CIX. THE COMPOSITION OF THE CROP MILK OF PIGEONS

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PIGEON squabs are hatched in the undeveloped state but grow very rapidly during the first few days after hatching. During this period they are fed on a special secretion formed in the crop of the parent birds. This secretion, commonly called "pigeon's milk", is a white, slimy, caseous material formed by the desquamation of epithelial cells and may be regarded as an example of a sacrifice of cell structure in the parent for the nutrition of the young. The endocrine control of its formation has been investigated by Riddle *et al.* [1932]. Its general composition and nutritive properties have been studied by Reed *et al.* [1932] and by Dabrovska [1932]. The former workers found the material to contain dry matter 35·7%, with protein 52·7, fat 35·6 and ash 4·5% of the dry matter; Dabrovska found dry matter 23·3%, and protein 57·4, fat 34·2 and ash 6·5% of the dry matter. The material did not contain carbohydrates.

In the present work, the compositions of four samples, pooled from 115 birds (three from 30 birds each, one from 25), have been investigated in detail. The birds had been used for prolactin assays, in which activity was measured by the wet weight of the crop glands. The gland contents were separated and made available for analysis as soon as possible after killing the birds.

Treatment of samples and methods of analysis

The samples were examined for small pieces of broken grain which were removed by hand-picking and the wet samples were weighed. The samples were dried in dishes with intermittent stirring, first at 60° and finally at 100°, and the weight of dry matter was determined. The powdered material was exhaustively extracted in a Soxhlet extraction apparatus for 18 hr. with light petroleum (B.P. below 40°) and the solvent-free fat determined and used for analysis.

The residue was further extracted with a boiling mixture of 3 parts ethyl alcohol and 1 part benzene for 12 hr. and the solvent-free extract was weighed and used for analysis.

The dried residue was used for the proximate and detailed analysis of organic constituents and ash. No further purification of the residue was carried out before acid hydrolysis of the protein to determine the Hausmann nitrogen distribution, since the material contained 15% of nitrogen on a moisture and ash-free basis. The values of the humin nitrogen in all cases were satisfactorily low.

Ash constituents. The phosphorus and metallic radicles were determined on the ash by the usual standard methods, but chloride was determined on the original material by the open-Carius method, all results being calculated on the basis of the dry matter of the secretion. The compositions of the four samples are given in Table I.

Protein. The protein-rich, fat-free residues were hydrolysed (1 g. portions) with 20% HCl in an autoclave at 130° and the distribution of nitrogen in three groups was determined. The results are given in Table II.

Table I. *Proximate composition and detailed analysis of crop milk of pigeons*

Sample no.	I	II	III	IV	Lactose-free dried milk
No. of birds	30	25	30	30	—
Yield of wet material g.	37·7	10·6	29·4	43·4	—
Yield of dry material g.	10·54	5·61	8·49	12·35	—
Dry matter per bird g.	0·35	0·22	0·28	0·41	—
Dry matter %	27·9	53·1*	29·1	28·5	—
% of dry matter:					
Total lipoids	33·4	32·7	32·6	36·3	46·4
Ether-sol. lipoids	28·4	27·7	27·7	31·1	—
EtOH-C_6H_6-sol. lipoids	5·0	5·0	4·9	5·2	—
Nitrogen	9·38	9·47	9·54	9·10	—
Protein (N × 6·25)	58·6	59·2	59·6	56·9	42·9
Ash	4·81	4·45	4·41	4·76	10·7
Calcium	0·261	0·313	0·276	0·362	1·79
Potassium	0·976	0·957	1·022	1·028	2·00
Sodium	0·311	0·340	0·306	0·294	1·14
Phosphorus	0·987	1·039	1·009	1·037	1·43
Chloride	0·055	0·066	0·052	0·059	1·43
Starch	3·23	5·21	3·59	3·57	—
True protein as % of total protein	93·4	95·7	92·7	94·9	94·0
Total accounted for	99·0	101·6	100·2	101·5	—
Ca/P (atom. equiv.)	3·8	3·3	3·7	2·9	1·0

* Sample was partly dried before analysis.

Table II. *Analysis of protein of pigeon crop milk. Nitrogen distribution*

Sample no.	I	II	III	IV	
Protein in dry matter (N × 6·25) %	58·6	59·2	59·6	56·9	—
Nitrogen in ash- and fat-free dry matter %	14·78	14·74	15·15	15·33	—
% of total N:					Chicken muscle
Amide-N	9·2	7·7	7·8	6·6	7·5
Diamino-N	31·2	29·3	33·6	32·5	30·0
Monoamino-N	55·9	59·0	55·7	56·8	59·8
Humin-N	3·7	4·0	2·9	4·1	2·7

Table III. *Analysis of lipoid extracts of pigeon crop milk*

Sample no.	I	II	III	IV
Total fat in wet matter %	12·0	—	11·2	12·7
Total fat in dry matter %	33·4	32·7	32·6	36·3
Light petroleum-extractable %	28·4	27·7	27·7	31·1
EtOH-C_6H_6-extractable %	5·0	5·0	4·9	5·2
Light petroleum extract:				
Refractive index (40°)	1·4642	1·4641	1·4642	1·4641
Saponification no.	181	180	181	182
Iodine value (Wijs)	60·5	60·3	62·4	61·3
Hehner number	93·5	92·8	93·8	93·0
Iodine value (fatty acids)	62·3	61·6	63·6	64·8
Phosphorus %	0·337	0·271	0·329	0·251
Nitrogen %	0·160	0·130	0·149	0·119
P/N (atomic)	0·95	0·94	1·00	0·95
Lecithin in extract %	8·7	7·0	8·5	6·5
EtOH-C_6H_6 extract:				
Iodine value (fatty acids)	76·8	79·4	79·3	80·2
Hehner number	69·2	68·4	69·1	66·8
Phosphorus %	1·66	1·79	1·61	1·93
Lecithin in extract %	43·0	46·4	41·7	50·0

Lipoids. The largest yields of fatty material were obtained by the light petroleum extraction and these fractions were examined in detail for the characteristics of the fat. The examination of the second extraction with alcohol-benzene was carried out as far as the weight of extract permitted. Both samples were found to contain lecithin, the second being richer in it than the first. The amounts of lecithin were determined from the phosphorus contents of the fractions and the P/N ratio was determined in all samples. The analyses of the two lipoid fractions are given in Table III.

