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Relative bioavailability of phosphorus from different inorganic sources in rats

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Abstract
Phosphorus (P) bioavailability from different sources i.e. Dicalcium phosphate (DCP), monosodium phosphate (SP) and Diammonium phosphate (DAP) using adult rats was determined in the present study. Relative bioavailability (RBV) and phosphorus retention using three balanced diets (T1, T2 and T3) were estimated. Initial phosphorus content in rat carcass was 0.912 g. While, the final phosphorus content in all the three groups i.e. T1, T2 and T3 were 1.65, 1.85 and 1.66 g, respectively. Feed efficiency in all the three groups was numerically very close i.e. 0.3, 0.3 and 0.33 in T1, T2 and T3, respectively. Net phosphorus retained in the body of rats during the period of 30 days was 0.744, 0.934 and 0.745 g in T1, T2 and T3 group, respectively. And thus finally relative bioavailability was calculated using initial and final P content which were 93.93% for dicalcium phosphate, 96.88% for monosodium phosphate and 87.03% for diammonium phosphate.

Keywords: bioavailability, dicalcium phosphate, diammonium phosphate and monosodium phosphate

1. Introduction
Diets fed to livestock usually contain a source of inorganic phosphorus, which has a greater availability and digestibility than organic phosphorus from feed ingredients. The inorganic phosphorus, therefore, compensates for the low availability and digestibility of phosphorus in plant feed sources [4]. Mono sodium phosphate (MSP) and Dicalcium phosphate (DCP) is common sources of inorganic P used in the Indian feed industry [4]. Calcium and phosphorus is considered as the major nutrient among macro elements and the found most abundant in the human body [2]. Phosphorus is very important as it plays a vital role in the body from childhood till elderly, and it is involved in many vital functions in the body. It is an essential dietary element to maintain the integrity of skeleton and essential nutrient required in substantial amounts, but many diets are deficient in phosphorus making supplementation necessary or desirable [3].

However, diammonium phosphate is a cheap source of phosphorus and having nearly same phosphorus content then dicalcium phosphate. Other then these two monosodium phosphate is also oftenly used as phosphorus source. The present study was planned to evaluate better source of phosphorus for livestock by testing the relative bioavailability of all the three sources.

2. Materials and Methods
Following work was conducted in the Department of Animal Nutrition, College of Veterinary Science and A.H., N.D.V.S.U., Jabalpur (M.P.). Experiment was conducted for the period of 1 month in the year 2011.

2.1 Materials: Ingredients were added to prepare the purified diets as follows;
Casein, pure cellulose, Sucrose, Corn starch, Corn oil, DL-Methionine, choline chloride, vitamin mixture, mineral mixture.

2.2 Balanced diets preparation: One basal diet was prepared using pure ingredients mentioned above (Table 1). Three different mineral mixtures were prepared with different phosphorus sources (Table 2). Each diet contained 22.5% protein, 5% fat, 50% sucrose, starch 17.5% and 5% cellulose. All dry ingredients with corn oil were weighed and mixed, and then the weight was completed with starch to make 100 g. They were mixed again till they became homogenous and then supplements and mineral mixture was added. Mineral mixture was prepared using all ingredients common and the test minerals were in equal proportion in all diets (in terms of phosphorus content).

Table 1: Basal diet for the experiment

S No.	Ingredients	(%)
1.	Sucrose	50.0
2.	Casein	22.5
3.	Corn starch	17.5
4.	Corn oil	5.0
5.	Cellulose	5.0
		100
	Supplements	
	DL methionine (g)	6.0
	Choline chloride (g)	4.0
	Vitamin Mix (g)	20.0
	Mineral mix (g)	20.0

Table 2: Mineral supplement prepared for the study

Ingredients	T1 (%)	T2 (%)	T3 (%)
Di calcium phosphate	39.770	-	-
Mono Sodium phosphate	-	34.295	-
Di Ammonium phosphate	-	-	37.266
Calcium carbonate	1.590	23.810	23.590
Potassium sulphate	4.375	4.287	4.247
Potassium iodate	0.001	0.001	0.001
Sodium selenite	0.001	0.001	0.001
Cupric chloride	0.016	0.016	0.015
Zinc carbonate	0.127	0.125	0.124
Chromium sulphate	0.040	0.039	0.039
Magnesium oxide	1.989	1.949	1.931
Ferrous sulphate	0.398	0.390	0.386
Potassium citrate	17.502	17.147	16.988
Salt	15.911	-	15.444
Urea	18.298	17.927	-
Total	100.00	100.00	100.00

Experimental animals: 20 adult rats were purchased from the market and after two days adaptation period, these animals were weighed and divided into 4 groups of five animals each with no statistical differences. All groups were housed individually in suspended mesh bottom and front stainless steel hanging cages of 25 X 22 X 20 cm in a controlled condition, between 20 – 25 °C, 12 hours light and dark cycle. They were fed experimental diet diets for 30 days. One group of five rats was sacrificed on day zero to obtain baseline animals tissues and endogenous organs for phosphorus determination. Animals were fed daily, their food intake was increased gradually, deionized distilled water was offered ad libitum. Animals were weighed on weekly basis. At the end of feeding period (30 days) the animals were anesthetized (using chloroform) and kept in deep freeze. When the body freezes down, it was chopped finely including hair, bones, skin and other organs. Chopped carcasses was dried in oven and saved for phosphorus determinations.

