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UTILIZATION OF RICE POLISHINGS IN MASH OR PELLETED DIETS FOR "MULE" DUCKLINGS

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ABSTRACT

The present study was undertaken to investigate the effects of feeding rice polishings (RP)-containing mash or pelleted diets on growth performance, digestibility of nutrients, carcass yield and some blood plasma constituents of "mule" ducklings. Day-old "mule" ducklings were fed a dry-mash corn-soybean-based practical starter diet (contained 22% crude protein, and 2900 kcal of metabolizable energy per kg) until the birds were three weeks of age. Then, they were individually leg-banded, weighed and randomly divided into 8 experimental groups (8 X 30), each with three equal replications, fed on experimental diets up to 11 weeks of age. Four dry mash and four pelleted iso-caloric (ME of about 3000 kcal/kg) and iso-nitrogenous (CP of about 18%) experimental diets containing graded levels of rice polishings (0.0, 15.0, 30.0 or 45.0% of the diet) were formulated. The performance of growing ducklings was evaluated in terms of live body weight (LBW), daily weight gain (DWG), daily feed intake (DFI) and feed conversion ratio (FCR). Total mortality and economic efficiency of feeding (EEF) were also determined. Digestibility coefficients of nutrients of the experimental diets were measured when the birds were 10 weeks of age. At the end of study, some measurements on carcass yield and components and concentrations of certain blood plasma constituents (glucose, total protein, triglycerides, Ca and inorganic P) were performed.

The results obtained for the entire experimental period could be summarized as follows: Regardless of the diet form, increasing dietary RP level from 0.0% (control) to 45% significantly improved FCR, EEF, N retention and digestibility of CP and EE of the experimental diets, whereas all other criteria were not affected. On the other hand, irrespective of dietary RP level, ducklings fed on pellets exhibited superior means for LBW, DWG, DFI, FCR and CP and EE digestibility compared with those obtained by their mash-fed counterparts whereas all other criteria were not affected. Dietary RP level by diet form interactions had no significant effects on all criteria investigated. Only four ducklings died during the course of this experiment and the deaths were not related to the dietary treatments. Based on the obtained results, from a practical and economical point of view, it is concluded that rice polishings can successfully be used at inclusion rates of up to 45% of pelleted diets for mule ducklings, with no adverse effects on growth performance or carcass traits.

Keywords: Rice polishings, mash and pelleted diets, growth performance, carcass traits, nutrient digestibility, blood constituents, mule ducklings

INTRODUCTION

Rice (*Oryza sativa L.*) is almost entirely cultivated for human consumption all over the world. However, huge amounts of rice by-products are produced annually during the processing operation of paddy rice to produce white rice. These by-products include rice hulls, rice bran, rice polishings, broken rice and others. With the exception of rice hulls all of rice by-products can be used as feed ingredients for poultry (e.g. Kratzer *et al.*, 1974; Raya, 1989; Raya and El-Shinnawy, 1989; Farrell, 1994; Adrizal *et al.*, 1996; Wang *et al.*, 1997; Farrell and Martin, 1998a,b; Martin *et al.*, 1998; El-Mallah *et al.*, 2000; Sherif, 2003). Actually, chemical compositions of rice bran and rice polishings are approximately similar, except that rice bran contains much higher crude fiber (11.7%) than do rice polishings (4.1%), as specified by NRC (1994); this is mainly due to the fact that rice bran includes both the true bran and polishings (Farrell, 1994). The nutritive value of rice bran, however, varies widely depending upon the processing techniques; some processors allow for adulteration with rice hulls, which have virtually no nutritional value for poultry (Farrell and Warren, 1982).

As far as the author aware, limited sporadic investigations are available in the scientific literature on the use of rice polishings, particularly, in poultry diets. With laying hens, Thirumalai *et al.* (1990) reported that dietary inclusion levels of rice polishings (RP) up to 40% did not adversely affect their laying performance. El-Ghamry *et al.*, (1997) investigated the influence of replacing both yellow corn (YC) and soybean meal (SBM) with RP and black cumin meal (BCM) in layer diets (at replacement ratios equivalent to 0, 25, 50 or 75% of the diet) on performance and egg quality and composition. They found no significant effects of dietary treatments on egg production rate, total egg mass, feed conversion or egg quality and composition, however, Haugh units and yolk color score were negatively affected. El-Mallah *et al.* (2000) studied the effects of partial or complete substitution of RP for YC in laying hen diets on the productive performance and egg quality. They found that replacing 25, 50, 75 or 100% of YC by RP caused significant reductions in egg production rate and efficiency of feed utilization compared with those of the control group. However, feed intake, egg weight, yolk index and Haugh unit score were not affected by the dietary treatments.

