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Effect of cereal sources and processing in diets for the growing rabbit. I. Effects on digestion and fermentative activity in the caecum

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Abstract – Four high-starch diets (20%) varying only by the source of starch (wheat = diet W; barley = diet B; maize = diet M; extruded maize = diet EM) were given ad libitum before weaning (at 29 d old) from 18 days of age, to 8 litters (2 litters per diet) of 8 rabbits caged separately from their mother. Starch concentration in the ileal digesta and caecal fermentative characteristics were assessed at weaning and at 50 d of age, while faecal digestibility was measured between 46 and 50 d of age. The energy digestibility coefficient was the highest for the barley based diet while the lowest were observed for wheat and maize based diets ($P < 0.05$). At weaning, the level of starch in the ileum was high and similar for W, B and M diets (meanly: 8.8% DM), but was 5 points lower for the EM diet. At 7 weeks of age, it remained high (>10% DM) with the maize based diet, while it decreased for the other groups (less than 6% DM). The faecal digestibility of the glucidic fraction (NNCC) was almost complete (> 92%) and significantly higher with the EM diet followed by the B diet. NNCC digestibility was negatively correlated with ileal starch concentration ($r = -0.63$, $P < 0.001$). The fibre and protein digestibility remained unaffected by the dietary treatment, and no significant correlation was detected between the ileal starch level and fibre digestibility (NDF or ADF). Caecal VFA concentration increased by 11 mmol (+20%) from weaning to 7 weeks of age, while ammonia level decreased by 15%. Compared to weaning, at 7 weeks of age, the butyrate proportions were 5 units higher. The starch source did not significantly affect the caecal traits or fermentations, except for a slight increase in the empty caecal weight for EM and B compared to the W and M diets ($P < 0.05$). The ileal starch concentration was not correlated with caecal fermentative activity.

rabbit / digestion / starch nature / extrusion / caecal fermentation

Résumé – **Effet du type de céréale et de l'extrusion dans l'alimentation du lapin en croissance. I – Conséquences sur la digestion et l'activité fermentaire cæcale.** Pour étudier les effets de la nature de l'amidon alimentaire sur la digestion du lapin en croissance, quatre aliments riches en amidon (20 %) variant seulement de par l'origine de l'amidon (blé = groupe W, orge = groupe B, maïs = groupe M, maïs extrudé = groupe EM) ont été distribués à volonté avant le sevrage (29 j) à partir de 18 jours d'âge, à 8 portées de 8 lapereaux (2 portées par régime) logés séparément de leur mère. La concentration en amidon iléal ainsi que l'activité fermentaire cæcale ont été mesurées au

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sevrage et à 50 jours d'âge, tandis que la digestibilité fécale des aliments a été mesurée entre 46 et 50 j d'âge. La digestibilité de l'énergie du régime à base d'orge (groupe B) est la plus élevée, alors que celle du régime à base de maïs est la plus faible ($P < 0{,}05$). Au sevrage, la concentration en amidon iléal est assez élevée et similaire entre les groupes W, B ou M (en moyenne 8,8 % MS), mais elle est 5 unités plus basse pour le groupe EM (maïs extrudé). A 7 semaines d'âge, le niveau d'amidon iléal reste élevé pour le groupe M, et baisse pour les autres groupes (inférieur à 6 % MS). La digestibilité fécale de la fraction glucidique (critère NNCC) est presque complète (>92 %). Elle est la plus élevée pour le groupe EM, suivie du groupe B (orge). La digestibilité fécale de la fraction NNCC est corrélée négativement avec la concentration en amidon dans l'iléon ($r = -0{,}63$, $P < 0{,}001$). La digestion des protéines et des fibres ne varie pas en fonction des traitements. Aucune corrélation n'a été détectée entre la teneur en amidon iléal et la digestion des fibres (NDF ou ADF). La concentration en AGV totaux dans le cæcum s'accroît de 11 mmol (+20 %) entre le sevrage et 7 semaines d'âge, tandis que la concentration en ammoniaque baisse de 15 %. A 7 semaines d'âge, la proportion de butyrate est 5 points plus élevée qu'au sevrage. La nature de l'amidon alimentaire n'affecte pas significativement les caractéristiques cæcales ou les fermentations, excepté un léger accroissement du poids du cæcum vide pour les groupes EM et B comparés aux groupes W et M (contraste : $P < 0.05$). La teneur en amidon dans l'iléon n'est pas corrélée avec l'activité fermentaire ou le pH cæcal. En conclusion, il existe une forte relation entre la qualité de l'amidon alimentaire et la quantité d'amidon résiduel non digéré dans l'intestin grêle du lapereau. Cependant, cela n'affecte pas la digestion des fibres ou les fermentations cæcales. L'extrusion présente un effet très positif sur la digestion intestinale de l'amidon de maïs du lapin en croissance.

