THE INFLUENCE OF FORCE FEEDING AND OF PROTEIN SUPPLEMENTATION TO THE DIET ON THE METABOLISABLE ENERGY OF DIETS, DIGESTIBILITY OF NUTRIENTS, NITROGEN RETENTION AND DIGESTIVE ENZYMES OUTPUT IN GEESE

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SUMMARY

In two balance experiments the effect of cooking corn, force feeding, and soya-bean meal supplementation on feed utilization, were investigated in geese. The process of cooking did not improve the metabolizable energy of the diet. The excess of food introduced into the gastrointestinal tract by force feeding was digested normally, and efficiently utilized when it attained up to 3-4 times the maintenance level. When higher amounts were force-fed, a 10 p. 100 reduction in the apparent digestibility of dry matter and a 7 p. 100 reduction in the metabolizable energy were noted. Force feeding caused steatorrhoea and inhibited fat absorption almost completely. The retention of the corn protein was quite low and decreased to negative values in the course of force feeding. Force feeding was accompanied by a gradual increase in the water released in excreta, up to 25-fold the amount excreted by the *ad lib.*-fed geese. The trypsin and chymotrypsin output in excreta were correlated with the feed intake. Amylase output in excreta was not parallel to feed intake and was even reduced by surfeit feeding. Supplementation of the force-fed corn diet with soya-bean meal, improved the crude protein digestibility and retention ; it also caused a more pronounced increase in the amylase level than in the proteolytic enzymes.

INTRODUCTION

Force feeding of geese with cooked corn is common practice in the production of enlarged fatty livers used in the preparation of « pâté de foie gras ». Excessive food intake in chickens can be caused by hypothalamic lesions (LEPKOVSKY and YASUDA,

1966) or achieved by force feeding (LEPKOVSKY and FURUTA, 1971). In such chickens, the introduction of excessive amounts of food into the gastrointestinal tract has apparently little effect on its digestion and utilization, as shown by gains in weight and body fat (NIR and PEREK, 1971). In the force-fed goose there is an increase of 80-100 p. 100 in its initial body weight, during a 4-week surfeit feeding. The increase in body weight is mostly fat, and the livers become enlarged and steatic. At the end of the force feeding, the emptying of the œsophagi is slowed down and shortly afterwards the passage is completely interrupted (NIR and PEREK, 1971 ; NIR and PEREK, 1972). Addition of soya-bean meal to the cooked corn force-fed diet caused a faster emptying of the œsophagi, increased the fatty liver weight and shortened the period required for fattening (NIR and PEREK, 1972).

The objective of this study was to secure information on the effects of (*a*) excessive amounts of food in the gastrointestinal tract of the goose on the absorption of nutrients and their relationship to the secretion of some digestive enzymes ; (*b*) protein supplementation of the corn diet ; and (*c*) cooking the corn, on the above parameters.

MATERIALS AND METHODS

Animals

Twelve-week-old geese of a local breed (NIR and PEREK, 1971) were used in these experiments. At the start of the experiments they weighed between 3.5 and 4 kg.

Experiment 1

Four geese were introduced into individual metabolic cages. During the first week (preparatory period) they received the test diet — raw yellow corn (R) supplemented with vitamins (1) — and 0.3 p. 100 sodium chloride. Following the preparatory period plastic bags were tied beneath each cage. Because the excreta was acidic during the experiments, no acid was added to the bags in order to prevent ammonia escape. The excreta were removed daily, weighed and frozen (— 22°C) for five consecutive days. The birds were then removed from the cages to the floor for a 10-day recovery period. During this period they received 16 p. 100 protein pelleted feed. The same procedure was repeated with cooked corn (C). Cooking was proceded by boiling 1.25 kg corn in 1 l water for 20 minutes. Using this ratio, all the water was absorbed by the kernels. The oven-dried feed consumption was recorded daily by determining the dry matter (100°C/24 h) on samples of the feed given and on the remaining feed in the feeders.

Experiment 2

Twenty geese, randomly divided into two equal groups, were weighed and placed in metabolic cages. One group was force-fed the cooked corn diet (C) supplemented with 1 p. 100 soya-bean oil (FC) and the other received the same diet with added 10 p. 100 soya-bean meal (air-dry basis) enriched with 0.26 p. 100 DL-methionine (FCS). The composition of the diets is shown in table 1.

During the experimental period the geese were force-fed increasing amounts of feed, starting with about 200 g/day (oven-dried), up to 700 g/day. For a period of 11 days all the geese were force-fed twice daily (8 a.m. and 8 p.m.) ; during the subsequent 9-day period, four times daily (6 a.m., 12 noon, 8 p.m. and 12 midnight) ; thereafter, reduced amounts were given, because of

(1) Added to supply per kg air-dry feed : Vit. A, 9 000 IU ; D, 900 IU ; E, 1.2 mg ; K, 1.2 mg ; pantothenic acid, 3.3 mg ; riboflavin, 1.5 mg ; niacin, 6 mg ; pyridoxine, 1.8 mg ; choline chloride, 0.9 g ; and B_{12}, 3 µg.

the slower œsophagi emptying, two, three or four times daily according to the capacity of the individual animal. Feed intake was calculated by weighing the cramming funnel before and after force-feeding. Dry matter in the feed was determined on aliquots of each meal in an oven at 100°C/24 h. For convenience we refer in the text to three periods as described in figure 1.

