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Guava By-Product Meal Processed in Various Ways and Fed in Differing Amounts as a Component in Laying Hen Diets

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Abstract: The effect of different dietary levels of sun dried Guava by-product (GBP, pulp, peel, seeds and inedible fruits) processed by various ways in laying hen diets was investigated. GBP was collected and sun dried and fine grinded. GBP was processed by boiling for half an hr or an hr in water, acid (0.1 N) and alkaline (0.1 N) and their chemical composition was done. Furthermore, a total of 264 laying hens were fed from 32-48 wk of age twenty two diets consist of three level of GBP at 5, 10 and 15% processed by seven techniques in addition to the control diet (GBP free-diet). Each diet was assigned to three replicates of 4 hens each. Different processing methods induced an alternation in chemical composition of GBP. The ME value of GBP sun dried only, boiled for half an hr or an hr in water, acid (0.1 N) and alkaline (0.1 N) was 2200, 2040, 2540, 2310, 2160, 2650 and 2480 kcal/kg, respectively. Hens fed 15% of sun dried GBP or 15% of GBP boiled for half an hr in acid laid significantly more eggs, whereas, those fed 5% GBP boiled for half an hr in water had the least egg number. Hens fed 5% sun dried GBP boiled for an hr in alkaline had significantly the best FCR. Sun dried or processed GBP in layer diets did not adversely affect quality of eggs and shell.

Key words: Guava by product, laying hens, egg production, egg quality

INTRODUCTION

In the tropics, exploitation of agricultural by-products may substantial contribute to better and more economic feeding of livestock due to feedstuff shortage. The nutritive value of a number of available by-products is inadequately known, a fact that discourages their efficient utilization in animal feeding despite the shortage of grains for poultry feeding. This is exaggerated by the total dependence on imported feedstuffs and use of grains for bio-fuel and bio-diesel production in developing countries (Attia *et al*., 2001; Attia *et al*., 2003; El-Ghamry *et al*., 2005).

A great quantity of Guava by-product (GBP; pulp, peel, seeds and inedible fruits) is produced as a waste of canning industry and was not fully evaluated as a feedstuff for poultry in Egypt, yet. Guava (*Psidium Gualala,* L. Myrtaceae) is a native fruit in tropic areas. Opute (1978) and Aly (1981) reported that guava seeds contained ~ 9.0% lipids which consisted almost of neutral compounds (triglycerides). Habib (1986) found that the chloroform methanol extracted lipids amounted to 9.1% on a dry weight basis and contained 12 fatty acids which are similar to that of cotton seed oil. The protein content of guava seeds was 9.73% on dry matter basis and consisted of 15 amino acids of which arginine, glutamic acid, aspartic acid, glycine and leucine presented 67% (Adsule and Kadam, 1995). GPB is a rich source of vitamin C 200-300 mg/100 g (Holland *et al*., 1991), pulp and peel fractions of guava had high content of dietary fibre (48.55-49.42%) and extractable polyphenols (2.62-7.79%) methoxylated pectin, which can be a suitable source of natural antioxidants (Marquina *et al*., 2008). The nutritive value of GBP can promote health benefits for human and animals (Uddin *et al*., 2002).

The low nutritive values of these by-products could be improved by, autoclaving, boiling in water, water soaking, steaming, radiation and treatment with acid or alkaline (González-Alvarado *et al*., 2007; García *et al*., 2008). El-Deek *et al*. (2009) showed that GBP processed by different methods such as sun dried only, boiled in water, alkaline and acid and autoclaved had different chemical composition. Whilst, the ME values were 2226, 969, 1402, 1206 and 1254 kcal/kg respectively. And, up to 8% sun dried or processed GBP in broiler diets had no significant effect on growth, meanwhile, a level of 2 or 4 % improved feed utilization. Unfortunately, most of agricultural by-products are characterized by low nutrient value and had high fibre content and/or anti-nutritional factors. Fibre influences the utilization of other nutrients in feed through changes in gut transit time, digestion and absorption and therefore feed intake (Abiola and Adekunle, 2002a; González-Alvarado *et al*., 2007; Mourão *et al*., 2008). The effect of GBP meal treated in different ways on productive performance and egg and shell quality were studied as a mean of improving GBP utilization as an alternative feedstuffs in laying hen diets up to 15%.