lapin / digestion / nature d'amidon / extrusion / fermentation cæcale

1. INTRODUCTION

Over the past 10 years, the effects of dietary fibre to starch ratio have been extensively studied on rabbit digestion and digestive pathology [5, 15, 24, 26]. In contrast, not many studies have addressed the impact of starch origin on the digestion and growth of the rabbit [4, 23]. It was supposed that high starch incorporation in rabbit feeds, or *starch of low digestibility*, leads to digestive disturbances, because an intestinal starch overload could result in a high starch flow in the ileum and to a caecal ecosystem unbalance [6, 18] and changes in caecal fermentative activity [13]. This problem would be particularly critical in the young rabbit having an incomplete maturation of starch digestive capacity [9, 19, 28] and a recent study addressed the problem of the starch quality in feeds for early weaned rabbits [17]. Moreover, very few works have only studied the effect of the starch nature, without variations in starch/fibre levels or in other nutrients.

Thus, a study was performed, using a complex dietary model (with numerous raw materials close to commercial feeds), to compare the effects of four starch origins, on several digestive variables including the potential impact of ileal residual starch on caecal fermentative activity.

2. MATERIALS AND METHODS

2.1. Feeding and animal management

The dietary model consisted in varying only the nature of the starch, without changes in starch, protein or fibre level. Therefore, four experimental diets were designed with starch supplied by four different ingredients (Tab. I): wheat (diet W), barley (diet B), maize (diet M) and extruded maize (EM). Moreover, the fibre and protein quality remained unchanged, since their origins were similar among the four diets. The level of lignocellulose (ADF = 18% DM) as well as that of lignin (ADL = 3.7% DM) were slightly below current recommendations [8, 11] (Tab. II). The four diets were manufactured and pelleted at one time (CCPA, Osny, France), using the same batches of raw

Table I. Ingredients (%) of the experimental diets.

	Diets			
	W	B	M	EM
Wheat	29.00	–	–	–
Barley	–	34.00	–	–
Maize	–	–	26.00	–
Extruded maize	–	–	–	26.00
Soya bean meal	9.10	11.40	11.00	11.00
Sunflower meal	10.00	9.00	10.40	10.40
Lucerne dehydrated meal	19.00	19.00	19.00	19.00
Wheat straw	9.00	8.00	9.00	9.00
Wheat bran (Milurex®)	9.00	4.00	10.00	10.00
Beet pulp	8.00	8.00	8.00	8.00
Beet molasses	4.00	4.00	4.00	4.00
Minerals and premix*	2.90	2.60	2.60	2.60

* Contained (% diet): calcium carbonate (0.4), bone phosphate (0.7, 3CaO, P_2O_5), DL methionine 15% (0.4), salt (0.6), L-Lysine (0.3, in W diet only) and 0.5% diet of a premix (containing, vitamins: A-1 500 000 IU·kg^{-1} premix, D3-200 000 IU·kg^{-1}, E-3 000 mg·kg^{-1}, B1-200 mg·kg^{-1}; oligo-elements: copper 4 g·kg^{-1}, iron 8 g·kg^{-1}, zinc 20 g·kg^{-1}, manganese 4 g·kg^{-1}), without an antibiotic or coccidiostatic.

materials. The diets did not contain any drug supplementation (antibiotic or coccidiostatic).

Rabbits were handled according to the principles for the care of animals in experimentation, in agreement with French national legislation.

Before weaning (29 d old), each diet was given ad libitum to two litters of 8 rabbits (equalised at birth, and individually identified) from 18 days of age, and caged separately from their mother, in a closed and ventilated room (18 ± 2 °C) and with 12 h light (7:00–19:00). The does were fed a commercial diet. From 18 d till weaning, the doe was introduced in the litter cage for milking (for five minutes, at 8:00). At weaning, half of each litter (2 × 4 kits per diet) was killed for ileal and caecal digesta sampling. The kits were chosen according to their weight ranks (2, 4, 6, 8). After weaning, the remaining rabbits (8 per diet) were placed in *individual* metabolism cages.