Working with broiler chicks, Ali and Leeson (1995) fed male broiler chicks diets containing 0, 8, 14 or 20% RP at the expense of corn and SBM. They found that live body weight and weight gain were significantly lower for broiler fed on RP-containing diets than those of broilers fed on the control diet, although the feed conversion was not affected. Also, Sherif (2003) investigated the effect of using graded levels of RP (0, 10, 20, 30 or 40% of the diet) in both starter and grower broiler diets on the performance of chicks. He found that using RP in broiler diets up to 40% improved the economic efficiency of feeding but did not significantly affect feed conversion, nutrients digestibility, carcass traits, blood parameters or mortality rate of chicks, while both marketing live body weight and feed intake were significantly decreased.

The inconsistent responses of birds to rice polishings as a feed ingredient in their diets may be attributed to variations in its nutrient content and availability, the composition of the basal diet, the length of the experimental period, type and age of birds or the interactions among these factors. Depending on the aforementioned publications, it was observed that diets containing high levels of rice polishings seem to be dusty and tend to stick to the beak of bird.

Therefore, the present study was performed to investigate the effects of feeding rice polishings in mash or pelleted diets on growth performance, digestibility of nutrients, carcass yield and some blood plasma constituents of "mule" ducklings.

MATERIALS AND METHODS

The present study was carried out (from July to September, 2003) at the Agricultural Experiments and Researches Station, Poultry Production Farm, Faculty of Agriculture, Mansoura University, El-Mansoura, Egypt.

Birds, management and diets

Day-old "mule" ducklings (Muscovy ♂ X Mallard-type ♀), imported from France, were used in this experiment. The ducklings were raised in a gas-heated open-sided house, equipped with feeders and drinkers and fed a dry mash corn-soybean-based practical starter diet (contained 22% crude protein, CP, and 2900 kcal of metabolizable energy, ME, per kg) until the birds were three weeks of age. Then, they were individually leg-banded, weighed and randomly divided into 8 equal experimental groups (8 X 30), each with three equal replications (3 X 10), and fed on experimental diets up to 11 weeks of age. Four dry mash and four pelleted experimental diets containing graded levels of rice polishings (0.0, 15.0, 30.0 or 45.0% of the diet) were formulated and fed to their respective experimental groups of ducklings. Rice polishings (RP) was incorporated into these experimental diets primarily at the expense of yellow corn and soybean meal in the basal diets. Beet molasses was used as a pellet binder. All diets were calculated to be iso-caloric (ME of about 3000 kcal/kg) and iso-nitrogenous (CP of about 18%) based on the nutrient compositions of feed ingredients outlined by NRC (1994). The formulae and proximate analyses of the experimental diets are presented in Table 1. Each replicate group was kept at a floor pen (measuring 3.0 X [illegible]), bedded with wood shavings and supplied with one circular trough feeder. A permanent source of fresh drinking water was used as a common watering system. Gas heaters were used only throughout the starting period; in order to maintain the ambient temperature during the cold portion of night in keeping with the usual brooding practice. All ducklings were kept under continuous lighting in order to reduce fright and stampeding of the birds. Feed and water were available for *ad libitum* consumption. The experiment lasted for eight weeks (from 3 to 11 weeks of age).

Growth performance of ducklings

The performance of growing ducklings was evaluated in terms of average live body weight (LBW), average daily weight gain (DWG), average daily feed intake (DFI), average feed conversion ratio (FCR) and mortality rate. Individual live body weights of ducklings were recorded biweekly. Records on body weight gain, feed intake and feed conversion were also maintained every two weeks, on a replicate group basis. Mortality of ducklings, however, was monitored and recorded daily. The economic efficiency of feeding (EEF) was also determined for the entire experimental period. EEF was calculated as net profit/kg gain times 100 divided by feed cost/kg gain. Net profit/kg gain was computed as price per kg gain (i.e. sale price per kg of live birds) minus feed cost per kg gain. Cost per kg diet (Table 1) and values of FCR for the three replicate groups of each dietary treatment were used to calculate the feed cost per kg gain.

