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Study on the nutritive value of dextrin as a carbohydrate source for pigs weaned at 21 days of age*

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ABSTRACT

Two experiments were conducted to compare the nutritive value of dextrin to that of various carbohydrate sources and to determine the optimal incorporation ratio with lactose for pigs weaned at 21 days of age. In each experiment, eighty pigs (BW 6.43±0.18 kg in experiment 1 and 6.93±0.19 kg in 2) were used as an experimental unit and allotted to 20 groups (4 pigs/group, 5 groups/treatment) using a completely randomized block design. Each group was assigned to one of 5 dietary treatments. Dextrin (control), maize starch and 3 different sources of sugar (lactose, glucose, and sucrose) composed 5 dietary treatments for experiment 1. Five 5 graded lactose:glucose ratios (100:0, 75:25, 50:50, 25:75 and 0:100, diet A, B, C, D and E, respectively) were used as the treatments in experiment 2. In experiment 1, pigs fed the diet containing maize starch showed the lowest (P<0.05) average daily gain (ADG) and average daily feed intake (ADFI). During the second week, ADG improved (P<0.05) for the pigs fed diets containing dextrin and 3 different

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sources of sugar (lactose, glucose and sucrose) compared to pigs fed maize starch diets. For the third week after weaning, pigs fed diets with maize starch, lactose, glucose and sucrose had improved ADFI compared with pigs fed the dextrin diet (P<0.05). Overall, there were no significant differences in ADG and ADFI among treatments. However, pigs fed the dextrin diet had improved feed conversion ratio (FCR) compared with pigs fed other diets (P<0.05). During the initial 14 d postweaning (phase I), no significant differences were found in digestibilities of gross energy (GE), dry matter (DM), crude protein (CP) and crude ash (CA) among treatments. During the third week postweaning (phase II), the digestibilities of GE and CP of pigs fed the diet containing sucrose were higher than those of the other treatments. In experiment 2, overall, no significant differences were found in ADG, ADFI and FCR. During the initial 14 d postweaning (phase I), no significant differences were found in nutrient digestibilities except for gross energy (GE) digestibility. GE digestibility obtained from diet A was greater (P<0.05) than that from diet D, while those for diets B, C and E were intermediate.

KEY WORDS: weaned pigs, dextrin, maize starch, lactose, glucose, sucrose, growth performance

INTRODUCTION

Nutritional variations among the carbohydrates have been reported in different species by many investigators. In the pig, however, there is relatively little data showing the effect of various carbohydrates in the diet.

In practice, lactose and dried whey are the most common carbohydrate sources for baby pigs. However, these milk-based carbohydrate sources are usually much more costly than other carbohydrate sources. Since modern baby pig diets contain highly digestible ingredients, the value of carbohydrate sources should be re-evaluated. Sucrose, or ordinary table sugar, long has been used extensively by the commercial feed industry to give a sweet flavour and is proposed as an energy source and appetite enhancer to pig starter diets (Mavromichalis et al., 1998). The volatile price of this commodity in recent years has led to the suggestion that consideration should be given to alternatives to sucrose. Dextrin, dextrose or glucose monohydrate are logical carbohydrates to consider. Dextrins or dextrose can be prepared easily from starch digestion. They are shorter chains of glucose molecules, but with no set number of glucose units per molecule (Ensminger et al., 1983). Eventually, dextrin or dextrose is split into glucose units, readily absorbed in the small intestine and metabolized by the pig. Hedonic preference tests conducted with human subjects generally rank dextrin only slightly below sucrose in sweetness (Chapple et al., 1981; Ensminger et al., 1983). Becker et al. (1954a) suggested that one-week-old pigs have survived when fed diets containing dextrin or maize starch. Mahan and Newton (1993) reported that dextrose was utilized as well as lactose by 3- or 4-week-old piglets. The feeding and management regimen employed may underlie the limited and inconsistent information regarding the age at which the baby pig can utilize dextrin and other carbohydrate sources (Manners and Stevens, 1972). Thus, the present study was conducted to compare different carbohydrate sources (dextrin, maize starch, lactose, sucrose and glucose) and to determine the optimal lactose:dextrin incorporation ratio for pigs weaned at 21 days of age.