TABLE I

Composition of diets used in experiments 1 and 2 (oven dry)

Composition des régimes utilisés dans les expériences 1 et 2

	Gross energy (cal/g)	Nitrogen (%)	Ether extract (%)	Phosphorus (%)
Experiment 1 :				
Raw (R) or cooked (C) corn	4 550	1.55	4.73	0.35
Experiment 2 :				
Cooked corn (FC) + 1 % soya-oil ...	4 630	1.54	5.59	0.35
Cooked corn + 10 % soya-bean meal (FCS) + 1 % soya-oil	4 620	2.05	5.22	0.37

The excreta were collected daily at 6 a.m. (before the first meal) for two consecutive days at each period. Collection was carried out only when it was ascertained that the œsophagus was empty ; otherwise the excreta were discarded. Because of these eliminations and also because of other technical failures, four geese were discarded from each group.

Care of excreta

The individual bags were thawed and pooled for each bird in exp. 1 and for each bird and period in exp. 2. They were homogenized in a Waring Blendor and aliquots of approximately 50 g were transferred to plastic containers. Triplicate samples were dried in a freeze-drying apparatus. Dry matter was determined when the lyophylizing process was completed. The triplicates were then pooled and ground in a Moulinex-type (MCV 1H) coffee mill. The dry material was equilibrated with atmospheric moisture before chemical analyses.

Ammonia, sugar, Na and K were determined on excreta filtrate (Whatman n° 1), fatty acids on whole excreta homogenate, and all the other tests were carried out on the lyophylized excreta powder.

Chemical methods

All analyses were carried out on duplicates or triplicates : total N according to the Kjeldahl semi-micro method ; ammonia by the phenol hypochlorite reaction (Tech. Autoanalyzer Meth. Industrial Meth. 18-69 W.) ; total phosphorus on samples digested with H_2SO_4 according to the Tech. Auto. Meth.-Industrial Meth. 4-68 W, with the Technicon autoanalyzer Model 9. pH was determined on the homogenized fresh samples at room temperature with the Beckman Zeromatic II pH meter. Fat was determined by continuous extraction with anhydrous ether for 12 h ; the lipid residue was dried *in vacuo* and weighed. Uric acid was determined according to TINSLEY and NOWAKOWSKI (1957). Cholesterol was determined on about 50-mg samples extracted with 10 ml chloroform : methanol 2 : 1, 1 ml of the filtered extract was evaporated *in vacuo* and saponified in 2 ml of ethanolic KOH solution according to ABBEL *et al.* (1952). The color reaction for the measurement of cholesterol was carried out with the ferrous sulfate reagent according to SEARCY and BERGQUIST (1960). Ashes were determined following incineration at 650°C for 3 h ; glucose on duplicates of 0.1 ml excreta filtrate by the glucose oxydase method with the Biochemica Test Combination (C. F. Bœhringer and Sœhne GMBH, Mannheim, Germany) ; and Na and

K on the excreta filtrate diluted with distilled water (20-200 times) with a flame photometer (Evans Electroselenium Ltd., Halstead Essex, England. Reg. Dis. n° 866150). Energy was determined on pelleted samples with a Balistic Bomb Calorimeter (Gallenkamp, England). Dry matter was determined on parallel pellets (100°C/24 h) in order to ascertain its caloric value. For fatty acids determination, 2 g fresh excreta homogenate was saponified with 20 ml ethanolic KOH (10 w/V) on a water bath, and then extracted twice with 30 ml petrol ether. The fatty acids were removed by petrol ether extraction after acidification. The methyl esters were prepared by refluxing with 20 ml, sulfuric acid in methanol 3 p. 100 (V/V) and 1 ml benzene for 1 h and extracted with petrol ether. The methyl esters were examined by gas liquid chromatography (Packard Gas Chromatograph 7 600 series), using a glass column 244 cm × 0.32 cm packed with 15 p. 100 diethylene-glycol succinate polyester (Applied Science Lab., Inc.).

Digestive enzymes determination was performed on the lyophylized excreta powder, which was redissolved with distilled water (about 30 mg/ml). The trypsin, chymotrypsin and amylase were determined as described by GERTLER and NITSAN (1970). The definition of the trypsin and chymotrypsin units are : 1 µmole substrates (tossyl-arginine methylester for trypsin and N-acetyl-L-tyrosine ethylester for chymotrypsin) hydrolyzed for 1 mn at pH 8.0, 30°C ; for amylase, increase in the reaction colour, 10^2E at 550, 12.7 mm light path, during 3 mn at pH 6.9, 37°C.