Table (1): Composition and chemical analysis of the experimental diets

Ingredients (%)	*Mash diets*				*Pelleted diets*			
	RP included (%)				RP included (%)			
	0.0	15	30	45	0.0	15	30	45
Yellow corn	69.15	57.00	44.00	30.98	68.45	55.40	42.70	29.70
Soybean meal (44%)	14.30	13.00	10.00	7.30	14.80	10.70	8.50	6.20
Corn gluten meal (60%	8.00	8.00	9.00	9.70	8.00	9.50	10.00	10.50
Wheat bran	5.00	3.45	3.45	3.45	3.20	3.80	3.20	3.00
Rice polishings (RP)	0.00	15.00	30.00	45.00	0.00	15.00	30.00	45.00
Beet molasses	0.00	0.00	0.00	0.00	2.00	2.00	2.00	2.00
Limestone	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Dicalcium phosphate	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
Common salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Vit. & Min. premix*	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
L- Lysine.HCl	0.05	0.05	0.05	0.07	0.05	0.10	0.10	0.10
DL-Methionine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Total	100	100	100	100	100	100	100	100
Cost, L.E./kg diet**	1.17	1.14	1.11	1.07	1.27	1.24	1.21	1.17
Calculated analysis (air-dry basis)***								
ME; kcal/kg	3004	3011	3010	3004	3008	3009	3008	3001
CP; %	18.03	18.02	18.04	18.03	18.04	18.04	18.04	18.03
Ca; %	0.87	0.87	0.87	0.86	0.87	0.87	0.86	0.86
Total P; %	0.68	0.82	0.97	1.11	0.67	0.82	0.96	1.11
Available P; %	0.38	0.39	0.39	0.40	0.39	0.39	0.39	0.40
Lysine; %	0.73	0.74	0.72	0.72	0.73	0.74	0.73	0.73
Methionine; %	0.44	0.44	0.45	0.45	0.44	0.45	0.45	0.45
Meth. + cys.; %	0.77	0.75	0.73	0.72	0.76	0.75	0.74	0.72
Determined analysis (dry mattser basis)								
DM; %	90.45	90.25	90.11	89.85	90.19	90.12	89.95	89.75
CP; %	19.90	19.78	19.70	19.66	20.02	19.95	19.88	19.77
EE; %	3.42	4.62	5.77	7.09	3.38	4.69	5.81	7.17
CF; %	3.35	3.61	3.75	3.87	3.33	3.45	3.69	3.83
Ash; %	5.98	6.15	6.27	6.22	6.09	6.22	6.31	6.25
NFE; %	67.35	65.84	64.51	63.16	67.18	65.69	64.31	62.98

* :Each kg of the product contains: 4,000,000 IU vit. A, 667,000 IU vit. D_3, 3,333 mg pantothenic acid, 500 mg vit. B_6, 3 mg vit. B_{12}, 10,000 mg nicotinic acid, 333 mg folic acid, 17 mg biotin, 91,667 mg choline, 10 g Fe, 2.167 g Cu, 18.333 g Zn, 20 g Mn, 167 mg I, 67 mg Co and 67 mg Se.

** :The calculation was made according to the prevalent market prices of feed components during the experimental period (cost of pelleting was included).

*** :NRC (1994), except for beet molasses based on Scott *et al.* (1976).

Digestibility of nutrients

Digestibility trials were undertaken at 9 weeks of ducklings' age wherein 3 birds per treatment were randomly chosen and kept in a separate compartment of a growing battery fitted with feeders and drinkers, and underneath galvanized metal trays for excreta collection. Each group of ducklings was fed *ad libitum* their respective experimental diet for a seven-day pretest acclimatization period, followed by a three-day test period during which daily feed intake and total droppings voided were quantitatively determined. Fractions of fecal and urinary nitrogen (N) in the droppings were chemically separated by the method of Jacobsen *et al.* (1960), in order to determine the protein digestibility. The percentage of the urinary organic matter was computed by multiplying the percentage of urinary N by the factor 2.62 (Abou-Raya and Galal, 1971). Digestibility coefficients were calculated for dry matter (DM), organic matter (OM), crude protein (CP), crude fiber (CF), ether extract (EE) and nitrogen-free extract (NFE). Percentages of ash and N retention were also determined. The proximate analyses of the experimental diets and dried droppings were accomplished according to the methods described by AOAC (1990).

Carcass yield

At 11 weeks of age, 3 ducklings were selected from each dietary treatment on the basis of average live body weight, and sacrificed by cutting the cervical jugular veins. Immediately after feather picking, their carcasses were eviscerated and traditionally processed. Procedures of cleaning out and excising the abdominal fat were performed on the hot carcasses. The abdominal fat weight (the adipose tissues surrounding the gizzard and bursa of Fabricius and those adjacent to the cloaca) was determined. Records on the individual weights of eviscerated carcasses, giblets (i.e. heart, liver without gall bladder and skinned empty gizzard) were also maintained. Carcass yield was calculated as eviscerated carcass plus giblets. All measurements on carcass traits were expressed as percent of live body weight at slaughter.

Blood constituents

At the termination of the experiment (11 weeks of age), individual blood samples were collected in heparinized tubes, by puncturing the wing veins of 3 ducklings per treatment. As soon as possible, blood plasma was separated by centrifugation and stored at –20 °C for later analysis. Plasma samples were analyzed, using commercial kits, for the determination of glucose, total protein, triglycerides, cholesterol, Ca and inorganic P, according to the methods of Trinder (1969), Henry (1964), Fossati and Prencipe (1982), Allain *et al.* (1974), Moorhead and Biggs (1974) and Goldenberg and Fernandez (1966), respectively.