MATERIALS AND METHODS

Preparation of guava by-product: GBP was collected from Vignobles Giancles Company, Alexandria, Egypt. GBP which considered as a waste material from the processing, was collected (pulp, peel, seeds and inedible fruits), sun dried for seven days and then fine grinded, well mixed and stored in plastic bags until utilizing in diet formulation. The sun dried GBP was treated or not by boiling in water, acid (0.1N HCl), alkaline (0.1 N KOH). The time of treatment was half an hr or an hr. The dilution ratio was 3:1 weight to weight. After treatment GBP was sun dried and turned for 7 days, then samples of GBP were collected for chemical analysis according to AOAC (1990), also Metabolizable Energy (ME) was calculated according to Carpenter and Clegg (1956) according to the following equation:

$$ME/Cal./kg = 53 + 38(CP(\%) + 2.25 \times fat(\%) + 1.1x\, starch(\%) + sugar(\%)$$

Biological evaluation of raw and processed guava by-product: A total of 264 brown egg layer hens (Hy-Line 737) were used in this experimental form 32-48 wk of age. They had been in laying for about 10 wk before initiation of the experiment. Hens were leg-banded and weighed (the initial body weight was 1725±25 g/hen). Hens were housed in a three-tier cage system, with four birds per cage. They located in a deep pit house ventilated mechanically and illuminated with 15:9 light-dark cycle. Twenty two experimental diets were formulated to include 3 levels (5, 10 and 15%) of GBP by 7 processing methods in addition to feeding a control diet that fed GBP free-diet (Tables 1, 2 and 3). The diets were formulated and met nutrient requirements for laying hens according to NRC (1994). Each diet was fed to three replicates of 4 hens each. Feeds and water were offered *ad libitum*.

Measurements: Individual body weight, egg production traits and egg quality traits were recorded and calculated according to Attia *et al.* (1995).

Statistical analysis: Data were analyzed using SAS program (SAS, 1996) using factorial arrangements of 3 (levels of guava by products) x 7 (processing methods) with added the control group (0% GBP). Duncan's a New multiple range test (Duncan, 1955) was used to test the significance among mean differences.

RESULTS

Chemical composition of sundried and GBP processed by various ways: Table 4 presents the effect of various processing ways on proximate chemical composition of GBP. Chemical composition of sun dried GBP showed 9.78% CP, 4.52% EE, 40.0% CF, 5.62% CA, 33.14 % NFE and 2200 kcal/kg ME. Different processing ways shown a considerable decrease in CF when boiled for 60 minutes in water or alkaline and for 30 minutes in acid. A decrease in CP was shown when GBP boiled in alkaline for 60 min or in water for 30 min. Ether extract exhibited considerable decease when GBP boiled for 60 minutes in acid. Furthermore, boiling for 30 min in alkaline and for 60 min in water increased ME value of GBP and this coincided with the increase in ether extract and NFE of these samples. Processing ways induced changes in crude ash and Ca levels, too showing that boiling for 30 min in water decreased ash and Ca of GBP, while boiling for 60 min in acid decreased Ca percentage.

Performance of laying hens

Body weight change: Table 5 shows the effects of various processing ways and/or levels of GBP on body weight changes of laying hens. Hens fed GBP boiled for half an hr in water gained significantly greater weight than its counterpart group fed GBP boiled in acid or in alkaline for half or an hr, but did not significantly different from the group fed the sundried GBP diet. Also, sundried group gained significantly more weight than those boiled in alkaline for an hr. On the other hand, the control group gained significantly less weight than those fed any GBP diets (Table 5). Other groups exhibited intermediate values.

Including of GBP at 10 and 15% significantly increased weight gain compared to only those fed the control group, indicating higher nutrient availability of GBP diets. There were no significant interaction between level of GBP and various processing ways and all diets supported weight gain compared to the control group during 32-48 wk of age, the peak production period.

Egg weight (g): Table 5 shows the effects of various processing ways and/or levels of GBP on Egg Weight (EW). Sundried GBP diet significantly increased EW compared to that of hens fed GBP boiled for half an hr or an hr in water, acid or alkaline and the control group, too, showing that sundried is adequate treatment.

Level of GBP had no significant effect on EW compared to the control group, showing no harmful effect of GBP. The interaction between processing methods and level of GBP was not significant.

Egg number (egg/hen) and egg mass (g/hen/day): Table 5 reports the effects of various processing ways and/or levels of GBP on number of laid eggs per hens and egg mass. Hens fed diet containing GBP boiled for half an hr or an hr in water laid significantly less egg number and egg mass than those fed the other experimental diets except for egg number of hens fed the GBP boiled for half an hr in acid. Meanwhile, other groups did not significantly differ from hens laid the highest number of eggs. Egg mass of hens fed GBP boiled for half an hr in acid or alkaline had similar egg mass to the control group.