Statistical analysis

The data in each experiment were subjected to analysis of variance according to COCHRAN and COX (1957), with separation of means by Duncan's multiple range test (DUNCAN, 1955).

RESULTS

Feed intake, body, liver and abdominal adipose tissue weights

The average daily feed consumption under *ad lib.* feeding (exp. 1) of raw (R) or cooked (C) corn was 125.8 ± 8.0 and 116.1 ± 7.6 respectively during the experimental periods. No change in body weight was noted during the twelve days of R

TABLE 2

Feed intake, and body, liver and abdominal adipose tissue weights of geese force-fed cooked corn (FC) *or cooked corn supplemented with soya-bean meal* (FCS) (6 geese per treatment)

Quantité de nourriture et poids du corps, du foie et du tissu adipeux abdominal, chez des Oies gavées au maïs cuit (FC) *ou au maïs cuit supplémenté en farine de soja* (FCS) (6 Oies par lot)

Variable	FC	FCS	SE
Initial body weight (g)	3 475	3 558	69
Final body weight (g)	6 318	6 216	190
Body gain (g)	2 843	2 658	176
Feed intake, oven dry (g)	11 760	10 962*	212
Feed/gain ratio	4.34	4.28	0.28
Liver weight (% of body weight)	7.70	8.03	0.63
Abdominal adipose tissue (% of body weight)	5.05	5.30	0.18

* Statistically significant difference between treatments P < 0.05.

or C treatments : 4 005 ± 52 g at the start and 4 072 ± 68 g at the end of the R experimental period, and 4 060 ± 49 g at the start and 4 048 ± 66 g at the end of the C period. It seems, therefore that 120 g of corn daily was the maintenance requirement during the experimental periods. In experiment 2, force feeding increased

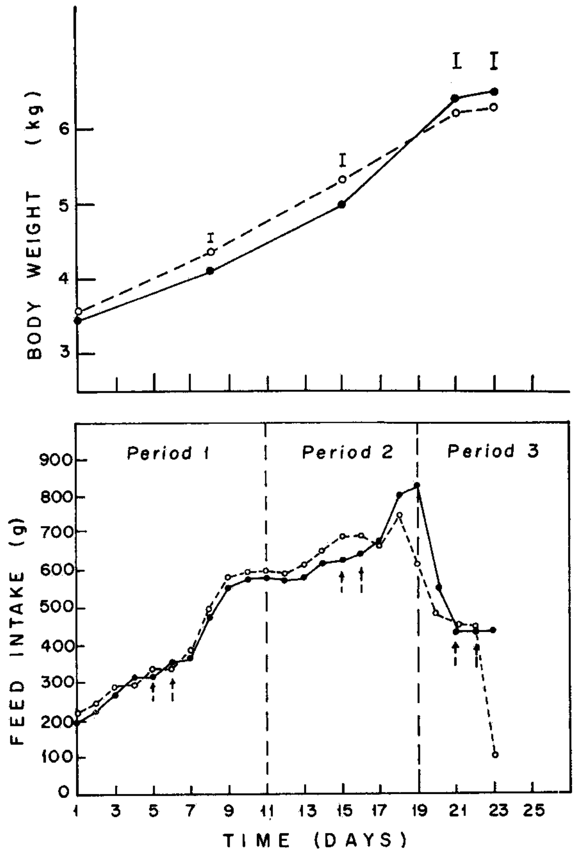

FIG. 1. — *Feed intake and body weight of the geese force fed* (exp. 2) *with cooked corn* (●——●) *or with cooked corn supplemented with soya-bean meal* (○----○)

Arrows indicate days of excreta collection. I± SE of the mean

Period 1 : Increasing feeding plane : 200 up to 700 g feed/day ; collection of excreta on days 5 and 6.
Period 2 : High feeding plane : about 700-800 g feed/day ; collection of excreta on days 15 and 16.
Period 3 : Reduced feeding plane because of reduction in the rate of clearance from the œsophagi ; collection of excreta on days 21 and 22.

FIG. 1. — *Nourriture ingérée et poids du corps d'oies gavées* (exp. 2) *avec du maïs cuit* (●——●) *ou du maïs cuit supplémenté en farine de soja* (○----○)

Les flèches indiquent les jours de collecte des excreta
Période 1 : Début du gavage. On passe de 200 à 700 g de nourriture/jour.
Période 2 : Gavage, 700 à 800 g de nourriture/jour.
Période 3 : Réduction du gavage à cause d'une réduction dans le taux de clearance de l'œsophage.

gradually the food consumption up to five times the maintenance level, followed by a marked reduction (fig. 1). This decrease was caused by the reduction in the rate of clearance from the upper digestive tract and occurred two days earlier in the soya-bean meal supplemented group (FCS) as compared with the corn force-fed group

(FC). This earlier reduction caused a decrease of 800 g in the total feed consumption of the FCS compared with FC group (tabl. 2). In spite of the lower total feed consumption, no significant differences were found in body gain (about 80 p. 100 of the initial weight), fatty livers and abdominal adipose tissue weights (tabl. 2).