Statistical analysis

Data were analyzed as a factorial design (4 × 2) with four dietary levels of rice polishings (0.0, 15.0, 30.0 and 45.0% of the diet) which were fed as mash or pelleted diets. The statistical processing of the data was accomplished by using a computerized multi-factor analysis of variance with P values of 0.05 or less considered significant. The significant differences among means for each criterion were separated by LSD- multiple range test (Quattro Program, Borland, 1990 and Statgraphics Program, Version 5.0, Rockville, 1991).

RESULTS AND DISCUSSION

The statistical analysis of the obtained results proved that dietary RP level by diet form (mash or pellets) interactions had no significant effects on all criteria measured in the present experiment, and hence, only effects of the main factors will be discussed herein below.

Performance of growing ducklings

Results presented in Tables 2 and 3 summarize the effects of feeding RP-based mash or pelleted diets on LBW, DWG, DFI and FCR of ducklings grown from 3 to 11 weeks of age. Regardless of the diet form, dietary RP level had no significant effects on growth performance of ducklings, as measured by LBW, DWG or DFI but significantly affected the FCR during the entire period of study. The best FCR (4.15) was achieved by the ducklings fed diets containing 30% RP and the lowest one (4.53) was attained by the ducklings fed on the control diets (0.0% RP).

Table (2): Effects of feeding rice polishings (RP)-based mash and pelleted diets on live body weight (LBW) and daily weight gain (DWG) of mule ducklings grown from 3 to 11 weeks of age.

Treatments	LBW (g)					DWG (g/bird)				
	3 wk	5 wk	7 wk	9 wk	11 wk	3-5 wk	5-7 wk	7-9 wk	9-11 wk	3-11 wk
RP level (A)										
1 (0%)	840	1707	2506	3111	3401	62.0	57.1	43.2	20.6	45.7
2 (15%)	851	1742	2552	3109	3471	63.7	57.9	39.8	25.6	46.8
3 (30%)	831	1718	2483	3080	3488	63.3	54.6	42.6	29.2	47.4
4 (45%)	831	1734	2490	3124	3539	64.5	54.0	45.4	29.7	48.4
Sig. level[1]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SEM[2]	13.4	22.7	31.8	33.2	38.6	2.1	1.5	1.7	2.4	1.0
Diet form (B)										
1 (Mash)	833	1689^b	2443^b	3018^b	3392^b	60.9^b	54.1^b	41.1	26.7	45.7^b
2 (Pellets)	843	1765^a	2572^a	3194^a	3558^a	65.9^a	57.7^a	44.4	25.9	48.5^a
Sig. level[1]	NS	**	**	**	**	*	*	NS	NS	*
SEM[2]	9 5	16.0	22.5	23.4	27.4	1.5	1.1	1.2	1.7	0.7
AB Interaction										
1 (1x1)	810	1657	2419	3015	3328	60.5	54.4	42.7	22.3	45.0
2 (1x2)	869	1757	2594	3207	3473	63.5	59.7	43.7	18.8	46.4
3 (2x1)	853	1724	2498	3029	3422	62.2	55.4	38.0	28.0	46.0
4 (2x2)	848	1760	2606	3189	3520	65.2	60.4	41.7	23.6	47.7
5 (3x1)	831	1688	2426	2938	3368	61.2	52.7	36.6	30.7	45.3
6 (3x2)	832	1748	2540	3221	3609	65.5	56.5	48.7	27.7	49.6
7 (4x1)	839	1675	2430	3090	3448	59.6	54.0	47.2	25.8	46.6
8 (4x2)	823	1794	2550	3159	3629	69.4	54.0	43.5	33.6	50.1
Sig. Level[1]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SEM[2]	19.0	32.0	45.0	46.9	54.6	3.0	2.1	2.4	3.3	1 4

[a-b]: Means in the same column, for each criterion, bearing different superscripts differ significantly.
[1]: significance level; NS = not significant, * = significant at P ≤ 0.05, ** = significant at P ≤ 0.01.
[2]: SEM refers to standard error of the means.

This result may manifest a better feed utilization by ducklings for the RP-containing diets as compared to the control diets. However, no clear-cut interpretation could be offered here; due to the absence of significant differences in feed intake and body weight gain among groups of ducklings, as affected by the dietary RP level. Irrespective of dietary RP level, feeding the pelleted diets produced significant improvements in LBW, DWG, DFI and FCR, for the entire experimental period, compared with those attained when the diets were offered in mash form. Although ducklings receiving the pelleted diets consumed significantly less feed compared with those fed on the mash diets, they attained more gains and better feed conversion ratios (Tables 2 and 3).

Table (3): Effects of feeding rice polishings (RP)-based mash and pelleted diets on daily feed intake feed conversion ratio (FCR) of mule ducklings grown from 3 to 11 weeks of age.