Table 1: Ingredient profile and calculated nutrient composition of the experimental diets contains 5% Guava by-product (GBP) processed by either sun dried, boiled in water, acid or alkaline for half or an hr

	Processing ways for Guava by product							
		Boiled in water for		Boiled in acid for		Boiled in alkaline for		Control
	Sun							diet (0)
Ingredients %	dried	30 min.	60 min.	30 min.	60 min.	30 min.	60 min.	GBP
Yellow corn	56.5	56.3	56.2	57.0	56.5	56.0	56.0	61.9
Soybean meal	18.5	18.7	18.8	18.0	18.5	19.0	19.0	18.8
Layer Conc.[1]	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
GBP	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Vegetable oil	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.30
Limestone	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Total	100	100	100	100	100	100	100	100
Calculated vaules [2],%								
Crude protein	17.90	17.91	18.00	17.90	17.89	18.00	17.96	18.00
ME(kcal/kg)	2720	2722	2734	2731	2718	2737	2728	2737
ME /CP ratio	152	152	152	152	152	152	152	152
Ether Extract	2.80	3.85	3.90	3.93	3.77	3.90	3.81	3.10
Crude fibre	4.64	4.70	4.02	4.55	4.67	4.80	4.49	2.97
Calcium	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75
Av. phosphorus	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43

[1]Vit+Min mixture provides per kilogram of diet: vitamin A, 6000 IU; vitamin E, 10 IU; menadione, 2.5 mg; Vit. D_3, 2000 ICU; riboflavin, 2.5 mg; Ca pantothenate, 10 mg; nicotinic acid, 12 mg; choline chloride, 300 mg; vitamin B_{12}, 4 µg; vitamin B_6, 5 mg; thiamine, 3 mg; folic acid, 0.50 mg; biotin, 0.2 mg. Trace mineral (milligrams per kilogram of diet): Zn, 40; Fe, 40; Cu, 4; Se, 0.10.
[2]Calculated values (NRC, 1994)

Table 2: Ingredient profile and calculated nutrient composition of the experimental diets contains 10% Guava by-product (GBP) processed by either sun dried, boiled in water, acid or alkaline for half or an hr

	Processing ways for Guava by product						
		Boiled in water for		Boiled in acid for		Boiled in alkaline for	
	Sun						
Ingredients %	dried	30 min.	60 min.	30 min.	60 min.	30 min.	60 min.
Yellow corn	52.5	52.2	52.0	53.3	52.5	52.0	51.5
Soybean meal	17.5	17.8	18.0	16.7	17.5	18.0	18.5
Layer Conc.[1]	10.0	10.0	10.0	10.0	10.0	10.0	10.0
GBP	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Vegetable oil	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Limestone	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Total	100	100	100	100	100	100	100
Calculated values[2],%							
Crude protein	17.60	17.59	17.78	17.69	17.59	17.79	17.72
ME (kcal/kg)	2673	2678	2701	2693	2669	2712	2690
ME /CP ratio	152	152	152	152	152	152	152
Ether Extract	3.86	3.96	4.02	3.92	3.80	4.09	3.89
Crude fibre	6.50	6.61	5.97	5.32	6.55	6.81	6.19
Calcium	3.75	3.74	3.74	3.74	3.75	3.75	3.74
Available phosphorus	0.42	0.42	0.42	0.42	0.42	0.42	0.42

[1;2]as shown in Table 1

Results showed that hens fed 5% GBP laid fewer eggs and less egg mass than the other levels and the control group, too. No significant differences were observed between the control group and those fed 10 and 15% GBP levels in terms of egg number and egg mass, showing safe use of 10 and 15% levels.

The interaction between processing way and level of GBP was significant, revealing that hens fed diets containing 5% sun dried GBP, 5% GBP boiled for half an hr in water or boiled for half an hr in acid and 10% GBP boiled for an hr in water produced the least egg number and egg mass. Whereas, hens fed diets containing 15% sun dried GBP, 15% GBP boiled for half an hr in acid and 15% GBP boiled for half an hr in alkali and 10% GBP boiled for an hr in alkali laid the greatest egg number and egg mass. The results reveal that half an hr reduced egg number and mass of hens fed 5% GBP boiled in water or acid, showing that half an hr was not adequate treatment compared to their counterpart groups.