Chemical composition of excreta

The chemical composition of excreta is shown in table 3. The pH was not affected by cooking the corn in the *ad lib.*-fed groups. Force feeding caused a marked reduction in the pH of the FC group, from 6.1 in period 1 to 4.4 in period 2 and 4.6

TABLE 3

Composition of excreta in experiments 1 and 2

Composition des excreta dans les expériences 1 et 2

	Experiment 1			Experiment 2						
	Fed *ad libitum* raw (R) or cooked (C) corn			Force-fed cooked corn (FC) or with soya-bean meal (FCS)						
			SE. T (1)		Period 1	Period 2	Period 3	X	SE. P (2)	SE. T (1)
Total N (%)	R C	7.29 6.85	0.09*	FC FCS	5.86 7.12	5.22 6.77	6.53 7.84	5.87 7.24	0.3	0.3**
Uric acid N (%)	R C	4.75 5.42	0.3	FC FCS	3.22 4.62	3.19 4.78	3.67 5.45	3.36 4.95	0.03	0.03**
Ammonia N (%)	R C	0.93 0.83	0.09	FC FCS	1.32 1.73	0.54 0.61	0.49 1.00	0.78 1.11	0.09**	0.07**
Ether extract (%)	R C	8.4 8.2	0.77	FC FCS	14.9 11.7	17.7 12.2	23.6 24.8	18.7 16.2	2.3*	1.9
Cholesterol (mg/g)	R C	6.6 5.8	0.24	FC FCS	6.7 5.8	6.2 5.1	5.7 6.0	6.2 5.6	0.19	0.15*
Gross energy (cal/g)	R C	4 033 4 129	48.3	FC FCS	4 176 3 925	3 977 3 949	4 226 3 975	4 126 3 950	49.7	40.6*
Ash (%)	R C	8.6 8.0	0.17	FC FCS	9.3 10.4	6.7 7.8	6.8 7.9	7.6 8.7	0.20**	0.17**
Total phosphorus (%)	R C	1.33 1.03	0.07	FC FCS	1.22 1.19	0.79 0.86	0.86 0.99	0.95 1.01	0.05*	0.04
pH in fresh excreta	R C	6.0 6.2	0.06	FC FCS	6.1 6.1	4.4 4.8	4.6 5.1	5.1 5.3	0.13**	0.11

(1) SE. T : SE of Treatment and statistical significance.
(2) SE. P : SE of Periods and statistical significance.
* Statistically significant degree $P < 0.05$.
** $P < 0.01$ between treatments or periods.

in period 3. Addition of soya-bean meal to the diet reduced the acidity consistently but not to a statistically significant degree. Force feeding caused a very sharp increase of ether extract in the excreta, which reached about 24 p. 100 in period 3. The cholesterol, however, remained low and stable throughout the experimental periods. This finding indicates that the fat extracted was not from endogenous origin. Its fatty acids pattern was quite similar to that of corn oil, which constituted the major part of the fat consumed (tabl. 4).

TABLE 4

Fatty acids composition of the excreta's lipid extract

Composition en acides gras de l'extrait lipidique des excreta

Source of fatty acids	Period	Fatty acids (% of total)				
		16 : 0	18 : 0	18 : 1	18 : 2	18 : 3
Excreta from geese						
Ad libitum fed with cooked corn						
Goose No. 2		15.6	0.8	24.1	61.1	0.4
Goose No. 4		10.0	0.6	24.6	63.5	1.2
Force fed with cooked corn Goose No. 6	1	13.2	0.1	25.4	60.7	0.6
	2	12.0	0.7	24.8	60.1	2.4
	3	13.7	2.5	31.2	52.1	0.5
Force fed with cooked corn supplemented with 10 % soya-bean meal Goose No. 18	1	12.2	1.6	23.7	60.8	1.8
	2	12.3	1.6	27.9	57.6	0.6
	3	16.0	0.6	18.2	64.1	1.0
Corn oil (1)		12.0	2.7	30.1	54.7	1.4
Soya-bean oil (1)		11.5	4.3	27.3	49.7	6.9
Liver triglycerides (2)		27.8	16.4	43.2	1.8	
Reserve fat triglycerides (2)		25.8	7.0	45.2	11.8	

(1) According to SCOTT *et al.* (1969).
(2) According to LECLERCQ *et al.* (1968), determined on geese force fed with cooked corn.

In the force-fed groups, supplementation of the corn diet with soya-bean meal caused an increase in the ash and nitrogen, a reduction in the energy content and a reduction in the cholesterol concentration of the excreta (tabl. 3).