2.2. Analysis of ileal and caecal digesta and digestibility measurements

A segment of the terminal ileum (20 cm prior to the ileo-caecal junction) and the whole caecal contents were obtained after slaughter by sudden cervical dislocation [2], at the end of the caecotrophy period (13:00 h).

Table II. Chemical composition of the experimental diets (% air dry basis).

		Diets			
	n	W	B	M	EM
Dry matter	*6*	87.9	88.1	88.5	89.5
Crude ash	*5*	6.9	6.8	7.1	7.2
Crude fat	*2*	1.9	1.8	2.4	2.2
Crude protein (N × 6.25)	*6*	16.0	16.4	16.4	16.6
Starch	*3*	21.9	19.5	20.8	21.0
Crude fibre	*6*	13.6	13.3	13.5	13.8
NDF[1]	*5*	28.9	28.7	29.2	29.8
Lignocellulose, ADF[1]	*5*	16.0	16.4	16.1	16.7
Lignins (ADL)[1]	*5*	3.7	3.7	3.6	3.7
Hemicellulose (NDF-ADF)	*5*	12.9	12.3	13.1	13.1
Cellulose (ADF-ADL)	*5*	12.3	12.7	12.5	13.0
NNCC[2]		36.1	36.2	35.8	35.9
Gross energy (Kcal·kg^{-1})	*1*	3860	3861	3921	3920

Mean values and standard deviation in parenthesis; *n* = number of laboratories for analysis;
[1]: according to the sequential procedure of Van Soest [1, 29]; NDF = neutral detergent fibre, ADF = acid detergent fibre, ADL = acid detergent lignin;
[2]: Non nitrogenous cellular content = Organic matter – NDF– Crude protein.

After a phase of adaptation to the diets, covering the period from 29–46 days of age, faecal apparent digestibility was measured individually (8 rabbits per diet) between 46 and 50 days of age according to the "European" reference method [25]. At 50 days of age, the rabbits were sacrificed for ileal and caecal digesta sampling, as mentioned before (at 13:00 h).

2.3. Chemical analyses of feeds and faeces and digesta

The following chemical analyses were carried out on feeds and faeces: dry matter (24 h at 103 °C), ash (5 h at 550 °C), crude protein (Kjeldahl method, N × 6.25), gross energy (adiabatic calorimeter PARR), fibres (NDF, ADF and ADL) according to the sequential method of Van Soest et al. [29] with an amylolytic pre-treatment (adopted by AFNOR [1]). In feeds and ileal digesta (lyophilised), starch was determined enzymatically after gelatinisation (autoclaving) using the hexokinase (EC 2.7.1.1) G6PDH (NAD) (EC 1.1.1.49) system (Böehringer Mannheim). Starch was not determined in the faeces, because starch is almost totally fermented in the caecum and thus faecal digestibility values are always close to 100% [13]. Therefore, because of the weak significance of starch faecal digestibility, we calculated the NNCC criteria (non nitrogenous cellular content) in order to analyse the faecal digestion of the highly fermentable saccharide fractions, such as pectins, starch, oligosaccharides and free sugars. NNCC was estimated according to the relation: NNCC(%) = OM(%) – CP(%) – NDF(%).

The pH of the caecal digesta was taken immediately after slaughter, with a glass electrode pH meter (pH 95, WTW, Weilherm, Germany). Portions of caecal digesta samples (5 to 10 g fresh matter) were placed in tubes containing (2%, v/v) H_3PO_4 or H_2SO_4 storage solution (1 and 2 mL per tube), respectively for further analyses of volatile fatty acid (VFA) and ammonia (NH_3), and stored at –18 °C. NH_3 concentrations were determined spectrophotometrically at 660 nm with an auto-analyser (Technicon, Domont, France) [30, 31], and VFA concentrations were measured by gas liquid chromatography (CP9000, Chrompack, Middelburg, Pays Bas) adapted to a semi-capillary column. Full and empty caecum were also weighed, as well as dry matter of caecal content. The VFA pool was defined as the total quantity of VFA in the caecum, and was calculated by multiplying the VFA concentration by the content of aqueous phase in the caecum (after DM determination of the caecal content).