Feed intake and feed conversion ratio: Table 5 shows the effects of various processing ways and/or levels of GBP on Feed Intake (FI) and Feed Conversion Ratio

Table 3: Ingredient profile and calculated nutrient composition of the experimental diets contains 15% Guava by-product (GBP) processed by either sun dried, boiled in water, acid or alkaline for half or an hr

	Processing ways for Guava by product						
		Boiled in water for		Boiled in acid for		Boiled in alkaline for	
Ingredients %	Sun dried	30 min.	60 min.	30 min.	60 min.	30 min.	60 min.
Yellow corn	48.5	47.9	47.8	49.5	48.3	47.5	47.0
Soybean meal	16.5	17.1	17.2	15.5	16.7	17.5	18.0
Layer Conc.[1]	10.0	10.0	10.0	10.0	10.0	10.0	10.0
GBP	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Vegetable oil	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Limestone	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Total	100	100	100	100	100	100	100
Calculated values[2], %							
Crude protein	17.30	17.17	17.56	17.51	17.36	17.68	17.48
ME (kcal/kg)	2626	2631	2669	2653	2639	2682	2650
ME /CP ratio	152	152	152	152	152	152	152
Ether Extract	3.92	3.21	3.26	4.00	4.82	4.25	4.06
Crude fibre	8.36	8.50	6.73	8.10	8.45	8.47	7.90
Calcium	3.74	3.74	3.75	3.74	3.72	3.75	3.75
Available phosphorus	0.41	0.41	0.41	0.41	0.41	0.41	0.41

[1;2]as shown in Table 1

Table 4: Chemical composition of sun dried and Guava by-product processed by various ways (on air dry matter basis)

	Processing ways for guava by product							
		Boiled in water for		Boiled in acid for		Boiled in alkaline for		El-Deek *et al.*
Constituent %	Sun dried	30 min.	60 min.	30 min.	60 min.	30 min.	60 min.	(2009)
Moisture	6.94	6.09	5.96	6.41	5.83	4.68	6.14	6.89
Crude protein	9.78	8.70	9.87	13.57	9.73	9.93	7.48	9.08
Ether extract	4.52	5.68	6.29	4.87	3.93	6.95	5.09	10.0
Crude fibre	40.00	40.95	34.46	38.51	40.53	42.53	36.50	39.50
Nitrogen free extract	33.14	33.63	37.75	31.57	33.56	38.84	40.76	32.97
Crud ash	5.62	4.96	5.67	5.07	6.42	6.73	4.03	1.56
Calcium.	0.37	0.32	0.67	0.51	0.27	0.61	0.66	NR
ME (kcal/kg)	2200	2040	2540	2310	2160	2650	2480	2226

(FCR) of laying hens. FI during the experimental period was satisfactory and no palatability problems could be attributed to all dietary treatments. Nevertheless, GBP had a significant effect on FI, showing similar increases due to inclusion of 10 and 15% GBP levels compared to 5%, while the control (0% GBP) exhibited intermediate value and this increase in feed intake may explain the increased laying rate and egg mass of hens fed 10 and 15% compared to 5% GBP% level.

Hens fed GBP boiled for half an hr and an hr in water and for half an hr in acid had significantly worse FCR than those fed GBP boiled for an hr in acid and for half an hr and an hr in alkaline and the control group, too. The letter groups did not show significant differences from each other. Meanwhile, sun dried only GBP had intermediate FCR.

There was no significant effect of GBP level up to 15% on FCR of laying hens, although the control group had numerically better value. Obviously, increasing GBP in the laying diet up to 15% reduce the differences from 5.85-3.0% between the control diet and those fed GBP at 5 and 10%, respectively showing improved feed utilization at the highest GBP.

There was a significant interaction between various processing ways and the level of GBP, showing that 5% GBP boiled in alkaline for an hr had the best FCR which was significantly better than those fed 10% sundried GBP, 5% GBP boiled for half an hr in water or in acid and 10% GBP boiled for an hr in water. Other groups exhibited intermediate FCR. Differences between groups fed diet containing 5% GBP boiled for an hr in alkaline and the control one was 1.55% in favor of those fed GBP although this was not significant.

Haugh unit score: Table 6 shows the effects of various processing ways and/or levels of GBP on Haugh Unit (HU) score of eggs of laying hens. Hens fed diets containing GBP boiled for an hr in water produced eggs of greater HU than the those fed sundried only GBP or that boiled for half an hr in water or acid or alkaline. Level of GBP had a significant effect on HU showing better similar values of GBP levels than the control group.