Dry matter retention and metabolizable energy

Dry matter retention and metabolizable energy (ME) were highly correlated in both experiments ($r = .936$ in exp. 1 and $r = .965$ in exp. 2). Cooking the corn reduced both dry matter retention and ME of the *ad lib.*-fed geese by about 10 p. 100 (tabl. 5). Force feeding caused a substantial reduction of about 10 p. 100 in dry matter retention and ME of the diets in period 2 only, when the highest amounts of feed were force fed. In period 3, with decreased amounts of feed consumption, the dry matter retention and ME increased again and approached the period 1 values. The addition of soya-bean meal to the corn caused a slight improvement in the ME of the force-fed diets (statistically significant). Correction of the ME value for nitrogen balance, as suggested by HILL and ANDERSON (1958) abolished the effect caused by cooking and reduced the improvements caused by soya-bean meal supplementation.

Fat retention

When the geese were fed *ad lib.*, the fat retention was 69.4 p. 100 for the raw corn and 55.7 p. 100 for the cooked corn (tabl. 5) ; the difference was not statistically significant. Force feeding caused a marked inhibition in fat retention, which was even negative in some individuals during period 3. Addition of soya-bean meal to the force-fed diet postponed the inhibitory effect of force feeding on fat retention.

Phosphorus retention

Cooking force feeding or addition of soya-bean meal to the force-fed diet had no effect on phosphorus retention, which was found to be about 1/3 of the intake (tabl. 5). Calcium retention could not be determined because of its relatively high concentration in the tap water, the consumption of which was not measured.

Nitrogen retention and digestibility

When the geese were fed raw corn, the N retention of the *ad lib.*-fed geese was positive and attained 18 p. 100 of the N intake (tabl. 5). When fed cooked corn two weeks later, the same geese showed a negative N balance (— 12.3 p. 100 retention). This negative balance was not caused by a reduced digestion but by an increased uric acid excretion (tabl. 5). N retention was positive during the first period of force feeding with corn (22.3 p. 100 of N intake), but was markedly reduced thereafter and became negative during periods 2 and 3. Addition of soya-bean meal to the force-fed diet alleviated the negative effect of force feeding on nitrogen retention, in spite of the higher N intake. The improvement caused by the soya-bean meal was due mostly to better digestibility (calculated) of the crude protein (86.3 p. 100 *versus* 71.5 p. 100). The excreted uric acid N, as p. 100 of N intake, was quite similar in the force-fed groups. The better N retention by the FCS group caused an average daily deposition of 1.36 g N, as compared with an average daily loss of — .57 g in the FC group.

Trypsin, chymotrypsin and amylase discharged in the excreta

The concentrations of trypsin and chymotrypsin in excreta were not affected by cooking, force feeding, or soya-bean supplementation to the force-fed diet (tabl. 6). Their total amount excreted was correlated to a statistically significant degree to the feed consumption level. In experiment 1 the correlation coefficient was

TABLE 5. — *Effect of cooking, force feeding and soya-bean meal supplementation, on averages of digestibility, metabolizable energy, nitrogen, fat, phosphorus retention, and uric acid excretion*

Effet de la cuisson, du gavage et de la supplémentation en farine de soja sur la digestibilité, l'énergie métabolisable, l'azote, les graisses, la rétention de phosphore et l'excrétion d'acide urique

	Experiment 1			Experiment 2						
			SE. T (1)		Period 1	Period 2	Period 3	X	SE. P (2)	SE. T (1)
Feed intake (g/day)	R C	125.8 116.1	7.8	FC FCS	365.3 370.0	656.9 687.2	426.8 435.7	483.0 497.6	15.4**	12.6
Dry excreta (g/day)	R C	22.4 29.5	1.3	FC FCS	74.8 76.8	199.0 203.2	109.2 93.5	127.7 124.5	5.3**	4.4
Dry matter retention (% ingested dry matter)	R C	82.6 74.6	1.10*	FC FCS	79.5 79.2	69.9 70.4	73.6 78.3	74.3 76.0	.84**	.68
Nitrogen retention (% ingested N)	R C	18.0 — 12.3	6.4*	FC FCS	22.3 27.8	— 1.2 2 3	— 9.7 16.9	3.7 15.7	3.9**	3.2*
(g/day)	R C	.34 — .20	.12*	FC FCS	1.28 2.14	— .78 .35	— .15 .35	— .57 1.36	.48*	.39*
Uric acid N (% ingested N)	R C	53.8 88.7	5.5*	FC FCS	43.8 47.0	62.3 69.0	60.3 58.9	55.5 58.3	4.1*	3.4
Calculated N digestibility (3) (% crude protein)	R C	82.2 90.2	3.1	FC FCS	83.4 92.2	71.8 80.3	59.2 86.4	71.5 86.3	3.6*	2.9**
Ether extract retention (% ingested)	R C	69.4 55.7	3.5	FC FCS	44.8 53.3	4.9 31.3	— 19.4 .6	10.1 28.4	11.9*	9.7
Metabolizable energy (% gross energy) (*a*) Uncorrected	R C	84.6 77.0	.96*	FC FCS	81.4 82.3	74.1 74.7	76.0 81.4	77.2 79.5	.89**	.73*
(*b*) Corrected (4)	R C	80.0 81.3	.93	FC FCS	80.8 81.3	74.1 74.6	76.3 80.8	77.1 78.9	.89**	.73
Phosphorus retention (% ingested)	R C	33.9 24.6	7.0	FC FCS	29.4 33.4	32.9 31.1	36.9 41.9	33.0 35.5	2.6	2.1

See footnotes to table 3.