MATERIAL AND METHODS

One hundred and sixty, three-way crossbreed (Landrace x Large White x Duroc) barrows weaned at 21 days of age were used for two experiments. At 21 days of age, pigs averaging 6.43±0.18 and 6.93±0.19 kg body weight were allocated in a completely randomized block design to experiment 1 and 2, eighty each. Treatments were dextrin, maize starch, lactose, glucose and sucrose for Experiment 1, and 100:0 (A), 75:25 (B), 50:50 (C), 25:75 (D) and 0:100 (E) acoording to 5 graded levels of lactose:dextrin ratio. Each treatment had 4 replicates with 4 pigs per replicate.

During phase I (0 to 14d post-weaning), all pigs were fed with high nutrient density diets (Tables 1 and 3 for experiments 1 and 2, respectively). The phase I diets were formulated to contain 3,400 kcal ME/kg, 1.65% lysine (Jin et al., 1998b). Phase II (15 to 21d postweaning) diets (Tables 2 and 4 for experiment 1 and 2, respectively) were formulated to contain 3,400 kcal ME/kg, 1.50% lysine with methionine to get the optimal inter-amino acid ratios suggested by Chung and Baker (1992), Ca 0.9% and P 0.8%.

The pigs were kept in concrete-floored pens, and feed and water were given *ad libitum* during the entire experimental period of 3 weeks. The temperature was maintained in the range of 26 to 30°C throughout the experimental period. Weight gain and feed intake were measured weekly.

For determining the nutrient digestibilities of experimental diets, pigs were fed diets containing 0.20% Cr_2O_3 during the experimental period and faeces were collected three times (08:00, 14:00, 20:00) a day after four days of adjustment period. Faecal samples were dried in an air-forced drying oven at 60°C for 72 h and ground in a Wiley mill through a 1 mm mesh screen for chemical analyses.

Feed and faecal samples were analyzed for proximate analysis and mineral composition by AOAC methods (1990). Chromium was measured using an atomic absorption spectrophotometer (Shimadzu, AA6145F, Japan). For energy utilisation, energy values of feed and faeces were measured by an adiabatic oxygen bomb calorimeter (Model 1241, Parr Instrument Co., Molin, IL.).

Treatment means were compared by the use of the GLM procedure of the SAS package (1985), and the Duncan's multiple range test (Duncan, 1955).

TABLE 1

Formula and chemical composition of experimental diets in phase I, Experiment 1

Treatments	Dextrin	Maize starch	Lactose	Glucose	Sucrose
Ingredients, %; as fed basis					
maize	13.91	13.91	13.91	13.91	13.91
soyabean meal (CP 44%)	15.00	15.00	15.00	15.00	15.00
spay dried plasma protein	5.15	5.15	5.15	5.15	5.15
fish meal (CP 65%)	5.00	5.00	5.00	5.00	5.00
dried porcine soluble	6.00	6.00	6.00	6.00	6.00
dextrin	20.00	-	-	-	-
maize starch	-	20.00	-	-	-
lactose	-	-	20.00	-	-
glucose	-	-	-	20.00	-
sucrose	-	-	-	-	20.00
dried skim milk	28.00	28.00	28.00	28.00	28.00
soya oil	4.00	4.00	4.00	4.00	4.00
monocalcium phosphate	0.98	0.98	0.98	0.98	0.98
limestone	0.60	0.60	0.60	0.60	0.60
vitamin mixture[1]	0.20	0.20	0.20	0.20	0.20
mineral mixture[1]	0.30	0.30	0.30	0.30	0.30
salt	0.30	0.30	0.30	0.30	0.30
antibiotics[2]	0.05	0.05	0.05	0.05	0.05
lysine-HCl	0.06	0.06	0.06	0.06	0.06
DL-methionine (50%)	0.25	0.25	0.25	0.25	0.25
Cr_2O_3	0.20	0.20	0.20	0.20	0.20
Chemical composition[3]					
crude protein, %	23.01	23.01	23.01	23.01	23.01
Ca, %	0.90	0.90	0.90	0.90	0.90
P, %	0.80	0.80	0.80	0.80	0.80
lysine, %	1.65	1.65	1.65	1.65	1.65
ME, Mcal/kg	3.4	3.4	3.4	3.4	3.4