There was a significant interaction between processing ways and level of GBP on HU score. The best HU was recorded by group fed diet had 5% GBP boiled for an hr

Table 5: The effect of various processing ways and/or levels of Guava by-product (GBP) level on egg production traits of laying hens during 32-48 wk of age

Treatments	Body weight change (g/hen)	Egg production (egg/hen)	Egg weight (g)	Egg mass (g/day)	Feed intake (g feed/hen/day)	Feed conversion (kg feed/kg egg)
Processing way for GBP						
Control (0% GPB)	78.7[d]	98.7[ab]	61.4[b]	54.8[a]	105.7	1.93[d]
Sun dried	175.1[ab]	96.8[ab]	63.4[a]	52.6[b]	107.3	2.04[bc]
Boiled in water (0.5h)	199.8[a]	91.7[c]	62.0[b]	50.2[c]	107.4	2.14[a]
Boiled in water (1.0 h)	127.3[bc]	93.0[c]	61.8[b]	51.1[c]	105.2	2.06[ab]
Boiled in acid (0.5 h)	129.9[bc]	95.2[bc]	60.7[b]	52.4[b]	107.9	2.06[ab]
Boiled in acid (1.0 h)	132.6[bc]	97.9[ab]	60.9[b]	54.1[a]	106.6	1.97[cd]
Boiledin alkaline (0.5h)	166.4[bc]	99.2[a]	60.9[b]	54.1[a]	107.1	1.96[cd]
Boiledinalkaline (1.0 h)	124.9[c]	98.0[ab]	61.8[b]	54.6[a]	105.6	1.95[d]
SEM	0.38	0.20	0.07	0.08	0.22	0.03
Probability	**	**	**	**	NS	**
Guava by product level (%)						
0%	78.7[b]	98.7[a]	61.4	54.8[a]	105.7[ab]	1.93
5%	139.4[ab]	92.6[b]	61.7	50.9[b]	104.4[b]	2.05
10%	159.5[a]	97.3[a]	61.7	53.3[a]	108.2[a]	2.03
15%	153.6[a]	98.1[a]	61.5	54.1[a]	107.6[a]	1.99
SEM	1.72	1.13	0.03	0.04	0.09	0.02
Probability	88	**	NS	**	**	NS
Interaction between processing ways and level of guava by product						
Control	78.7	98.7[abc]	61.4	54.8	105.7	1.93[cde]
5% SD	159.0	90.0[ef]	62.9	49.7	103.3	2.08[bcde]
10% SD	222.0	97.3[abc]	64.0	52.0	109.7	2.11[bc]
15% SD*	144.0	103.0[a]	63.2	56.8	109.0	1.92[de]
5% WB for 0.5 hr	215.0	81.3[g]	62.4	44.6	105.7	2.37[a]
10% WB for 0.5 hr	204.0	98.7[abc]	62.6	54.4	111.0	2.04[bcde]
15% WB for 0.5 hr	180.0	95.0[bcde]	60.9	52.6	105.7	2.01[bcde]
5% WB for 1.0 hr	156.0	96.7[abcde]	62.4	53.5	150.3	1.97[cde]
10% WB for 1.0 hr	101.0	90.3[def]	62.2	49.6	104.7	2.11[bc]
15% WB for 1.0 hr	124.8	92.0[cdef]	60.9	50.6	105.7	2.09[bcd]
5% ACB for 0.5 hr	112.0	86.7[fg]	60.2	47.8	104.3	2.18[d]
10% ACB for 0.5 hr	124.0	96.7[abcde]	60.9	53.3	109.7	2.06[bcde]
15% ACB for 0.5 hr	154.0	102.3[a]	60.9	56.6	109.7	1.94[cde]
5% ACB for 1.0 hr	132.0	98.7[abc]	61.2	54.5	104.7	1.92[de]
10% ACB for 1.0 hr	124.0	97.7[abc]	60.9	53.8	108.7	2.02[bcde]
15% ACB for 1.0 hr	142.0	97.3[abc]	60.5	53.7	106.3	1.98[cde]
5% ALB for 0.5 hr	131.0	97.7[abc]	61.8	54.2	105.7	1.95[cde]
10% ALB for 0.5 hr	202.0	99.7[ab]	59.1	54.5	105.7	1.94[cde]
15% ALB for 0.5 hr	167.0	100.3[ab]	61.8	55.7	110.0	1.99[cde]
5% ALB for 1.0 hr	72.7	96.3[abcde]	60.8	53.5	101.7	1.90[e]
10% ALB for 1.0 hr	140.0	100.7[ab]	62.4	55.5	108.3	1.95[cde]
15% ALB for 1.0 hr	163.0	97.0[abcd]	62.3	53.6	106.7	1.99[cde]
SEM	0.02	0.13	0.04	0.05	0.05	0.02
Probability	NS	**	NS	NS	NS	**

WB = Boiled in water. ACB = Boiled in acid, ALB = Boiled in alkaline. NS = Not significant, ** = (p<0.01).