(3) $= \frac{\text{N intake} - (\text{N excreted} - (\text{Uric acid N} + \text{Ammonia N}))}{\text{N intake}} \times 100.$

(4) Corrected according to HILL and ANDERSON (1958).

$r = .690$ for trypsin and $r = .902$ for chymotrypsin. In exp. 2 the values were $r = .655$ and $r = .701$, respectively.

The amylase activity was not affected by cooking in the *ad lib.*-fed geese and its total release was also correlated to food intake ($r = .765$). Force feeding with corn caused a drastic reduction in the amylase concentration in the excreta. During

TABLE 6

Concentration and total daily output of digestive enzymes in dry excreta of geese fed ad libitum *or force fed with corn or corn supplemented with soya-bean meal*

Concentration et excrétion journalière totale des enzymes digestifs dans les excreta secs d'Oies nourries ad libitum *ou gavées avec du maïs ou du maïs supplémenté avec de la farine de soja*

	Experiment 1			Experiment 2						
			SE. T (1)		Period 1	Period 2	Period 3	X̄	SE. P (2)	SE. T (1)
Trypsin										
(u/g)	R C	64.1 65.2	10.6	FC FCS	49.3 67.1	40.1 78.9	87.9 77.2	59.1 74.4	7.9	6.5
(u/day)	R C	1 507 1 823	283	FC FCS	3 599 5 166	7 761 16 389	9 622 7 468	6 994 9 674	1 358**	1 358
Chymotrypsin										
(u/g)	R C	63.8 51.0	11.0	FC FCS	31.2 47.4	45.2 64.2	84.8 71.3	53.7 60.9	8.2*	6.7
(u/day)	R C	1 625 1 476	301	FC FCS	2 357 3 682	8 619 13 212	9 147 7 070	6 708 7 988	1 060**	857
Amylase										
(u/g)	R C	431 517	143	FC FCS	131 75	157 330	19 298	102 234	27*	22*
(u/day)	R C	11 595 14 950	3 623	FC FCS	10 269 5 826	29 477 65 524	1 983 28 981	13 909 33 444	5 466**	4 463*

(1) SE. T : SE of Treatment and statistical significance.
(2) SE. P : SE of Periods and statistical significance.
* Statistically significant degree $P < 0.05$.
** $P < 0.01$ between treatments or periods.

period 3, the total output of amylase was markedly reduced and reached a lower value than in the *ad lib.*-fed geese although their feed intake was still 31/2 times higher than the *ad lib.*-fed group. Supplementation of the corn diet with soya-bean meal highly increased the amylase concentration and its total output in excreta.

Water excreted and concentrations of glucose, K and Na in excreta filtrates

The *ad lib.*-fed geese excreted daily an average of 190 g water in the excreta. Force feeding increased this amount gradually up to 25-fold (tabl. 7). Some geese excreted daily up to 10 kg water. The K and Na concentrations in excreta filtrates of *ad lib.*-fed geese were not affected by cooking the corn. Force feeding caused a temporary increase followed by a gradual decrease in K and Na concentrations. Addition of soya-meal to the force-fed diet increased the K concentration in excreta filtrate. This was most certainly due to the higher level of K in soya-bean meal than in corn. The glucose concentration in excreta filtrates was quite low in the *ad lib.*-fed geese and was not affected by cooking (tabl. 7). Force feeding markedly increased the glucose concentration and daily total output mainly in period 2. The latter was found to be correlated to the average daily feed intake ($r = .746$). Addition of soya-bean meal to the corn caused a consistent decrease in glucose excretion (not significant).

TABLE 7

Daily excretion of water, and concentrations of sodium potassium and glucose in excreta filtrate of ad libitum-*fed geese and of geese force fed with cooked corn alone or with cooked corn supplemented with soya-bean meal*

Excretion journalière d'eau et concentrations en Na, K et glucose dans les filtrats d'excreta d'Oies nourries ad libitum *ou gavées avec du maïs cuit seul ou supplémenté en farine de soja*