Treatments	DFI (g/bird)					FCR (g feed: g gain)				
	3-5 wk	5-7 wk	7-9 wk	9-11 wk	3-11 wk	3-5 wk	5-7 wk	7-9 wk	9-11 wk	3-11 wk
RP level (A)										
1 (0%)	186.3	188.7	224.2	229.3	206.6	3.04	3.33	5.21^{ab}	11.87^{a}	4.53^{a}
2 (15%)	185.7	186.3	216.2	220.0	201.7	2.92	3.24	5.47^{a}	8.98^{ab}	4.32^{ab}
3 (30%)	183.3	184.5	206.0	208.7	195.6	2.91	3.39	5.06^{bc}	7.31^{bc}	4.15^{bc}
4 (45%)	192.3	190.9	212.3	219.2	203.5	3.03	3.54	4.69^{b}	7.75^{b}	4.23^{b}
Sig. level[1]	NS	NS	NS	NS	NS	NS	NS	*	*	*
SEM[2]	6.0	5.0	6.2	5.8	3.7	0.13	0.10	0.18	1.07	0.08
Diet form (B)										
1 (Mash)	199.7^{a}	201.1^{a}	232.7^{a}	238.2^{a}	217.6^{a}	3.30^{a}	3.72^{a}	5.75^{a}	9.27	4.76^{a}
2 (Pellets)	174.1^{b}	174.1^{b}	196.6^{b}	200.4^{b}	186.2^{b}	2.65^{b}	3.03^{b}	4.46^{b}	8.69	3.85^{b}
Sig. level[1]	**	**	**	**	**	**	**	**	NS	**
SEM[2]	4.3	3 5	4.4	4.1	2.6	0.09	0 07	0.12	0.76	0.06
AB Interaction										
1 (1x1)	198.8	203.6	234.7	241.2	219.0	3.34	3.74	5.51	11.19	4.87
2 (1x2)	173.8	173 8	213.8	217.5	194.1	2.74	2.92	4.91	12.55	4.20
3 (2x1)	197.6	198 8	239 6	243.4	219.2	3.18	3.60	6.30	8.83	4.78
4 (2x2)	173.8	173.8	193.0	196.7	184.3	2.67	2.89	4.64	9.14	3.86
5 (3x1)	194.0	196.4	227.4	228.8	211.7	3.17	3.73	6.32	7.66	4.68
6 (3x2)	172.0	172.6	184.5	188.6	179.6	2.64	3.05	3.80	6.96	3.62
7 (4x1)	208.3	205.7	229.4	239.4	220.4	3.53	3.81	4.88	9.39	4.73
8 (4x2)	176.2	176.2	195.2	199.4	186.7	2.54	3.27	4.50	6.12	3.73
Sig. level[1]	NS	NS	NS	NS	NS	NS	NS	**	NS	NS
SEM[2]	8.5	7.0	8.7	8.1	5.2	0.19	0.14	0.25	1.51	0.11

a-c: Means in the same column, for each criterion, bearing different superscripts differ significantly.

1: significance level; NS = not significant, * = significant at P ≤ 0.05, ** = significant at P ≤ 0.01.

2: SEM refers to standard error of the means.

It appears that the improved performance, obtained by feeding pellets in the present study, may be due to a better feed utilization but was not attributable to hyperphagia. However, the reasons for the improved performance of birds in response to feed pelleting are still not completely understood. This may imply that efficient utilization of the pelleted diets may be a consequence of a better digestion or attributed to some other factors which may have been operated at the metabolic level, and thus, improved availability and/or utilization of nutrients. In general, pelleted diets are utilized more efficiently by ducks than are diets in mash form, primarily because of reduced wastage and ease of consumption (Wilson, 1973; Dean, 1986).

No comparable studies could be found in the literature concerning the use of RP as a feed ingredient in growing duckling diets. In contrast to the present results, Sherif (2003) found that live body weight and feed intake of broiler chicks were significantly depressed while feed conversion ratio was not affected when the chick were fed up to 40% RP in their starter and grower diets. Similarly, depressed growth performance has been reported when RP was included up to 20 % in broiler diets compared with the performance of the control group, although feed:gain ratio was not affected (Ali and Leeson,1995). However, Wang *et al.* (1997) fed broiler chicks on diets containing up to 50% rice bran and found that growth performance, as measured by feed intake, weight gain and feed:gain ratio, was significantly depressed in chicks fed on the rice bran-containing diets as compared to their control counterparts.

Generally the present results are in partial agreement with those reported by other investigators (Tangendjaja *et al.*, 1985; Tangendjaja *et al.*, 1986; wang *et al., 1997*). Tangendjaja *et al* (1985) concluded that Alabio ducklings could tolerate up to 75% rice bran in their diets without a depression in growth rate or feed conversion. In another study, Tangendjaja *et al.* (1986) found that feeding diets containing up to 45% rice bran did not depress the performance of growing ducks, compared with their control counterparts. Wang *et al.* (1997), however, demonstrated that feeding the Leghorn chicks on diets containing high level of rice bran (25 to 50% of the diet) attained equivalent growth performance (in terms of body weight gain and feed conversion ratio) to that obtained for the control birds fed corn- or wheat-based diets. Also, in accordance with the results of the present study, pelleting has been reported to improve the growth performance of chicks (Munt *et al.*, 1995; Nir *et al.*, 1995). Only four deaths have occurred during the last two weeks of the experimental period, and the deaths were not related to the dietary treatments.