[a,b,c,d,e,f,g]Means in the same column beamy similar superscripts are significantly different

in water, whereas the lowest was observed of those fed 10% sun dried GBP whether or not boiled for half an hr in water. Other groups showed intermediate values, even though; in most cases HU of GBP processed by various ways did not differ from the control.

Yolk index: Table 6 reports the effects of various processing ways and/or levels of GBP on egg yolk index. Boiling for an hr in acid or for both periods in alkaline significantly increased yolk index compared to the other treatments which showed no significant differences among them. The increase in yolk index may be indicative of increasing yolk membrane permeability, and thus decreasing keep quality of eggs.

Level of GBP had no significant effect on yolk index, moreover, there were no differences between the control group and those fed guava processed by different ways. There was a significant interaction between level of GBP and various processing ways. Eggs from hens fed diets containing GBP boiled for half or an hr in alkaline had significantly greater yolk index than those fed diet containing GBP boiled for different periods in water or

Table 6: The effect of various processing ways and /or levels of Guava by-product (GBP) level on some egg quality traits of laying hens during 32-48 wk of age

Treatments	Haugh units (HU)	Yolk index	Shell thickness (mm)
Processing way for GBP			
Control	89.8[b]	0.42[c]	0.23[b]
Sun dried	91.7[c]	0.42[c]	0.26[ab]
Boiled in water (0.5 hr)	92.3[c]	0.42[c]	0.26[ab]
Boiled in water (1.0 hr)	94.8[a]	0.42[c]	0.24[c]
Boiled in acid (0.5 hr)	92.1[c]	0.42[c]	0.25[bc]
Boiled in acid (1.0 hr)	94.7[ab]	0.44[b]	0.27[a]
Boiled in alkaline (0.5 hr)	93.2[bc]	0.46[a]	0.24[c]
Boiled in alkaline (1.0 hr)	94.5[ab]	0.44[b]	0.24[c]
SEM	0.09	0.02	0.02
Probability	**	**	**
GBP level			
0%	89.8[b]	0.42	0.23[b]
5%	93.3[a]	0.42	0.25 [a]
10%	92.9 [a]	0.42	0.25 [a]
15%	93.7 [a]	042	0.25 [a]
SEM	0.03	0.01	0.01
Probability	**	NS	**
Interaction between processing way and level of GBP			
Control	89.8[h]	0.42[c]	0.23[ef]
5% SD	92.1[defgh]	0.40[d]	0.26[bc]
10% SD	90.7[gh]	0.42[c]	0.25[cd]
15% SD *	92.3[defgh]	0.40[d]	0.26[bc]
5% WB for 0.5 hr	93.0[defg]	0.40[d]	0.25[cd]
10% WB for 0.5 hr	90.0[h]	0.42[c]	0.24[cd]
15% WB for 0.5 hr	94.0[bcdef]	0.42[c]	0.27[ab]
5% WB for 1.0 hr	97.0[a]	0.42[c]	0.24[de]
10% WB for 1.0 hr	94.3[abcde]	0.42[c]	0.25[cd]
15% WB for 1.0 hr	93.1[defg]	0.42[c]	0.24[de]
5% ACB for 0.5 hr	90.8[gh]	0.42[c]	0.22[f]
10% ACB for 0.5 hr	91.0[fgh]	0.42[c]	0.25[cd]
15% ACB for 0.5 hr	94.6[abcd]	0.42[c]	0.27[ab]
5% ACB for 1.0 hr	96.2[abc]	0.42[c]	0.28[a]
10% ACB for 1.0 hr	94.7[abcd]	0.42[c]	0.27[ab]
15% ACB for 1.0 hr	93.3[cdefg]	0.42[c]	0.24[de]
5% ALB for 0.5 hr	91.3[efgh]	0.46[a]	0.26[bc]
10% ALB for 0.5 hr	93.3[cdefg]	0.44[b]	0.24[de]
15% ALB for 0.5 hr	94.9[abcd]	0.46[a]	0.23[ef]
5% ALB for 1.0 hr	93.0[defg]	0.46[a]	0.24[de]
10% ALB for 1.0 hr	96.5[ab]	0.44[b]	0.24[de]
15% ALB for 1.0 hr	93.9[bcdef]	0.44[b]	0.23[ef]
SEM	0.06	0.01	0.01
Probability	**	**	**

WB = Boiled in water. ACB = Boiled in acid, ALB = Boiled in alkaline. NS = Not significant, **= (p<0.01).