	Experiment 1			Experiment 2						
			SE.T (1)		Period 1	Period 2	Period 3	$\bar{X}$	SE.P (2)	SE.T (1)
Fresh excreta (g/day)	R C	212 220	14.7	FC FCS	1 081 956	4 192 4 142	5 562 3 450	3 612 2 849	300**	245
Water excreted (g/day)	R C	190 190	13.1	FC FCS	1 006 879	3 993 3 939	5 453 3 357	3 483 2 724	279**	239
Na concentration (meq/liter)	R C	15.3 10.6	8.2	FC FCS	31.2 23.1	6.3 12.9	3.2 1.7	13.6 12.6	3.0**	2.5
K concentration (meq/liter)	R C	25.5 14.5	12.0	FC FCS	23.9 36.5	6.3 16.9	6.8 9.7	12.3 21.0	2.2*	1.8*
Glucose concentration (mg/100 ml)	R C	37.5 46.2	15.0	FC FCS	58.0 53.5	288.0 220.7	42.8 64.2	129.6 112.8	15.7**	12.8
Glucose excreted (g/day)	R C	.08 .10	.02	FC FCS	.58 .49	10.35 7.39	2.19 1.29	4.37 3.05	.90**	.74

(1) SE. T : SE of Treatment and statistical significance.
(2) SE. P : SE of Periods and statistical significance.
* Statistically significant degree $P < 0.05$.
** $P < 0.01$ between treatments or periods.

DISCUSSION

The animal body can excrete the surplus of most nutrients when fed in excess. Energy is an exception and when fed in amounts exceeding the animal's needs, it accumulates as adipose tissue and leads to obesity.

According to LEPKOVSKY and FURUTA (1971), homeostasis in the adipose tissues plays an important role in the regulation of food intake, and the hypothalamus does not differentiate between calories from the adipose tissue and those from food. Each species, strain, sex and age has its specific adipose tissue level (set point) which regulates the food intake and avoids further fat deposition (LEPKOVSKY, 1972). The interruption in the passage of food in the upper digestive tract at the end of the force-feeding period may be considered as the last defensive mechanism against lethal obesity caused by overpassing the natural regulatory mechanisms during force feeding. We observed that force-fed obese geese reduce their voluntary food intake to zero, as do chickens under similar circumstances (LEPKOVSKY and FURUTA, 1971). Force feeding geese to the stage of upper digestive tract hindrance, almost inevitably caused their death. The mechanism of this phenomenon and its origin is worthy of further investigation. It is notable that excessive amounts of feed introduced to the gastrointestinal tract were digested normally and efficiently utilized, as shown by the metabolizability of the feed (tabl. 5) and by gains in weight and body fat (fig. 1, tabl. 2 and 5).

Restricted feeding (up to 50 p. 100 of *ad lib.* intake) had no effect on the metabolizability of feed in growing chicks (HILL and ANDERSON, 1958). The present study shows that in geese the metabolizability of a high-energy diet is not affected when feed intake is increased up to three fold the maintenance level by force feeding. Further surfeit feeding caused only a moderate decrease in this value. The reduced metabolizability of corn due to cooking (exp. 1), and its improvement by the addition of soya-bean meal to the force-fed corn diet (exp. 2), resulted from the effects of these treatments on N balance, because these differences diminished when the ME was corrected for nitrogen balance using 8.22 kcal per gram nitrogen retained (HILL and ANDERSON, 1958). This finding is in agreement with the reports that in the chick, amino acid deficiency has no effect on the corrected metabolizable energy value of the diet (CAREW and HILL, 1961 ; SIBBALD and SLINGER, 1963 ; HILL, 1965 ; SOLBERG, 1971). The negative N balance found in the geese fed cooked corn *ad lib.* was not caused by lower digestibility (tabl. 5), but it could have been due to the older age of the geese during this experimental period and/or to a destruction of limiting essential amino acids in the diet. The higher N retention found in geese during the first period of force-feeding (exp. 2) as compared to the *ad lib.* fed geese (exp. 1) could be attributed to their younger age.

Surfeit feeding with corn caused a consistent reduction in the digestibility of N and in its retention which was negative during the major part of the experimental period. It can, therefore, be concluded that in the geese force-fed with corn, the increase in weight was caused mostly by fat. Consumption of exaggerated amounts of corn protein probably aggravated the amino acids imbalance of this protein, and therefore soya-bean meal supplementation improved most markedly both protein digestibility and retention. This confirms the findings of THOMAS *et al.* (1969) that supplementation of deficient diets by amino acids improved the nitrogen digestibility in the fowl, but is at variance with the data of other workers (SOLBERG, 1971 ; GRUHN, 1969 *a* ; GRUHN, 1969 *b*).

The total production of proteolytic digestive enzymes measured in the excreta was correlated to the feeding level. However, this was not true for amylase, the concentration of which was reduced in excreta by surfeit feeding (tabl. 6). This latter result is at variance with the reports stating that amylase concentration in the intestinal gut is related to the amounts of starch in the diet (HOWARD and YUDKIN, 1963). Addition of soya protein to the diet had almost no effect on proteolytic enzymes, but greatly increased the amylase concentration in excreta and its total output (tabl. 6). This finding could be attributed to higher amylase production by the pancreas (NITSAN *et al.*, 1973) or/and to a protective effect of the soya-bean protein (TWOMBLY-SNOOK and MEYER, 1964). The geese force fed with corn only, probably suffered from some essential amino acid deficiency which is cardinal in pancreatic amylase synthesis. Among the pancreatic enzymes, amylase appears to be most sensitive to this deficiency, as shown by its more pronounced response to soya-bean meal supplementation than the proteolytic enzymes. The same trend was shown in the pancreatic amylase activity in geese fed corn supplemented with 10 p. 100 soya-bean meal (NITSAN *et al.*, 1973). Moreover, it was shown that addition of methionine to raw and heated soya-bean meal increased the amylase/proteolytic enzymes ratio in the chick pancreas (NITSAN and GERTLER, 1972).