Economic efficiency of feeding (EEF)

Data on the economic efficiency of feeding, determined as an absolute net profit per kg gain or relative to the cost of feeding, of mule ducklings fed the experimental diets from 3 to 11 weeks of age are presented in Table 4. Apart from the diet form, EEF for the whole experimental period was significantly increased with increasing the RP level in the diet up to 45%; the highest EEF value (4.29 L.E.; equivalent to 92.18%) was attained by ducklings fed on the 45%-RP diets and the lowest one (3.49 L.E.; equivalent to 63.97%) was obtained by the control ducklings (0.0%-RP diets). The improvement in EEF for ducklings fed on the RP-containing diets compared with their control counterparts (on 0.0% RP diets) may be due mainly to the low price of RP as opposed to those of corn and soybean meal. Similarly, ducklings fed on the pelleted diets exhibited significantly higher EEF values as compared to those achieved by the mash-fed ducklings. This may be attributed primarily to the improved performance of ducklings for growth and feed conversion that was achieved with less feed intake upon feeding on the pelleted diets in comparison with mash diets. It was interesting to note that further improvements in the EEF could be achieved if ducklings were marketed (or processed) two weeks earlier (at 9 weeks of age). However, due to some considerations related to the ease of feather picking during processing of the carcasses, and thus carcass quality and consumer acceptability, we had to delay the age of marketing until 11 weeks of age. In consistent with this concept Baeza *et al.* (2000) concluded that the ideal slaughter age for mule ducks was 10 weeks when only the growth variables were taken into consideration; whereas based on the chemical analysis and technological characteristics of the meat, the maturity of *Pectoralis major* was reached at 11 weeks of age.

Table (4): Economic efficiency (EEF)[3] of feeding rice polishings (RP)-based mash and pelleted diets to mule ducklings from 3 up to 11 weeks of age

Treatments	Net profit/kg gain (L.E.) 3-9 weeks	Net profit/kg gain (L.E.) 3-11 weeks	EEF (%) 3-9 weeks	EEF (%) 3-11 weeks
RP level (A)				
1 (0%)	4.29[b]	3.49[c]	100.73[c]	63.97[c]
2 (15%)	4.66[ab]	3.88[b]	108.97[bc]	76.72[b]
3 (30%)	4.84[a]	4.21[a]	118.78[ab]	89.43[a]
4 (45%)	4.94[a]	4.29[a]	122.30[a]	92.18[a]
Sig. level[1]	*	**	*	**
SEM[2]	0.09	0.10	4.33	3.35
Diet form (B)				
1 (Mash)	4.44[b]	3.65[b]	97.97[b]	68.68[b]
2 (Pellets)	5.03[a]	4.28[a]	127.43[a]	92.46[a]
Sig. level[1]	**	**	**	**
SEM[2]	0.06	0.07	3.06	2.37
AB interaction				
1 (1x1)	4.26	3.30	90.48	58.03
2 (1x2)	4.72	3.67	110.98	69.91
3 (2x1)	4.34	3.55	93.27	65.29
4 (2x2)	4.99	4.21	124.68	88.18
5 (3x1)	4.44	3.80	97.96	73.48
6 (3x2)	5.24	4.62	139.61	105.38
7 (4x1)	4.72	3.94	110.17	77.94
8 (4x2)	5.15	4.64	134.44	106.42
Sig. level[1]	NS	NS	NS	NS
SEM[2]S	0.13	0.13	6.12	4.73

[a-c]: Means in the same column, for each criterion, bearing different superscripts differ significantly.

[1]: significance level; NS = not significant, * = significant at $P \leq 0.05$, ** = significant at $P \leq 0.01$.

[2]: SEM refers to standard error of the means.

[3]: EEF= 100 [Net profit/kg gain]/[Feed cost per kg gain].

Digestibility of nutrients

The digestibility coefficients of nutrients and percentages of ash and N retention in 10-week-old mule ducklings as affected by RP-based mash and pelleted diets are shown in Table 5. Apart from diet form (mash or pellets), CP and EE digestibility and N retention were significantly improved with increasing the inclusion level of dietary RP; whereas digestibility of the other nutrients (DM, OM, CF and NFE), and ash retention were not affected. However, ducklings fed on pellets exhibited significantly higher digestibility coefficients only for CP and EE compared with those obtained by their mash-fed counterparts, irrespective of dietary level of RP. But percentages of ash and N retention and digestibility of DM, OM, CF and NFE were not affected by the diet form.