2.4. Statistical analyses

Data of intake and weight gain from weaning to 50 d of age, were treated using a covariance analysis (covariate = weight at 21 d of age), and considering the effect of the litter: $Y = \mu + D + L(D) + W21 + \varepsilon$, with D = diet effect, L = litter effect, W21 = weight at 21d (GLM procedure of SAS [27]). Measurements of digestibility were subjected to a bifactorial variance analysis according to a split-splot model: $Y = \mu + D + L(D) + \varepsilon$. Multiple comparison of least squares means were treated using the PDIFF test [27]. Caecal characteristics and fermentative traits and starch concentration at the ileum were subjected to a bifactorial variance analysis: the effect of age, diet and interaction (age × diet), and including the effect of the litter (split splot model): $Y = \mu + D + A + A \times D + L(D) + \varepsilon$, with A = effect of age. Multiple comparisons of means were treated using the Scheffe test [27]. Animals showing abnormal feed intake or faecal excretion (over 2.5 s.d. under the mean) were not included in the statistical analysis.

3. RESULTS

3.1. Feed intake, growth and digestion

From 21 to 29 d (weaning), a lower weight gain (–5 g per d) was registered for the EM

Table III. Intake and growth performance from 21 to 50 days of age*, according to the dietary starch source.

	Diets					
	W (wheat)	B (barley)	M (maize)	EM (ext. maize)	*SEM*	*Effect of diet*
Live weight (g)						
at 21 days old	296[a]	251[b]	296[a]	260[b]	*6.4*	*<0.01*
at weaning (29 d)	474[ab]	473[ab]	486[a]	437[b]	*9.9*	*0.021*
at 50 days old	1294	1271	1316	1214	*31.3*	*NS*
Weight gain (g·d^{-1}, per rabbit)						
21 to 29 days old	25.0[ab]	24.9[ab]	26.5[a]	20.4[b]	*1.2*	*0.022*
29 to 50 days old	39.8	37.8	39.5	37.8	*1.4*	*NS*
Feed intake (g·d^{-1}, per rabbit)						
29 to 50 days old	77.9	75.2	75.3	65.3	*2.8*	*NS*

* Rabbits were caged collectively before weaning (2 litters of 8 pups per diet), and they were caged in individual metabolism cages after weaning (8 rabbits per diet). Data were statistically analysed using the weight at 21d as a covariate and including the effect of the litter (doe);
a, b: least squares means having a common superscript are not different at the level $P = 0.05$; NS: not significant ($P > 0.15$);
SEM = pooled standard error of the mean.

group (Tab. III), while after weaning, no significant differences were observed among the four groups, neither for intake nor for weight gain. Nevertheless, during the week after weaning (period 29–36 d) the feed intake tended to be lower for the EM diet compared to the others (37.8 vs. 50.7 g per d, $P < 0.05$ for EM vs. "W+B+M"), and this was associated to a 12% lower live weight (633 vs. 720 g, $P < 0.05$ for EM vs. "W+B+M").

The diet affected the digestibility of energy, organic matter (Tab. IV), with a significantly lower value for the W compared to the B diet (–5 units). Accordingly, the highest digestibility of energy was observed for a Barley based diet, while the lowest was observed for wheat and for maize based diets ($P < 0.05$). The digestion of the glucidic fraction (NNCC mainly constituted of starch) was almost complete (> 92%), and the faecal digestibility of NNCC was significantly higher with the EM diet followed by the B diet. Thus, NNCC digestibility was negatively correlated with ileal starch concentration ($r = -0.63$, $P < 0.001$, $n = 28$).

The digestibility of the W diet was relatively low, and remained similar to that of the M diet. The digestibility of the fibrous fractions as well as that of protein was unaffected by the dietary treatment, and no significant correlation was detected between the ileal starch level and fibre digestibility or the quantity of digested fibre (g NDF or ADF digested per d).

A significant interaction ($P = 0.02$) between the effect of diet and age was detected for the starch concentration in the ileum. This interaction originated from the M diet, since ileal starch remained high (>8%) at 29 and 50 d of age (Fig. 1), on the contrary to the other three diets where ileal starch was significantly lower at 50 d ($P < 0.001$). For rabbits at weaning (29 d), the residual starch in the ileum was at a similar level for the W, B and M diets (8.8% DM on average). At weaning and 3 weeks after, the effect of extrusion of maize was highly significant ($P < 0.001$) on starch ileal digestion, since the starch level in the terminal ileum was at least two times lower for the EM diet compared to M.

Table IV. Whole tract digestion according to the dietary starch source, and nutritive value of the experimental diets.