[1] provided the followings by per kg vitamin and mineral mixture respectively: vit. A, 2000,000 IU; vit. D_3, 400,000 IU; vit. E, 250 IU; vit. K_3, 200 mg; vit. B_1, 20 mg; vit. B_2, 700 mg; pantothenic acid, 3,000 mg; choline chloride, 30,000 mg; niacin, 8,000 mg; vit. B_{12}, 13 mg; Mn, 12,000 mg; Zn, 15,000 mg; Co, 100 mg; Cu, 500 mg; Fe, 4,000 mg; folic acid, 40 mg; BHT, 5,000 mg, Mg, 200 mg; I, 250 mg

[2] Avilamycin

[3] calculated value

TABLE 2

Formula and chemical composition of experimental diets in phase II, Experiment 1

Treatments	Dextrin	Maize starch	Lactose	Glucose	Sucrose
Ingredients (%; as fed basis)					
maize	24.84	24.84	24.84	24.84	24.84
soyabean meal (CP 44%)	16.28	16.28	16.28	16.28	16.28
spray dried plasma protein	3.80	3.80	3.80	3.80	3.80
fish meal (CP 65%)	3.80	3.80	3.80	3.80	3.80
dried porcine soluble	5.00	5.00	5.00	5.00	5.00
dextrin	20.00	-	-	-	-
maize starch	-	20.00	-	-	-
lactose	-	-	20.00	-	-
glucose	-	-	-	20.00	-
sucrose	-	-	-	-	20.00
dried skim milk	20.00	20.00	20.00	20.00	20.00
soya oil	3.20	3.20	3.20	3.20	3.20
monocalcium phosphate	0.93	0.93	0.93	0.93	0.93
limestone	0.65	0.65	0.65	0.65	0.65
vitamin mixture[1]	0.20	0.20	0.20	0.20	0.20
mineral mixture[1]	0.30	0.30	0.30	0.30	0.30
salt	0.30	0.30	0.30	0.30	0.30
antibiotics[2]	0.05	0.05	0.05	0.05	0.05
lysine-HCl	0.19	0.19	0.19	0.19	0.19
DL-methionine (50%)	0.26	0.26	0.26	0.26	0.26
Cr_2O_3	0.20	0.20	0.20	0.20	0.20
Chemical composition[3]					
crude protein, %	21.03	21.03	21.03	21.03	21.03
Ca, %	0.90	0.90	0.90	0.90	0.90
P, %	0.80	0.80	0.80	0.80	0.80
lysine, %	1.50	1.50	1.50	1.50	1.50
ME, Mcal/kg	3.4	3.4	3.4	3.4	3.4

[1] provided the followings by per kg vitamin and mineral mixture respectively: vit. A, 2000,000 IU; vit. D_3, 400,000 IU; vit. E, 250 IU; vit. K_3, 200 mg; vit. B_1, 20 mg; vit. B_2, 700 mg; pantothenic acid, 3,000 mg; choline chloride, 30,000 mg; niacin, 8,000 mg; vit. B_{12}, 13 mg; Mn, 12,000 mg; Zn, 15,000 mg; Co, 100 mg; Cu, 500 mg; Fe, 4,000 mg; folic acid, 40 mg; BHT, 5,000 mg, Mg, 200 mg; I, 250 mg