[a,b,c,d,e,f,h]Means in the same column beamy similar superscripts are significantly different

acid. Groups fed 5% sun dried GBP whether or not boiled for half an hr in water and those fed 15% sun dried only GBP showed the best yolk index.

Shell quality: Table 6 shows the effects of various processing ways and/or levels of GBP on shell thickness of eggs of laying hens. Different processing ways had no beneficial effects over that of only sun dried on shell quality and the control group, too. Although sundried GBP had better values than the control group, showing that sundried is adequate and safe treatment for mineral profiles of GBP. Hens fed diets containing GBP whether sun dried only or processed for different periods at various levels produced egg with significantly higher shell thickness than those fed the control diet except those given diet had 5% GBP boiled for half an hr in acid. The latter groups showed similar shell thickness to those fed the control diets.

There was significant interaction between various processing ways and levels of GBP. The results revealed that the best shell thickness among the experimental group was from group fed GBP boiled for an hr in acid although did not significantly differ from those fed 15% GBP boiled for half an hr in water or acid and 10% GBP boiled for an hr in acid and these groups had better values than the control group, too. Other groups exhibited intermediate values.

DISCUSSION

The goal behind using different processing ways was to improve the nutritive of GBP practically fibrous fractions for which poultry have a limited digestion capacity. The GBP is high in fibre content (40%; Table 4) and its fibre constituents are mainly pectin and lignin. Pectin is a hydrophilic polymer that contains ionizable carboxylic group of galacturonic acid. Unlike cellulose, it can form a gel-matrix that is viscous in nature. This viscous property may decrease accessibility of protein molecules held in the matrix to the digestive enzyme and of the products of digestion to the absorptive sites. Moreover, it can inhibit enzyme activity (Arnal and Adria, 1974). At intestinal pH levels, binding of some specific amino acid might occur, analogous to the binding of bile acid (Eastwood and Haniltion, 1973).

Pectin may also cote the absorptive lining of the gut thereby interfering with the absorptive of the products of digestion (Forman and Schneeman, 1980). The abovementioned mechanisms could explain why pectin reduces protein utilization. Furthermore lignin is a polymer of phenyl propyl alcohols and acid insoluble and hydrophilic in nature. At the lower level lignin had little effect on fecal nitrogen excretion but lowered the biological value of the nitrogen absorbed due to hydrophilic binding of essential amino acids. Therefore the processing techniques explored during this study were an attempt to render the GBP fibre more digestible. However, 10 or 15% of sun dried GBP could be utilized in layers diets without further processing.

A noticeable decrease in CF content was shown in samples boiled for an hr in water, for half an hr in acid or boiled for an hr in alkaline compared to the corresponding value of the sundried GBP, showing improved carbohydrate availability. The chemical composition of guava seed ranged from 8.9-9.4% lipids and 9.73% CP (Opute, 1978; Aly, 1981; Habib, 1986). They revealed the presence of 12 fatty acids and 15 amino acids. Guava pulp and peel fractions had high content of dietary fibre 48.55-49.12% (Marquina *et al.*, 2008), showing valuable nutrient contents of different fractions of GBP.

The alteration in the chemical composition of GBP processed in various-ways, particularly in EE and CP contents might be due to losses of volatile components such as volatile fatty acids and ammonia. In this regard, Mohamed *et al.* (1971) observed that the processing methods induce an alteration in the proximate analysis of date stones. In addition, Abiola *et al.* (2002b) indicated that the chemical analysis of melon husk showed that alkali treatment increased the ash content from 15.70 to 16.86% and reduced the CF from 29.0 to 14.0%. However, González-Alvarado *et al.* (2007) reported that rice can be used successfully in broiler diets and that heat processing of the cereal does not have any beneficial effect on broiler performance. On the other hand, García *et al.* (2008) observed that heat processing of barley improved broiler performance from 1-7 d of age. Moreover, El-Deek *et al.* (2009) observed an alteration in the chemical composition of GBP due to different processing techniques and reported ME value of 2226, 969, 1402, 1206 and 1254 kcal/kg, respectively for sun dried only, boiled in water, alkaline and acid or autoclaved for GBP. The ME values found herein are within the range of the values reported by El-Deek *et al.* (2009).