Table (5): Digestibility coefficients of nutrients in 10-week-old mule ducklings fed rice polishings (RP)-based mash and pelleted diets

Treatments	Digestion coefficients (%)						Retention (%)	
	DM	OM	CP	CF	EE	NFE	Ash	N
RP level (A)								
1 (0%)	73.19	76.46	90.37[b]	27.74	87.12[c]	82.62	25.63	60.75[b]
2 (15%)	73.63	76.75	92.35[a]	29.19	86.93[c]	82.29	27.41	64.15[ab]
3 (30%)	74.38	77.70	92.28[a]	30.52	88.85[b]	83.29	25.84	64.79[a]
4 (45%)	75.18	78.11	91.72[a]	29.92	91.23[a]	83.41	28.60	66.63[a]
Sig. level[1]	NS	NS	*	NS	**	NS	NS	*
SEM[2]	0.61	0.60	0.41	1.30	0.39	0.58	1.82	1.16
Diet form (B)								
1 (Mash)	73.91	77.01	90.65[b]	29.90	87.25[b]	82.85	26.32	63.56
2 (Pellets)	74.28	77.49	92.71[a]	28.75	89.81[a]	82.95	27.42	64.61
Sig. level[1]	NS	NS	**	NS	**	NS	NS	NS
SEM[2]	0.43	0.43	0.29	0.92	0.28	0.41	1.29	0.82
AB Interaction								
1 (1x1)	72.85	76.21	89.33	28.34	84.83	82.66	24.04	59.18
2 (1x2)	73.54	76.71	91.42	27.14	89.42	82.58	27.22	62.33
3 (2x1)	73.35	76.20	91.29	29.12	86.11	81.57	26.92	65.51
4 (2x2)	73.91	77.30	93.41	29.13	87.75	83.01	27.91	62.80
5 (3x1)	74.10	77.47	91.49	31.22	87.74	83.45	25.45	63.11
6 (3x2)	74.66	77.92	93.07	29.81	89.96	83.14	26.24	66.47
7 (4x1)	75.34	78.17	90.49	30.90	90.34	83.73	28.89	66.42
8 (4x2)	75.02	78.04	92.95	28.93	92.12	83.08	28.31	66.84
Sig. level[1]	NS	NS	NS	NS	NS	NS	NS	NS
SEM[2]S	0.86	0.85	0.58	1.84	0.55	0.81	2.58	1.64

a-c: Means in the same column, for each criterion, bearing different superscripts differ significantly.

1: significance level; NS = not significant, * = significant at $P \leq 0.05$, ** = significant at $P \leq 0.01$.

2: SEM refers to standard error of the means.

The improvement in CP and EE digestibility and N retention of the RP-containing diets, used in the present study, might be explained by a decreased rate of feed passage through the gastrointestinal tract and therefore, improved digestion and absorption of these nutrients. This explanation, however, is in contradiction with the findings of Alvarez and Sanz (1984) and Sanz (1987) that RP have had a laxative effect when it was used as a feed ingredient in broiler chicken diets. However, the magnitude of response to a certain feedstuff in poultry diets can vary considerably depending upon its chemical composition and level of inclusion, composition and physical nature (i.e. particle size and texture) of the basal diet, type and age of the experimental birds and/or other factors. It is important to note that the current experimental diets were iso-energetic and iso-nitrogenous but had higher contents of EE in the RP-containing diets than did the control diets (Table 1). Such an increase in EE contents might have been enhanced the digestive ability of ducklings fed the RP-containing diets by decreasing the rate of feed passage. On the other hand, there was no explanation for the higher digestibility of CP and EE achieved by ducklings fed on pellets compared with those fed on the mash diets. Nevertheless, some beneficial effect relevant to the heat and mechanical pressure of the pelleting process on nutrients digestibility could not be ruled out.

Carcass yield and components

Data in Table 6 summarize the effects of feeding four levels of RP in mash and pelleted diets and their interactions on the percentages of carcass yield and components of 11-week-old mule ducklings. The statistical analysis of these data proved that dietary treatments had no significant effects on the relative weights of eviscerated carcass, carcass yield, giblets or abdominal fat contents. The absence of significant differences in carcass fat content could be attributed mainly to that the different duckling groups were fed on isocaloric-isonitrogenous experimental diets.

Blood constituents

The effects of feeding RP-based mash and pelleted diets on the concentrations of certain blood plasma constituents of 11-week-old mule ducklings are presented in Table 7. Concentrations of blood plasma glucose, total protein, triglycerides, total cholesterol, calcium and inorganic phosphorus were not affected by the dietary treatments. The insignificant differences among the dietary treatments for all blood constituents, measured herein, may reflect normal metabolic processes and functions of organs and tissues. In keeping with the present result, Sherif (2003) observed no change in levels of blood plasma constituents in broiler chicks fed on RP-containing diets compared with their control group. Generally, means of blood constituents, examined in the present study, fell within the normal physiological range for the growing birds, as published by Ross *et al.* (1978) and Meluzzi *et al.* (1992). Regardless of differences in the dietary treatments, the present results are in good agreement with those found by Chen *et al.* (1994) who reported comparable levels for blood plasma constituents in geese.

