADL	1.00	18.64	10.63
Hemi-cellulose*	6.80	8.76	5.87
Cellulose**	1.20	6.83	9.72
NFE%	84.80	63.16	71.22
GE kcal/kg§	3900.00	3920.00	3980.00
DE kcal/kg§§	2694.48	2716.08	2736.68

*Hemi-cellulose = NDF-ADF; **Cellules = ADF-ADL.

§Determination by caloric bump according (AOAC) 2000.

§§DE = 4.36-0.049 x [28.924 + 0.657 (CF %)] according to Cheeke (1987)

Analysis was carried out to illustrate the proportional content of Dry Matter (DM), Organic Matter (OM), Crude Protein (CP), Crude Fiber (CF), Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), Acid Detergent Lignin (ADL), Ether Extract (EE), ash, Nitrogen Free Extract (NFE), Gross Energy (GE) and Digestible Energy (DE) which together give a good indication to the nutritive value.

The obtained results illustrated that Dry Matter (DM) content of lemon and orange pulps are lower than yellow corn. The values were 14.76 and 18.90% for lemon and orange pulps vs 88.00% for yellow corn, respectively. These results in present study goes in partial agreement with reported by Madrid *et al.* (2002) who found that the values of DM in lemon and orange pulps were 17.70 and 15.20%, but these values were found to be lower than obtained by Oluremi *et al.* (2007) who found that the lemon and orange pulps content 89.71 and 89.35% for DM, respectively.

The organic matter content of lemon and orange pulps was higher than OM content in yellow corn. The recorded values were 94.83% and 94.98% for lemon and orange pulps vs 98.60% for yellow corn, respectively. This result was found to be higher than those obtained by Lemo *et al*. (1984) who found that the values of organic matter orange pulp and lemon pulp were 90.57 and 86.60%, respectively.

Inspection of data showed that the lemon pulp and orange pulp approximately equal for the crude protein with yellow corn (7.04 and 6.40% vs 7.70%). The same value of crude protein for orange pulp was obtained by Lemo *et al*. (1984). While, the crude protein of orange pulp in present study was lower than those obtained by Madrid *et al*. (2002); Oluremi *et al*. (2006); Oluremi *et al*. (2007) who reported that CP content of orange pulp ranged from 9.30 to 11.40%. However, the values of CP content in lemon pulp here in were higher than those obtained by Lemo *et al*. (1984) and Alicata *et al*. (1985) who reported that CP content of lemon pulp was 5.78%. While, the results obtained by Madrid *et al*. (2002); Oluremi *et al*.(2007) who reported that the CP content of lemon pulp ranged from 10.96 to 15.2%.

The Ether Extract (EE) content of lemon pulp, orange pulp and yellow corn was 3.60, 4.76 and 3.80%, respectively. The values obtained of ether extract were higher than those obtained by Lemo *et al*. (1984) and Oluremi *et al*. (2007) who reported that ether extract content of lemon pulp was 2.77% and it ranged from 2.35 to 2.54% in orange pulp. The results obtained in the present study of ether extract were lower than those obtained by Oluremi *et al*. (2006) who reported that the content of ether extract for corn and orange pulp was 3.98% and 12.6%, respectively.

The Crude Fiber (CF) content of lemon pulp and orange pulp was found to be higher than that of CF for yellow corn (21.03, 12.60 and 2.30, respectively). These results are in good agreement with those reported by Lemo *et al*. (1984); Alicata *et al*. (1985) who found that lemon pulp contain 12.23% CF. While, Oluremi *et al*. (2007) reported that CF of lemon and orange pulps was 13.66% for lemon pulp and orange pulp value ranged from 2.57 to 2.77%.

The values of Neutral Detergent Fiber (NDF) for lemon pulp and orange pulp were higher than the yellow corn (34.23, 26.21 and 9.00%, respectively). The result of present study was partial agreement with that reported by Madrid *et al*. (2002) for orange pulp while, the lemon pulp content of NDF was higher than that obtained by Madrid *et al*. (2002) who reported the NDF content of lemon pulp was 24.5%. In present study, NDF was lower than that recorded by Oluremi *et al*. (2007) who reported that NDF of lemon pulp was 38.84% and NDF of orange pulp ranged from 39.71 to 41.39%. Moreover, NDF of orange pulp was 38.28% (Hon *et al*., 2009).