The significant increase in weight gain of laying hens due to inclusion of 10 and 15% GBP, indicated that GBP supported gain of laying hens behind supporting egg production traits (Table 5). These results are in general agreement with those reported by El-Deek *et al.* (2009) who noticed that growth of broiler chicks was not affected by GBP level; however, soaking in water or acid for GBP improved its nutritive value. Moreover, soaking in alkaline or autoclaving improved the nutritive value of different feedstuffs (Squires *et al.*, 1992; Abiola *et al.*, 2002b; Farran *et al.*, 2005).

The lack of beneficial effect of various processing ways on egg production traits compared to the control group and those fed sun dried GBP diets indicating that nutrient availability of GBP was not affected by different processing ways. Guava is a rich source of ascorbic acid (Holland *et al.*, 1991) which has antioxidant properties and anti-stress agent (Sahin *et al.*, 2003; Attia *et al.*, 2009). Heat treatment had a negative effect on Vit. C contents of GBP decreasing its antioxidant capacity. In addition, boiling in water, acid or alkaline may also resulted in loss in volatile compounds and water soluble vitamins. In this regard, Marquina *et al.* (2008) indicated that guava had extractable polyphenols (2.62-7.79%) which is a suitable source of natural antioxidants and guava peel and pulp could be used to obtain AODF.

No harmful effect of GBP at 10 and 15% levels was quoted in egg number, egg mass and egg weight and these could be ascribed to high Vit. C 200-300 mg/100 g (Holland *et al.*, 1991), methoxylated pectin and AODF (Marquina *et al.*, 2008) which could boost heath and thus productive performance of laying hens (Uddin *et al.*, 2002). Furthermore, Opute (1978) and Aly (1981) reported that the presence of 12 fatty acids and 15 amino acids, while the major amino acids were arginine, glutamic acid, aspartic acid, glycine and leucine which presented 67% of total amino acids (Habib, 1986).

The increase in feed intake at 10 and 15% compared to 5% may indicate that GBP improved diet palatability and/or lower ME value than the calculated one. Marquina *et al.* (2008) indicated that pulp and peel fractions of guava (*Psidium guajava L.*) had high content of dietary fibre (48.55-49.42%). FI and ME of diet are inversely related and laying hens had the ability to regulate FI according to dietary ME value (NRC, 1994; Daghir, 2008). Furthermore, Abiola and Adekunle (2002a) and Hartini *et al.* (2002) reported that high fibre diets increased FI, however, Chaturvedi and Singh (2000) and Abdel-Azeem (2005) found that FI decreased as the dietary CF levels increased.

It is worth noticing that GBP at 15% improved FCR compared to 5 and 10%, showing an improvement in feed utilization at the highest GBP level, but the control level was not achieved. In this regard, El-Deek *et al.* (2009) found that the best FCR was from chicks fed diets containing 4% GBP regardless of processing techniques. This discrepancy is expected since laying hens are better able to overcome the anti-nutritional factors and/or poor digestibility compared to broilers (Jeroch and Danicke, 1995; Attia *et al.*, 2001). The results reported herein however indicated no harmful effect GBP processed by various ways on FCR of group fed diet containing 5% GBP boiled for an hr in alkaline recorded the best FCR.

HU of GBP processed by various ways did not differ from the control, showing no beneficial effect of processing ways on HU. Furthermore, GBP at all levels improved HU compared to the control group and this enhancement may be due to the antioxidant factors of GBP such as Vit C and AODF which might help in keeping quality of eggs after harvest. Various processing ways had no beneficial effects over that sun dried on shell quality and the control group, too. Although sun dried GBP had better values than the control group, showing that sun dried is adequate and safe treatment for nutrient and mineral profiles of GBP. The improvement in shell thickness of groups fed 5% GBP boiled for an hr in acid, 15% GBP boiled for half an hr in water or acid and 10% GBP boiled for an hr in acid compared to the control group could be explained by higher calcium and phosphorous availability.

Conclusion: Sun dried GBP could be including at 15% in laying hen diets during 32-48 wks of age without adverse effect on productive performance and egg quality traits offering a source of feed ingredients, further processing of GBP after sundried is not necessary based on the techniques employed herein.

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