CONCLUSION

Based on the obtained results, from the practical and economical point of view, it is concluded that rice polishings can successfully be used in mule duckling pelleted diets (up to 45% of the diet) with no adverse effects on growth performance or carcass traits.

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استخدام مخلف تبييض الأرز في علائق مجروشة أو محببة لتغذية بغال البط

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هدفت هذه الدراسة إلى بحث تأثير تغذية بغال البط (ذكور المسكوفي×اناث المولارد) على علائق مجروشة أو محببة تحتوي مخلف تبييض الأرز على معايير النمو ومعاملات الـهضم ومحصول الذبيحة ومكوناتها و بعض مكونات بلازما الدم. تغذت كتاكيت البط من عمر يوم حتى عمر ٣ أسابيع على علف بادئ تم تكوينه بحيث يحتوي على ٢٢% بروتين خام و٢٩٠٠كيلو كالوري طاقة ممثلة. عند ذلك العمر تم تقسيم الطيور إلى ٨ مجموعات تجريبية بكل منها عدد ٣٠ طائر كما تم تقسيم طيور كل مجموعة إلى ٣ مكررات متساوية وتم ترقيم الطيور في الأرجل ووزنها ثم وضعت في حظائر أرضية مفروشة بنشارة الخشب ومزودة بمعالف وعائية مستديرة، مع مصدر دائم لماء الشرب الطازج النظيف(عبارة عن خط منحدر من الأنابيب المشطوفة على شكل نصف اسطوانة ومتصل بصنبور المياه من ناحية وبفتحة الصرف من الناحية الأخرى). تم تكوين ٨ علائق تجريبية (٤على شكل مجروش ناعم و ٤ على شكل محببات) ذات محتويات متساوية من الطاقة الممثلة (حوالي٣٠٠٠كيلو كالورى) و البروتين الخام (حوالي ١٨%) تحتوي علي مستويات متدرجة من مخلف تبييض الأرز (صفر أو ١٥% أو٣٠ % أو٤٥% من الغذاء). وتم تغذية طيور كل حظيرة على العليقة التجريبية الخاصة بها طوال الفترة التجريبية (من ٣ إلى ١١أسبوعا من العمر). وتمت التربية تحت نظام الإضاءة المستمرة مع توفير الغذاء و الماء للطيور طوال الوقت. تم تسجيل البيانات يوميا عن النفوق و كل أسبوعين عن وزن الجسم و الزيادة اليومية في وزن الجسم و استهلاك العلف و التحويل الغذائي. كما تم حساب الكفاءة الاقتصادية للتغذية. أيضا تم تقدير معاملات هضم العناصر الغذائية في العلائق التجريبية المستخدمة علي الطيور عند عمر عشر أسابيع. عند نهاية التجربة تم إجراء اختبار ذبح و تم اخذ عينات دم لتقدير بعض مكونات بلازما الدم (الجلوكوز-البروتين الكلي-الجليسريدات الثلاثية-الكوليستيرول-الكالسيوم-الفسفور غير العضوي. ويمكن تلخيص النتائج المتحصل عليها للفترة التجريبية الكلية فيما يلي: بصرف النظر عن شكل العليقة المقدمة، نتج عن زيادة مستوي مخلف تبييض الأرز في العليقة من صفر% (عليقة الكنترول) إلي ٤٥% تحسنا معنويا في كل من التحويل الغذائي و الكفاءة الاقتصادية للتغذية و نسبة احتجاز النيتروجين و معاملات هضم البروتين الخام والمستخلص الايثيري للعلائق التجريبية ولم تتأثر باقي القياسات. حققت الطيور المغذاة على المحببات متوسطات أفضل في كل من وزن الجسم والزيادة اليومية في الوزن واستهلاك العلف اليومي ومعامل التحويل الغذائي عن نظائرها المغذاة على العلائق المجروشة وذلك إذا ما صرف النظر عن مستوى مخلف تبييض الأرز في الغذاء ولم تتأثر باقي القياسات. كانت التفاعلات غير معنوية بين مستوى مخلف تبييض الأرز في الغذاء وشكل العليقة بالنسبة إلى كل الصفات المدروسة. لم تكن هناك علاقة بين نسبة النفوق و المعاملات الغذائية. بناءا على النتائج المتحصل عليها نستنتج انه من الناحية العملية والاقتصادية يمكن استخدام مخلف تبييض الأرز بنجاح في العلائق المحببة (بمستوى يصل إلى ٤٥% من الغذاء) لبغال البط دون حدوث تأثيرات سلبية على معايير النمو أو خصائص الذبيحة.