Acid Detergent Fiber (ADF) for lemon pulp and orange pulp was higher than the yellow corn (25.47, 20.35 and 2.2%, respectively). The result of present study for ADF was partial agreement with result obtained by Madrid *et al*. (2002) and Hon *et al*. (2009) who found that ADF of orange pulp was 18.32%. Nevertheless, the values of ADF here in were higher than those obtained by Oluremi *et al*. (2007) who reported that ADF for lemon was 5.46% and ADF of orange pulp ranged from 5.24 to 5.46%.

Acid Detergent Lignine (ADL) content of lemon pulp and orange pulp was higher than the yellow corn (18.64, 10.63 and 1.0%). The results of present study were lower than those obtained by Madrid *et al*. (2002) and Oluremi *et al*. (2007) who reported that the ADL was 60.21% for lemon and ranged from 61.33 to 62.50% for orange pulp.

Hemi-cellulose content of lemon pulp was higher than the yellow corn while, the Hemi-cellulose content for orange pulp was lower than yellow corn. Cellulose content of lemon pulp and orange pulp was higher than the yellow corn. These values were lower than those obtained by Oluremi *et al*. (2007) who reported that the lemon pulp content 21.30% hemi-cellulose and 33.38% cellulose. These authors also noted that hemi-cellulose and cellulose were ranged from 21.10 to 21.62% and from 34.07 to 35.29% for orange pulp, respectively.

Obviously, lemon and orange pulps are rich in NDF, ADF, ADL, Hemi-cellulose and cellulose compared to yellow corn. These nutrients are necessary to nutritional role for young rabbits during the weaning period due to stimulating activity of cecal flora, especially hemi-cellulose and cellulose (Gidenne, 2003). The fibrolytic activity of cecal bacteria is the highest for pectic substrates followed by hemicellulose and then by cellulose (Garcia *et al*., 2000).

The Nitrogen Free Extract (NFE) content of lemon pulp and orange pulp was 63.16 and 71.22%, respectively. This result obtained was partial agreement with Lemo *et al*. (1984) and Hon *et al*. (2009) for orange pulp.

The gross energy of yellow corn compared with lemon pulp and orange pulp was 3900, 3920 and 3980 kcal/kg, respectively. Moreover, the digestible energy was 2694.48, 2716.08 and 2736.68 kcal/kg for yellow corn, lemon pulp and orange pulp, respectively.

Vitamin C, anti-oxidants and fatty acids contain in lemon pulp and orange pulp: The content of vitamin C (ascorbic acid) in lemon pulp and orange pulp was 0.068 and 0.144 g/100 g compared with yellow corn 0.030 g/100 g, respectively (Table 3). These results here in were lower than those reported by Antongiovanni *et al*. (2005) who found that the content citrus by-product of ascorbic acid was 0.50 g/100 g and this value obtained was higher than that reported by Oluremi *et al*. (2006) who found that vitamin C content in orange and lemon at

Table 3: Vitamin C, anti-oxidants and fatty acids content in citrus by-products compared to yellow corn

Items			Yellow corn	Lemon pulp	Orange pulp
Vitamin C (g/100 g)			0.030	0.068	0.144
Anti-oxidants					
DPPH* Decolouration (%)		Standard**			
At 25 µl		50.7	8.29	11.60	12.20
At 50 µl		55.6	15.24	16.40	17.90
Fatty acids (Area %)					
Saturated fatty acids		Standard			
Myristic	14:0	1.66	9.83	2.88	1.00
Palmitic	16:0	6.61	18.82	23.71	30.15
Stearic	18:0	4.14	1.60	3.90	3.67
Total		12.41	30.25	30.49	34.82
Unsaturated fatty acids					
Palmitolic	16:1	-	-	1.96	1.15
Oleic	18:1	16.98	24.84	22.04	21.20
Linoleic	18:2	14.45	43.88	37.17	37.99
Linolenic	18:3	55.24	1.04	8.35	4.84
Total		86.67	69.76	67.56	64.03

*DPPH (Diphenyl Picryl Hydrazyl). **Standard concentration as vitamin E (0.1 g/100 ml methanol), decolouration %

storage was 0.045 and 0.026 g/100 g, respectively. Moreover, vitamin C content in orange pulp was higher than that of lemon pulp. This fact was confirmed by Padayatty *et al*. (2003) who reported that the variable of vitamin C content attributed to harvesting season, duration of transport to the marketplace and period of storage.