[2] Avilamycin

[3] calculated value

TABLE 3

Formula and chemical composition of experimental diets in phase I, Experiment 2

Treatments	Lactose : Dextrin				
	100:0	75:25	50:50	25:75	0:100
Ingredients, %; as fed basis					
maize	15.80	15.80	15.80	15.80	15.80
soyabean meal (CP 44%)	18.00	18.00	18.00	18.00	18.00
spray dried plasma protein	5.00	5.00	5.00	5.00	5.00
fish meal (CP 65%)	5.00	5.00	5.00	5.00	5.00
dried porcine soluble	6.00	6.00	6.00	6.00	6.00
lactose	20.00	15.00	10.00	5.00	-
dextrin	-	5.00	10.00	15.00	20.00
Soya oil	4.27	4.27	4.27	4.27	4.27
dried skim milk	23.00	23.00	23.00	23.00	23.00
monocalcium phosphate	1.02	1.02	1.02	1.02	1.02
limestone	0.66	0.66	0.66	0.66	0.66
vitamin mixture[1]	0.20	0.20	0.20	0.20	0.20
mineral mixture[1]	0.30	0.30	0.30	0.30	0.30
salt	0.30	0.30	0.30	0.30	0.30
antibiotics[2]	0.05	0.05	0.05	0.05	0.05
lysine-HCl	0.09	0.09	0.09	0.09	0.09
DL-methionine (50%)	0.09	0.09	0.09	0.09	0.09
Cr_2O_3	0.20	0.20	0.20	0.20	0.20
Chemical composition[3]					
crude protein, %	23.01	23.01	23.01	23.01	23.01
Ca, %	0.90	0.90	0.90	0.90	0.90
P, %	0.80	0.80	0.80	0.80	0.80
lysine, %	1.65	1.65	1.65	1.65	1.65
ME, Mcal/kg	3.4	3.4	3.4	3.4	3.4

[1] provided the followings by per kg vitamin and mineral mixture respectively: vit. A, 2000,000 IU; vit. D_3, 400,000 IU; vit. E, 250 IU; vit. K_3, 200 mg; vit. B_1, 20 mg; vit. B_2, 700 mg; pantothenic acid, 3,000 mg; choline chloride, 30,000 mg; niacin, 8,000 mg; vit. B_{12}, 13 mg; Mn, 12,000 mg; Zn, 15,000 mg; Co, 100 mg; Cu, 500 mg; Fe, 4,000 mg; Folic acid, 40 mg; BHT, 5,000 mg, Mg, 200 mg; I, 250 mg

[2] Avilamycin

[3] calculated value

TABLE 4

Formula and chemical composition of experimental diets in phase II, Experiment 2

Treatments	Lactose:Dextrin				
	100:0	75:25	50:50	25:75	0:100
Ingredients, %; as fed basis					
maize	21.60	21.60	21.60	21.60	21.60
soyabean meal (CP 44%)	16.80	16.80	16.80	16.80	16.80
spray dried plasma protein	4.00	4.00	4.00	4.00	4.00
fish meal (CP 65%)	4.00	4.00	4.00	4.00	4.00
dried porcine soluble	6.00	6.00	6.00	6.00	6.00
lactose	20.00	15.00	10.00	5.00	-
dextrin	-	5.00	10.00	15.00	20.00
soya oil	4.35	4.35	4.35	4.35	4.35
dried skim milk	20.00	20.00	20.00	20.00	20.00
monocalcium phosphorus	1.26	1.26	1.26	1.26	1.26
limestone	0.74	0.74	0.74	0.74	0.74
vitamin mixture[1]	0.20	0.20	0.20	0.20	0.20
mineral mixture[1]	0.30	0.30	0.30	0.30	0.30
salt	0.30	0.30	0.30	0.30	0.30
antibiotics[2]	0.05	0.05	0.05	0.05	0.05
lysine-HCl	0.12	0.12	0.12	0.12	0.12
DL-methionine, 50%	0.08	0.08	0.08	0.08	0.08
Cr_2O_3	0.20	0.20	0.20	0.20	0.20
Chemical composition[3]					
crude protein, %	21.03	21.03	21.03	21.03	21.03
Ca, %	0.90	0.90	0.90	0.90	0.90
P, %	0.80	0.80	0.80	0.80	0.80
lysine, %	1.50	1.50	1.50	1.50	1.50
ME, kcal/kg	3.40	3.40	3.40	3.40	3.40