Chemical analysis: Moisture and ash were determined according to the methods of [1]. Phosphorus was determined as per the method developed by [8].

2.3 Statistical analysis

Statistical analysis was performed as per the method given by [7].

3. Results and Discussion

The initial body weight of rats in different treatments is shown in Table 3. Average body weights in different groups were 160, 160, 162 and 160 g in initial, T1, T2 and T3 group respectively. Initial slaughter group was sacrificed to analyse the net phosphorus content of carcass before feeding of experimental diets.

Table 3: Initial body weight of the rats in different experimental groups

S. No	Initial	I (DCP)	II (SP)	III (DAP)
1	140	120	120	120
2	140	150	140	140
3	160	150	160	160
4	160	190	190	180
5	200	190	200	200
Avg BW	160±10.95	160±13.41	162±14.96	160±14.14

Dry matter (%), ash (%) and phosphorus (%) is presented in table 4. DM percent of carcass was found to be 33.12% while, ash was 8.64%. Phosphorus content in carcass of initial slaughter group was 0.912 g i.e. 0.57% these values were in agreement with the study conducted by [6]. They analyzed the normal phosphorus content of male and female rats from birth to maturity at different body weights.

Table 4: Dry matter, ash and phosphorus content of initial slaughter group

Gr.	Avg. live wt. (g)	DM (%)	Ash (%)	Phosphorus content (%) in carcass		Net P content of carcass (g)
				% DM basis	% as such basis	
Initial	160	33.12	8.64	1.72	0.57	0.912

Initial and final body weights of rats fed on experimental diets is presented in table 5. Average body weight gain was 80, 98 and 95 g in T1, T2 and T3 group, respectively. The feed efficiency ratio in T1 was 0.30, T2 0.30 and T3 0.33. Final body weights of the rats in T2 and T3 groups were having no significant difference but, both these groups were having significantly (P<0.05) higher body weight then T1. Similar results were obtained for body weight gain. While, in T2 group feed intake was significantly higher than T1 and T3 group.

Table 5: Body weight gain and FER of rats on experimental diet

Trt.	Initial BW (g)	Final BW (g)	BW gain (g)	Avg. Feed intake (g)	FER
T1 (DCP)	160±13.41	240^{b}±10.25	80^{b}±2.55	264.2^{b}±10.46	0.30
T2 (SP)	162±14.96	260^{a}±11.54	98^{a}±3.84	321.4^{a}±10.25	0.30
T3 (DAP)	160±14.14	255^{a}±10.12	95^{a}±3.56	285.6^{b}±11.81	0.33

Phosphorus intake of rats was calculated for the whole period of 30 days (Table 6). Total phosphorus consumed by the rats through feed was 0.792, 0.964 and 0.856 g in T1, T2 and T3 group, respectively.

Table 6: Phosphorus intake of rats in different treatments (30 days)

Group	Avg. Feed intake/rat (g)	% P in diet	Total P consumed (g)
T1 (DCP)	264.2	0.30	0.792
T2(SP)	321.4	0.30	0.964
T3 (DAP)	285.6	0.30	0.856

After slaughter of rats from different treatment their dry matter, ash and phosphorus content was calculated (Table 7). This gives the total phosphorus content deposited in the body of rats in 30 days feeding of different sources of phosphorus. [5] referred that apparent absorption of minerals in rats was higher when consumed at marginal level.

Table 7: Dry matter, ash and phosphorus content of final slaughter groups

Group	% DM of carcass	Ash (%)	Phosphorus content of carcasses		Total phosphorus content of carcass (g)
			(on % DM basis)	(on % as such basis)	
T1	31.25	7.50	2.208	0.69	1.65
T2	33.07	10.47	2.146	0.71	1.85
T3	30.58	8.65	2.125	0.65	1.66

Considering the initial and final phosphorus content of carcasses, net retention was calculated (Table 8). Net phosphorus retention in T1, T2 and T3 group was 0.744, 0.934 and 0.745 g, respectively. Many factors increase fecal phosphorus, such as high content of fat in diet and or the presence of some substances e.g. phytate [9, 10].

Table 8: Net phosphorus retained in treatment groups for the period of 30 days

Group	Initial P content of rat (g)	Final P content of rat (g)	Net P retained (g)
T1	0.912	1.656	0.744
T2	0.912	1.846	0.934
T3	0.912	1.657	0.745

Finally after calculating the net retention relative bioavailability of all the three sources i.e. DCP, mono sodium phosphate and DAP was calculated using total phosphorus consumed and net retention (table 9). Bioavailability of monosodium phosphate was found to be highest among all three i.e. 96.88% followed by dicalcium phosphate 93.93% and lowest was diammonium phosphate 87.03%. Results of bioavailability from all sources were in agreement with [4].

Table 9: Relative bioavailability of phosphorus from different sources

Gr	Avg. Feed intake/rat (g)	Total P Consumed (g)	Initial P content of rat (g)	Final P content of rat (g)	Net P retained (g)	Relative Bioavailability (%)
T1	264.2	0.792	0.912	1.656	0.744	93.93
T2	321.4	0.964	0.912	1.846	0.934	96.88
T3	285.6	0.856	0.912	1.657	0.745	87.03

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