The anti-oxidant content of lemon and orange pulps at 25 µl DPPH recorded higher values compared to yellow corn (11.60 and 12.20 vs 8.29%). Also, anti-oxidant content of orange pulp was higher than lemon pulp. Moreover, at 50 µl DPPH, the anti-oxidant content of lemon and orange pulps recorded higher value compared to yellow corn (16.4 and 17.9 vs. 15.24%). Besides, orange pulp was higher in anti-oxidant content than lemon pulp. This result was coincided with Carlsen *et al*. (2010) who reported that anti-oxidant contents of orange were higher than those of lemon pulp (0.9 vs 0.14 mmol/100 g).

Generally, the lemon and orange pulps anti-oxidant content was recorded the highest values compared to yellow corn. Therefore, this may be useful in preventing cells from oxidative stress causes damage in cells (Aqil *et al*., 2006).

The total saturated fatty acids content of lemon pulp and yellow corn was approximately equal (30.49 and 30.25%, respectively) but, this content of orange pulp was higher than the yellow corn (34.82 and 30.25, respectively). The same trend was observed with myristic, being 2.877 and 1.003% vs 9.83%. Palmitic and stearic acids content of lemon pulp and orange pulp were higher than that of yellow corn (23.71 and 30.15% vs 18.82% for palmitic and 3.90 and 3.67% vs 1.60% for stearic acid, respectively).

Total unsaturated fatty acids content of lemon pulp and orange pulp was lower than that of yellow corn (67.56 and 64.03% vs 69.76%). Palmitolic content of lemon pulp and orange pulp was 1.96% and 1.15%, respectively but yellow corn does not contain it. Oleic and linoleic acids content of lemon pulp and orange pulp were lower than that of yellow corn. The respective values were 22.04, 21.20 vs 24.84 for oleic acid and 37.17, 37.99 vs 43.88% for linoleic acid. While, the opposite trend was noticed with linolenic acid; whereas the values were higher (8.35, 4.84 vs 1.04%).

It's worthy to note that content of essential and nonessential fatty acids in either lemon pulp or orange pulp were comparable to that of yellow corn. Therefore, lemon and orange pulps can be replaced for yellow corn in the rabbit diets. Also, increasing the omega-3 fatty acids content especially, linoleic acid in lemon and orange pulps are safe and healthy and can be utilized this property in formulating safe diets due to mixture between the yellow corn and citrus pulp and obtained safety meat products.

Nutrients digestibilities: Digestion coefficients values of DM, OM, CP, CF, EE and NFE for the experimental diets containing the several substitution levels of lemon pulp and orange pulp compared to control diet are presented in Table 4.

The obtained results showed that there were insignificant differences in both DM and OM digestibilities among the different experimental diets including the control.

Significant ($p \leq 0.05$) differences in CP digestibility due to the different substitution levels of both lemon pulp and orange pulp. It could be noticed that 40% substitution level of lemon pulp recorded the highest ($p \leq 0.05$) value for CP digestibility (84.77%) compared others substitution levels of lemon pulp and control diet. While, insignificant differences on CP digestibility were observed among the several substitution levels of orange pulp diets and control diet.

Lemon pulp at replacement level up to 60% had insignificant effects on CF digestibility, while the

Table 4: Effect of replacement lemon pulp and orange pulp for yellow corn on digestion coefficients (%) of rabbits

		Experimental diets					
		Replacement levels of citrus pulp					
		Lemon pulp			Orange pulp		
Items	Control diet	20%	40%	60%	20%	40%	60%
Digestion coefficients (%)							
DM	68.19±2.62	69.67±2.83	72.50±2.68	67.96±3.44	71.92±3.31	70.55±1.38	72.47±2.55
OM	65.73±2.61	70.81±2.78	72.87±2.67	68.36± 3.46	72.37±3.22	71.00±1.26	72.83±2.60
CP	77.12^{b}±0.65	78.24^{b}±2.13	84.77^{a}±2.55	73.84^{b}±2.64	77.52^{b}±1.08	74.42^{b}±0.76	77.63^{b}±2.55
CF	27.80^{b}±2.30	30.37^{ab}±1.29	35.46^{ab}±1.25	34.62^{ab}±4.04	35.08^{ab}±1.01	34.32^{ab}±3.35	39.87^{a}±4.92
EE	76.43^{a}±0.85	76.38^{a}±1.68	76.29^{a}±1.67	65.24^{b}±6.24	72.80^{ab}±1.53	70.70^{ab}±0.42	69.02^{ab}±2.90
NFE	78.32^{c}±2.24	82.11^{bc}±1.50	84.92^{b}±1.32	80.00^{bc}±2.88	90.53^{a}±1.22	79.88^{bc}±0.94	81.78^{bc}±1.70