The somewhat lower energy retention could be caused by either lower absorption of both fat and glucose or by an increased excretion of glucose through the kidneys (diabetes mellitus). The origin of glucose in the excreta, whether from the urine or from the feces, should be clarified.

Force feeding caused a marked steatorrhoea (tabl. 3) accompanied by a gradual decrease in fat retention, which toward the end of the experimental period was practically zero (tabl. 5). The reason for the lack of fat absorption could be the shortage of bile acids in the gut caused by an impairment of vasculary drainage in the hepatic tissue. This assumption is sustained by the report of BLUM *et al.* (1970), who found that at the end of the forced feeding period jaundice appeared in all geese. Another explanation could be the development of an intestinal flora which can split conjugated bile acids into taurine or choline and the constituent acids, causing impaired fat absorption and steatorrhoea (JAYNE-WILLIAMS and FULLER, 1971). Acid fermentation in the gut could also be the cause (HAMILTON, 1967). Actually surfeit feeding caused a marked reduction in the excreta pH.

The tremendous amounts of water found in excreta could be partly due to the environmental temperature during the experimental period (MAY-JUNE, 1971). This increased water volume in excreta seems to be caused by polyuria and not by diarrhea. Diarrhea is usually accompanied by a reduction in digestibility, which was not noticed in this work.

In judging serum osmolality by Na^+ concentration, no increase was found by BLUM *et al.* (1970) in force-fed obese geese. In the present work the concentration of Na^+ and K^+ in excreta filtrate decreased gradually, and therefore the overdrinking was probably not due to increased blood osmolality caused by Na^+ or K^+ concentration in plasma. It could however be due to 1) Disturbances in some physiological mechanisms regulating water intake and excretion as Arginine Vasotocin release from the posterior pituitary gland (SHIRLEY and NALBANDOV, 1956 ; SKADHAUGE, 1964). 2) The need to excrete increased amounts of uric acid produced by the excessive amounts of protein (SYKES, 1971). 3) A mechanism to regulate glycemia which regulation is disturbed in the obese goose (BLUM *et al.*, 1970 ; NIR, 1972) by excreting glucose in the urine (*diabetes mellitus*). The origin of excreted glucose is being studied by the authors with colostomized geese in order to clarify this assumption.

Further studies are needed in order to explain the disorders caused by surfeit feeding on the physiology and biochemistry of avian species.

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RÉSUMÉ

INFLUENCE DU GAVAGE ET DE LA SUPPLÉMENTATION EN PROTÉINES DU RÉGIME SUR L'ÉNERGIE MÉTABOLISABLE, LA DIGESTIBILITÉ DES NUTRIMENTS, LA RÉTENTION D'AZOTE ET L'EXCRÉTION D'ENZYMES DIGESTIVES CHEZ L'OIE

Nous avons étudié au cours de deux expériences balancées l'effet de la cuisson du maïs, du gavage et de la supplémentation par la farine de soja sur l'utilisation de la nourriture chez l'Oie.

La cuisson du maïs n'augmente pas l'énergie métabolisable du régime. Un excès de nourriture allant jusqu'à 3-4 fois la ration d'entretien, introduit dans le tractus gastro-intestinal par gavage, est digéré normalement et utilisé efficacement. Quand on gave avec des quantités plus importantes, on note une diminution de 10 p. 100 de la digestibilité apparente de la matière sèche et une perte de 7 p. 100 de l'énergie métabolisable.

Le gavage inhibe à peu près totalement l'absorption des graisses et provoque une stéatorrhée. La rétention azotée, quand l'Oie est nourrie *ad libitum* avec du maïs cru, est assez faible ; elle tombe à des valeurs négatives quand le régime est composé de maïs cuit ainsi qu'au cours du gavage.

Le gavage est accompagné par une augmentation progressive de l'élimination d'eau dans les excreta, atteignant jusqu'à 25 fois la quantité excrétée chez les Oies nourries *ad libitum*. L'élimination de trypsine et de chymotrypsine dans les excreta est fonction de la quantité de nourriture ingérée. Il n'en est pas de même pour l'amylase dont l'excrétion diminue avec la surabondance de nourriture.

La supplémentation du régime de gavage à base de maïs avec de la farine de soja augmente la digestibilité et la rétention des protéines ; elle augmente davantage le taux d'amylase que le taux des enzymes protéolytiques.

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