[1] provided the followings by per kg vitamin and mineral mixture respectively: vit. A, 2000,000 IU; vit. D_3, 400,000 IU; vit. E, 250 IU; vit. K_3, 200 mg; vit. B_1, 20 mg; vit. B_2, 700 mg; pantothenic acid, 3,000 mg; choline chloride, 30,000 mg; niacin, 8,000 mg; vit. B_{12}, 13 mg; Mn, 12,000 mg; Zn, 15,000 mg; Co, 100 mg; Cu, 500 mg; Fe, 4,000 mg; folic acid, 40 mg; BHT, 5,000 mg, Mg, 200 mg; I, 250 mg

[2] Avilamycin

[3] calculated value

RESULTS AND DISCUSSION

Experiment 1

Growth performance

Table 5 summarizes the growth performance of pigs fed different carbohydrate sources. For the first week after weaning, ADG and ADFI improved (P<0.05) for the pigs fed diets containing dextrin and 3 different sources of sugar (lactose, glucose and sucrose) compared with pigs fed diet with maize starch, but differences in the feed conversion ratio (FCR) were not significant among treatments. These results suggest that baby pigs could utilize dextrin at 21 and 28 days of age with a performance similar to those of pigs fed a diet containing glucose,

TABLE 5

Growth performance of pigs fed different carbohydrate sources

Item	Dextrin	Maize starch	Lactose	Glucose	Sucrose	SE[1]
D 0 to 7						
ADG, g	194[a]	150[b]	191[a]	185[a]	173[a]	9.35
ADFI, g	215[a]	162[b]	222[a]	215[a]	203[ab]	9.40
Feed/Gain	1.12	1.09	1.16	1.21	1.20	0.04
D 8 to 14						
ADG, g	302[ab]	258[b]	298[ab]	311[a]	294[ab]	9.52
ADFI, g	386	367	383	410	396	11.00
Feed/Gain	1.29	1.44	1.29	1.33	1.37	0.04
D 0 to 14						
ADG, g	249	203	248	248	233	7.38
ADFI, g	300	264	302	313	300	8.44
Feed/Gain	1.21	1.32	1.22	1.28	1.29	0.03
D 15 to 21						
ADG, g	442	446	481	468	446	12.55
ADFI, g	613[b]	685[ab]	666[ab]	724[a]	654[ab]	16.11
Feed/Gain	1.39	1.54	1.39	1.58	1.47	0.03
D 0 to 21						
ADG, g	315	284	323	321	304	7.71
ADFI, g	405	404	423	450	418	8.99
Feed/Gain	1.29[b]	1.44[a]	1.31[ab]	1.42[ab]	1.37[ab]	0.03

[1] pooled standard error of mean, n=20

[a,b] P<0.05

sucrose and lactose. This indicates that the nutritive value of dextrin is similar to that of lactose as a carbohydrate source for growth performance in a weaner diet. This conclusion is also supported by the fact that pigs can utilize dextrin or dextrose at over 1 week of age (Becker et al., 1954a; Chapple et al., 1981; Mahan and Newton, 1993).

For the second week after weaning, ADG improved ($P<0.05$) for the pigs fed diets containing dextrin and 3 different sources of sugar (lactose, glucose and sucrose) compared with pigs fed diet with maize starch. However, ADFI and FCR were not significantly different among treatments.

For the third week after weaning, ADFI of pigs fed diets containing dextrin, maize starch, lactose and glucose were similar and lower ($P<0.05$) than that of the pigs fed the diet containing sucrose, although there were no significant differences among treatments in either ADG or FCR. The results of growth performance are in good agreement with the reports of increased sucrase activity with increasing age (Bailey et al., 1956; Walker, 1959; Dahlqvist, 1961) and of an increased rate of hydrolysis of sucrose as the pig matures (Dollar et al., 1957; Kidder et al., 1963).