	Diets					
	W (n = 7)	B (n = 7)	M (n = 7)	EM (n = 7)	*SEM*	*Effect of diet*
Live weight (g)[1]	1272	1086	1210	1190	*59*	*NS*
Feed intake ($g \cdot d^{-1} \cdot kg\ LW^{-1}$)	89.0	75.9	85.3	81.3	*7.4*	*NS*
Digestibility (%)						
Dry matter	63.9^{b}	68.7^{a}	64.5^{ab}	66.3^{ab}	*1.3*	*0.043*
Organic matter	64.7^{b}	69.6^{a}	65.0^{ab}	67.3^{ab}	*1.3*	*0.029*
Energy	62.7^{a}	67.6^{b}	63.7^{ab}	65.6^{ab}	*0.8*	*0.045*
NNCC	93.7^{bc}	95.3^{b}	92.5^{c}	98.6^{a}	*0.6*	*<0.001*
Crude protein	69.3	73.2	71.8	72.2	*0.6*	*NS*
NDF	31.6	34.3	29.0	33.9	*2.3*	*NS*
ADF	16.8	23.2	13.2	21.8	*3.3*	*0.14*
Hemicelluloses	47.7	47.6	46.9	47.9	*2.0*	*0.11*
Cellulose	19.3	26.9	14.9	23.6	*0.3*	*0.091*
Nutritive value (air dry basis)						
DP ($g \cdot kg^{-1}$)	111	120	118	120		
DE ($MJ \cdot kg^{-1}$)	11.49	12.24	11.68	11.97		

SEM = pooled standard error of the mean;
[1]: mean live weight and feed intake during digestibility measurements (4 days, from 46 to 50 d old); NNCC (non nitrogenous cellular content) = OM – CP – NDF; Hemicelluloses: NDF – ADF; Cellulose: ADF – ADL; DP: digestible crude protein; DE: digestible energy;
[a, b] means having a common superscript are not different at the level P = 0.05; NS: not significant (P > 0.15).

3.2. Caecal traits and fermentative activity

According to age, we observed an increase of the caecum relative weight and of its content, associated with a significant decrease of its dry matter concentration and pH of caecal content (Tab. V). Similarly, the caecal VFA concentration increased by 11 mmol (+20%) from weaning to 7 weeks of age, while the ammonia level decreased by 15% (Tab. V). In parallel, the fermentation pattern evolved significantly with a larger proportion of butyrate (+5 units) balanced by lower proportions of acetate and propionate. No significant effect of the diet was detected on caecal traits or caecal fermentations, except for a slight increase in the empty caecal weight for EM and B compared to the W and M diet (contrast: P < 0.05).

No significant relationship was evidenced between the concentration of starch in the ileum and the levels or proportions of caecal VFA or ammonia or pH.

4. DISCUSSION

Before weaning (21 to 29 d old), the technological treatment of maize starch affected the weight of rabbits. This might be explained by a lower feed intake. A similar result was obtained by Gidenne and Perez [12] and by Maertens [20], and it might be attributed to

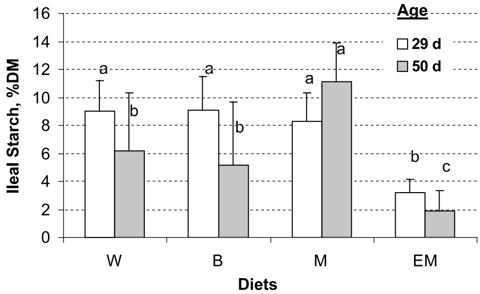

Figure 1. Ileal starch concentration according to age and to dietary starch source. Means and standard error, for eight replicates per diet and per age. Within age, means among diets having a superscript in common are not different at the level $P = 0.05$.

a weak appetency possibly because of the very small particle size provided by the extrusion process. It should not be due to the digestible energy content of this diet, since in the young rabbit the feed intake is not dependent on the dietary digestible energy level [10].

The extrusion process had a positive effect on the digestibility of maize starch before the caecum. On the contrary, the ileal starch content was little affected by the starch origin, when starches from barley and wheat were compared, while maize based diets led to the highest ileal residual starch level. Similarly, in the adult rabbit, starch from maize is more resistant to intestinal digestion than that of wheat or pea [13]. We expected that this effect would be amplified in the young rabbit, as shown by Pinheiro and Gidenne for 6 week old rabbits fed diets containing crude potato starch [23]. Our results did not indicate such an amplification for maize starch, since at weaning, the level of ileal residual starch was high (>8%) and was similar to that observed three weeks later. In return, for wheat and barley starches, we observed a significant reduction in ileal starch concentration with age.

Table V. Characteristics of the caecum and caecal fermentative traits according to age and dietary starch source.