^{a,b,c}Means within the same column with common letter(s) are not significantly different ($p \leq 0.05$)

Table 5: Effect of substitution lemon pulp and orange pulp by yellow corn on nutritive value of rabbits

		Experimental diets					
		Replacement levels of citrus pulp					
		Lemon pulp			Orange pulp		
Items	Control diet	20%	40%	60%	20%	40%	60%
DCP (%)	12.92^{ab}±0.11	12.91^{ab}± 0.35	13.77^{a}±0.42	11.82^{c}±0.42	12.85^{abc}±0.18	12.12^{bc}±0.12	12.46^{abc}±0.42
TDN (%)	62.76^{b}±1.08	63.92^{ab}±0.98	66.04^{ab}±0.37	61.01^{b}±2.65	69.23^{a}±2.45	64.46^{ab}±1.34	65.70^{ab}±2.36
DE (kcal/kg)	2780.30^{b}±47.67	2831.80^{ab}±43.44	2925.60^{ab}±16.58	2702.60^{b}±117.40	3066.90^{a}±108.40	2855.40^{ab}±59.57	2910.50^{ab}±104.75

^{a,b,c}Means within the same column with common letter(s) are not significantly different ($p \leq 0.05$)

differences among orange pulp levels were significant ($p \leq 0.05$) compared to control diet. The highest value of CF digestibility (39.87%) was recorded with 60% substitution level of orange pulp while, the lowest value (27.80%) with the control diet.

Regardless the effect of lemon pulp replacement levels, there was insignificant decrease in EE digestibility with replacing orange pulp at levels of 20, 40 and 60% in rabbit diets compared to the control diets. While there was a decrease ($p \leq 0.05$) in EE digestibility with replacing lemon pulp only up to 60% in comparison to the other tested levels (20 and 40%) and control (65.24 vs 76.38, 76.29 and 76.43, respectively). In this connection, Just (1982) reported that fat digestibility is reduced when fiber in diet is increased. Also, increasing chain length for saturated acids from 14 to 18 atoms lead to decreased fat digestibility (Lessire *et al*., 1996). Digestibility of NFE was improved significantly ($p \leq 0.05$) with replacing lemon pulp or orange pulp at levels of 40 and 20% comparison to the control diet. The recorded values were 84.92, 90.53 and 78.32%, respectively. While the differences in NFE digestibility were insignificant among the other tested replacing levels compared to the control diet.

These results somewhat agreed with those of Perez *et al*. (1991); Hon *et al*. (2009) and Gholizadeh and Naserian (2010) who reported that apparent digestibility of DM, NDF, ADF and CP did not differ between diets containing 70% concentrate supplement barely or citrus pulp.

Nutritive values: Data concerning the nutritive value of experimental diets are illustrated in Table 5. The results showed insignificant differences in Digestible Crude Protein (DCP%) among the control diet and 20% and 40% substitution levels of lemon pulp while, the diet containing 60% substitution level was the lowest ($p \leq 0.05$) value when compared to control diet and others substitution levels of lemon pulp. The several substitution levels of orange pulp showed insignificant differences when compared to the control diet.

The Total Digestible Nutrients (TDN) and Digestible Energy (DE) recorded insignificant differences among control diet and 20, 40 and 60% substitution levels of lemon pulp. The diet containing 20% substitution level of orange pulp recorded the highest values compared to control diet (69.23 vs 62.76% and 3066.9 vs 2780.3, respectively). Besides, the diets containing 40 and 60% substitution levels for orange pulp recorded insignificant differences when compared to the control diet.

These results agreed with those of Blas and Villamide (1990) who reported that Digestibility energy values for beet pulp and citrus pulp improved with high or low energy basal diets. However, Papadomichelakis *et al*. (2004) noticed that the digestible energy decreased with the diet containing 20% citrus pulp.

Generally, increasing replacement levels of lemon and orange pulps for yellow corn in rabbit diets improved both the digestion coefficients of most nutrients and nutritive value in form of TDN and DE compared to the control diets. This improvement may be attributed to the

increased fiber content in dietary lemon and orange pulps which lead to decrease rate of passage and increase the retention time of digesta in gut due to meet and increase utilization of the nutrients intake (Fraga *et al*., 1991).

Conclusively, according to beneficial effects of lemon and orange pulps on improving nutrients digestibility and nutritive value, besides, to their high content of both anti-oxidant and essential fatty acids (omega-3), it could be incorporate in rabbit diets for achieving good performance and formulating healthy and economic diets.

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