During the overall period, there were no significant differences in ADG, ADFI and among treatments. Even though no significant differences were found in ADG and ADFI among treatments, the mean of ADG for pigs fed diets containing dextrin, lactose, glucose and sucrose was slightly greater than that of pigs fed diets containing maize starch. However, pigs fed the dextrin diet had improved FCR compared with pigs fed other diets ($P<0.05$).

One published report (Bayley and Carlson, 1970) has been found that deals with the use of glucose as a sweetener in starter diets. The addition of 5% glucose to a complex diet fed to weaning pigs failed to improve pig performance. This result is in agreement with this experiment. Previously, several workers (Corring et al., 1978; Sloat et al., 1985; Hampson and Kidder, 1986) have suggested that the young pig's ability to digest the protein and carbohydrate fraction (starch) from cereal grains is not fully developed until the pig is approximately 5 week of age. Maize starch contains approximately 25% amylose and 75% amylopectin. The activity of pancreatic α-amylase may be more effective with amylose than with amylopectin because of the greater chemical simplicity of the straight-chain carbohydrate (Riss, 1983). The activities of maltase II and III produced in the brush border cells of the small intestinal mucosa may be important avenues for amylopectin digestion (Graham et al, 1981). Pancreatic α-amylase and maltase II and III production increase with age (Riss, 1983) but may be inadequate at 4 to 5 weeks of age to obtain maximum digestion of maize starch. Our results support their conclusion. These results indicate that maize starch as a carbohydrate source was not used as effectively as dextrin or lactose by the young weanling pig during the initial 14 d postweaning period.

In the comparison of glucose with sucrose, we observed that growth performance did not differ depending on the type of supplemented sugar. This is in a good agreement with Veum and Mateo (1981) who reported that glucose was utilized as well as sucrose with similar performance by 1-week-old piglets, but not with results of Jin et al. (1998a), which showed that the pig more efficiently utilized sucrose than glucose.

Dextrin, in summary, can be used for pigs weaned at 21 days of age as efficiently as other supplemented sugars over 3 weeks postweaning. Dextrin and all other sugar sources were better in ADG than maize starch for pigs during the first two weeks after weaning.

Nutrient digestibility

Tables 6 and 7 summarize the effects of different carbohydrate sources on proximate nutrient digestibility during phases I and II. During the initial 14 d postweaning (phase I), no significant differences were found in digestibilities of GE, DM, CP and CA among treatments. EE and P digestibilities were not affected by treatments, except sucrose, which showed significantly lower digestibilities of EE and P. This result is not in agreement with growth performance from the present experiment. However, pigs fed the maize starch diet had considerably lower ADFI ($P<0.05$), and with a similar trend in ADG compared with pigs fed other carbohydrate sources.

During the third week postweaning (phase II), the best GE digestibility was found in pigs fed sucrose, and the worst found in pigs fed dextrin ($P<0.05$). The results are in good agreement with several reports that increased sucrase activity with increasing age (Bailey et al., 1956; Walker, 1959; Dahlqvist, 1961) and of an increased rate of hydrolysis of sucrose as the pig matures (Dollar et al., 1957; Kidder et al., 1963). However, there was no significant difference in GE digestibility among maize starch, lactose and glucose. No significant differences were found in digestibilities of DM and P among treatments. Pigs fed sucrose showed the best CP digestibility ($P<0.05$), and worse CP digestibility was in pigs fed glucose and dextrin. However, there was no significant difference between glucose and dextrin. This result is in contrast with reports that pigs fed diets containing lactose had higher ($P<0.05$) apparent N digestibility (Sewell and West, 1965). This improvement may be caused by the high rate of screen of lactase, the enzyme responsible for lactose degradation, present in the digestive system of the young pig (Corring et al., 1978). However, Turlington et al. (1989) and Jin et al. (1998a) reported there were no significant differences in proximate nutrient digestibility of pigs fed lactose, glucose, and sucrose at 17 days and 28 days of age, respectively. Factors other than age that influence the rate of carbohydrate