Food residues from the crop. The presence of traces of food taken in by the parent birds was suspected in the samples. A microscopic examination of the dry matter after staining with aqueous I-KI revealed the presence of starch granules in all samples. The starch was determined by alcoholic precipitation after digestion with alcoholic KOH, hydrolysis with dilute HCl and oxidation with alkaline iodine. The values found varied from 3 to 5% and are given in Table I.

Discussion of results

The dry matter content of the secretion, except for the dried sample, averaged 28·5%, which is between the values given by other workers. The yield of dry matter per bird was very variable, namely, from 0·22 to 0·41 g.

The protein in the samples, at the degree of purification reached, contained from 14·8 to 15·3% of nitrogen. This value is somewhat low owing to the presence of starch. The average N content on a moisture-, ash- and starch-free basis, was 15·6%. Acid hydrolysis showed that the protein was in a fairly pure condition since the humin nitrogen did not exceed 4%.

The nitrogen distribution showed that the protein resembled closely chicken muscle protein. The content of diamino-acids was relatively low and that of the monoamino-acids consequently high. The composition of the protein, derived as it is from tissue protein, thus conformed more closely to that of muscle protein than to that of either egg albumin or blood serum proteins. The protein fraction contained roughly 6% of nitrogen in a non-protein form, or roughly the same amount as in blood serum and cow's milk. The composition of this fraction is probably the same as the "residual" fraction of blood and of other secretions.

The composition of the fat is unique in that it contains considerable quantities of lecithin. Some lecithin was directly extractable from the samples by light petroleum at 40° and a subsequent fraction extracted with an alcohol-benzene mixture was richer in lecithin. This pointed to the presence of lecithin in loose combination with protein in the material, namely, as a lecitho-protein. The behaviour of the lecithin during extraction was similar to that of the lecitho-protein of the protein residue obtained by Rewald [1939] from the extraction of butter fat from butter, in which the lecithin could be removed from protein combination by prolonged extraction with a hot alcohol-benzene mixture. The light petroleum extract contained on the average 7·7% of lecithin calculated from the phosphorus content of the extract, while the alcohol-benzene extract contained 45·3% of lecithin. Acetone precipitated the lecithin in the latter but not in the former fraction. The N/P ratio in the larger fraction was 0·96.

The fat on analysis yielded neither volatile fatty acids nor those of low molecular weight. The iodine value of the fats was 60·3–62·4, and of the fatty acids 61·6–64·8. The fat was of the same degree of unsaturation as goose-fat (58–62) but more saturated than hen fats (79–80) [cf. Hilditch *et al.* 1934]. The fatty acids of the alcohol-benzene fraction, however, showed a higher iodine value (77–80), which for a stearo-oleo-lecithin means 88% of oleic acid in the

fatty acid fraction. The Hehner number for lecithin is 70·5, but the values found for the second fraction were 67–69, which are considered low owing to loss during hydrolysis. The small amount of scum containing solid particles, which usually forms during the ether extraction of acidified, saponified extracts containing lecithin, formed in these cases also and was judged to contribute to the low values obtained for the Hehner number. The petroleum ether extracts behaved normally in this determination, and gave Hehner values comparable with those usually obtained for pure fats.

The mineral matter was characterized by its high K and P contents, medium Ca and low Na and Cl contents. The bulk of the ash consisted of potassium phosphate, as was shown by the readiness with which it fused. P/Ca ratios (atomic equivalents) were 3 or 4 : 1. Appreciable amounts of the P were present in the dried material in forms other than inorganic. Dilute acetic acid extracted only 60–70 % of the P in 16 hr., while a cold digestion for 16 hr. with 0·25 *N* KOH extracted only 64–73 %. There was no evidence of a phospho-protein present in the secretion.

Generally, the scheme of nutrition provided by the crop secretion favours muscular development, increase in blood volume and bone development. The scheme closely resembles that functioning in the egg before hatching, in that the secretion is devoid of carbohydrates, rich in fat, lecithin, P, K and protein, comparatively rich in Na and Ca and poor in chloride. The secretion bears some resemblance in composition to that of lactose-free dried cow's milk.

Summary

Four samples of crop milk from 115 birds have been investigated in detail. The samples contained 28 % dry matter, with 33·8 % fat, 58·6 % protein, 4·6 % ash and 3·9 % starch (from an extraneous source) in the dry matter. The protein contained 94 % true protein; its nitrogen distribution resembled that of chicken muscle more closely than that of egg or serum proteins.

A light petroleum extract contained 7·7 %, and a subsequent alcohol-benzene extract 45·3 %, of lecithin, and it appeared as if the lecithin were in loose combination with the protein as lecitho-protein.

The ash was rich in K, Na, Ca and P, and about 30–40 % of the P was in organic combination. The secretion was poor in chloride.

The type of food furnished by the crop secretion is very similar to that provided by the egg before hatching.

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