	Diets				Age			*Effect of*		
	W	B	M	EM	29 d	50 d	*RMSE*	*Age*	*Diet*	*Age × Diet*
Body weight (g)	961	856	878	907	486	1301	*153*	*<0.001*	*NS*	*NS*
Caecum										
Organ (empty) (% BW)	1.7^a	2.0^b	1.7^a	2.2^b	1.6	2.1	*0.3*	*<0.001*	*0.052*	*NS*
Fresh content (% BW)	5.7	6.3	5.1	7.0	5.0	7.0	*27.9*	*0.013*	*NS*	*NS*
Dry matter (%)	23.1	22.1	23.3	22.4	23.5	21.9	*1.9*	*<0.001*	*NS*	*NS*
pH	6.03	6.11	6.09	6.25	6.27	5.97	*0.31*	*<0.001*	*NS*	*0.074*
Total VFA (mmol·L^{-1})	63.8	66.5	58.1	58.3	55.9	67.2	*16.2*	*0.014*	*NS*	*NS*
Acetate (%)	85.0	87.3	87.8	87.8	89.3	84.4	*4.3*	*<0.001*	*NS*	*NS*
Propionate (%)	4.3	4.0	3.4	5.6	4.6	2.0	*2.2*	*0.14*	*0.093*	*NS*
Butyrate (%)	10.4	8.5	8.5	6.3	5.9	11.3	*4.0*	*<0.001*	*0.073*	*NS*
VFA pool (mmol)	2.7	3.4	2.3	3.0	1.0	4.6	*1.3*	*<0.001*	*NS*	*NS*
NH3-N (mmol·L^{-1})	4.9	5.3	5.4	5.5	5.7	4.9	*1.2*	*0.031*	*NS*	*NS*

[a, b] Means having a common superscript are not different at the level $P = 0.05$ (contrast B+M vs. EM+W); Means from eight replicates per diet and per age; NS: not significant ($P > 0.15$).

Besides, during the post-weaning period, the decrease in starch level at the ileum with age (except for the maize group) indicated an improvement of the starch digestion in the small intestine, as suggested by the increase in amylase pancreatic secretion [7] and amylase intraluminal intestinal concentration [28] with age.

The higher resistance of maize starch to intestinal digestion, in comparison with other sources, was associated to a low digestibility of NNCC, and on the contrary for extruded maize starch, it corresponded to the highest NNCC digestibility. A lower digestion of maize compared to wheat [21] or barley [3, 32] has been previously reported, and that led to a lower digestion of the organic matter, proportional to the maize incorporation. A higher OM digestibility for the barley-based diet, compared to wheat, has not previously been reported in the growing rabbit. However, the negative effect of starch from wheat on the whole digestion tract remained unexplained, since it could not originate from starch digestion before the caecum, since starch from wheat was in low concentration in the ileum. More generally, a relationship between ileal residual starch and overall feed digestion seemed difficult to establish, since a higher ileal starch was found in the B compared to the EM diet, while their OM digestion values were similar.

Furthermore, Parigi-Bini [22] suggested that fibre digestion may be depressed when high quantities of starch enter the caecum, which could be a favourable factor for increasing the incidence of diarrhoea in the young rabbit. Blas et al. [4] thus reported lower hemicellulosic digestibility with a high-starch diet. Our results did not support such a hypothesis since no change in fibre digestion was observed while the quantity of starch entering the caecum varied greatly among the treatments (without changes in fibre quality or level). Belenguer et al. [3] observed no effect of starch source (barley vs. maize) on fibre digestibility, in agreement with our results.

A slightly higher development of the caecum was registered for rabbits fed the extruded maize based diet. However, we could not relate this result with change in fibre digestion or with the fermentative activity. Similarly, residual ileal starch was not correlated with caecal traits or fermentative parameters, whatever the age (weaning or 3 weeks after). Two recent studies [3, 32] also failed to observe any significant effect of the starch source (barley vs. maize) on the fermentative activity or on the cellulolytic bacterial population.

From weaning to 7 weeks of age, the increase in VFA level associated with a change in the fermentation pattern (higher proportion of butyrate with age), and with a lower caecal pH was in agreement with previous studies [14].

In conclusion, we observed a strong relationship between the starch nature and the quantity of undigested starch at the end of the small intestine, particularly in the young rabbit. However, this did not seem to interfere with the caecal fermentation activity or fibre digestion. The digestion of the wheat based diet was relatively low and similar to the maize based diet. The technology of extrusion clearly improved the digestion of maize starch, but it possibly affected feed intake before weaning. In the future, growth performances and mortality using a high number of animals in a network of experimental stations will be studied (a second part of this study [16]).

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