TABLE 6

Effects of different carbohydrate sources on nutrient digestibilities in phase I, %

Treatments	GE	DM	CP	EE	CA	P
Dextrin	77.91	90.63	86.25	74.27[a]	78.53	65.87[ab]
Maize starch	77.08	91.15	86.35	82.00[a]	79.87	71.52[a]
Lactose	80.44	90.35	87.04	77.15[a]	80.44	66.36[ab]
Glucose	79.01	91.20	88.74	75.03[a]	79.01	70.66[ab]
Sucrose	77.10	90.20	86.78	61.50[b]	77.09	63.03[b]
SE[1]	0.32	0.25	0.39	1.90	0.72	1.10

[1] pooled standard error of mean, n=20

[a,b] $P<0.05$

TABLE 7

Effects of different carbohydrate sources on nutrient digestibilities in phase II, %

Treatments	GE	DM	CP	EE	CA	P
Dextrin	87.51[b]	89.29	83.78[b]	70.22[b]	71.99[bc]	64.42
Maize starch	88.46[ab]	89.54	84.59[ab]	78.76[a]	74.65[ab]	61.72
Lactose	88.02[ab]	89.48	85.45[ab]	75.35[ab]	76.40[a]	63.69
Glucose	87.97[ab]	89.30	84.19[b]	75.20[ab]	70.89[c]	61.39
Sucrose	89.43[a]	90.22	86.21[a]	71.34[b]	74.87[ab]	64.24
SE[1]	0.29	0.16	0.39	1.33	0.94	0.64

[1] pooled standard error of mean, n=20

[a,b,c] $P<0.05$

secretion in the small intestine include: creep feeding during the suckling period (Hampson and Kidder, 1986), weaning on to dry diets or liquid diets (Deprez et al., 1987), growth factor (James et al., 1987a,b; Jaeger et al., 1990), and hormones, e.g. insulin, corticosteroids and ACTH (Sangild et al., 1991a,b). In this trial, pigs were fed creep feed from 7 days of age, and consumed about 120 g/head/day of solid feed before weaning. Several studies have shown that the provision of solid feed containing complex carbohydrates to sucking pigs increases acid and pepsin secretion in the stomach (Cranwell, 1977, 1985; Cranwell and Stuart, 1984) and activity of some stomach and pancreatic enzymes (Friend et al., 1970; Aumaitre, 1972; Corring et al., 1978; English et al., 1980; Sloat et al., 1985). Friend et al. (1970) and Okai et al. (1976) observed a significant increase in daily gain of pigs offered creep feeding.

Experiment 2

Growth performance

Table 8 summarizes the effects of the dietary lactose:dextrin ratio on growth performance in weaned pigs. From d 0 to 7 postweaning, no significant differences were found in ADG, ADFI and FCR among treatments. From d 8 to 14 postweaning, the ratio of lactose:dextrin did not affect either ADG, ADFI or FCR which is in agreement with Becker et al. (1954b) and Chapple et al. (1989). From d 15 to 21 postweaning, there were no significant differences among treatments in ADG and FCR. However, ADFI increased as the lactose content in the diet increased. This response of ADFI is in good agreement with that from our previous study, experi-

TABLE 8

Effects of dietary lactose:dextrin ratio on growth performance in weaned pigs

Treatments	Lactose : Dextrin					SE[1]
	100:0	75:25	50:50	25:75	0:100	
D 0 to 7						
ADG, g	283	309	280	343	314	10.20
ADFI, g	302	346	297	344	331	10.55
Feed/Gain	1.07	1.13	1.08	1.01	1.05	0.02
D 8 to 14						
ADG, g	381	357	365	357	364	6.74
ADFI, g	465	421	430	429	467	11.32
Feed/Gain	1.22	1.18	1.18	1.20	1.28	0.02
D 0 to 14						
ADG, g	338	332	327	356	334	7.59
ADFI, g	384	383	363	387	399	8.75
Feed/Gain	1.14	1.15	1.11	1.09	1.20	0.02
D 15 to 21						
ADG, g	456	442	449	394	373	12.73
ADFI, g	679[a]	614[ab]	630[ab]	580[b]	576[b]	14.93
Feed/Gain	1.49	1.40	1.42	1.49	1.56	0.03
D 0 to 21						
ADG, g	381	368	362	349	355	6.89
ADFI, g	482	460	452	451	458	9.31
Feed/Gain	1.26	1.25	1.26	1.29	1.29	0.01

[1] pooled standard error of mean, n=20

[a,b] $P<0.05$

ment I. During the entire period of this experiment, no significant differences were found in ADG, ADFI and FCR.

In summary, from 21 to 42 days of age all of the treatments produced equal ADG, ADFI and FCR. This experiment clearly indicates that some pigs develop a marked ability to utilize dextrin in case lactose is not adequately supplemented to diets.

Nutrient digestibility

Tables 9 and 10 summarize the effects of the lactose:dextrin ratio on nutrient digestibilities in phases I and II. During the initial 14 d postweaning (phase I), no significant differences were found in digestibilities of DM, EE, CA and P among treatments. These data on nutrient digestibilities are well matched with the two

TABLE 9

Effects of dietary lactose:dextrin ratio on nutrient digestibilities in phase I, %

Treatments	GE	DM	CP	EE	CA	P
			Lactose : Dextrin, %			
100:0	90.23[a]	90.37	88.05[a]	68.49	75.10	56.28
75:25	89.96[ab]	90.57	87.68[ab]	65.30	75.91	60.16
50:50	89.63[ab]	90.36	87.50[ab]	60.61	75.34	58.68
25:75	88.71[b]	90.01	86.62[ab]	60.83	76.34	58.54
0:100	89.37[ab]	89.91	86.18[b]	63.27	73.51	55.45
SE[1]	0.21	0.13	0.25	1.17	0.55	1.09

[1] pooled standard error of mean, n=20

[a,b] $P<0.05$

TABLE 10

Effects of dietary lactose:dextrin ratio on nutrient digestibilities in phase II, %

Treatments	GE	DM	CP	EE	CA	P
			Lactose : Dextrin, %			
100:0	87.28	88.23	82.89	57.58	71.01	53.47
75:25	87.21	88.14	82.85	65.00	69.75	49.34
50:50	86.85	88.21	81.07	52.62	70.77	54.72
25:75	86.73	88.11	83.25	66.75	70.26	50.80
0:100	87.33	88.13	82.51	60.75	67.90	54.04
SE[1]	0.33	0.32	0.52	2.52	0.82	1.43

[1] pooled standard error of mean, n=20

reports (Chapple et al., 1981; Ensminger et al., 1983) showing that dextrin is shorter chains of glucose molecules, but no set number of glucose units per molecule and eventually, dextrin is split into glucose units, readily absorbed in the small intestine and metabolized by the pig. Other workers (Dahlqvist, 1961; Coffee, 1998) reported that dextrinase is released from the brush border of the small intestine and splits α-limit dextrin to glucose, maltose and maltotriose. Gross energy (GE) digestibility obtained from diet A was greater ($P<0.05$) than that from diet D, while those for diets B, C and E were intermediate. This improvement may be caused, similarly as in the case of crude protein digestibility as mentioned above, by the high level of lactase (Ekstrom et al., 1975; Corring et al., 1978; Giesting et al., 1985). The best crude protein (CP) digestibility was found in pigs fed diet A, and the worst was found in pigs fed diet E; those for diets B, C and D were intermediate. This result is supported by reports (Sewell and West, 1965) that pigs fed diets containing lactose had higher ($P<0.05$) apparent N digestibility.

During the third week postweaning (phase II), there were no significant differences in any nutrient digestibilities among treatments. This may explain why pigs fed different diets showed similar growth performance from d 15 to 21 postweaning. In phase I, the GE digestibility of pigs fed diet A was greater ($P<0.05$) than those of other treatments, but GE digestibility was not affected by treatments in phase II. This trend can be explained by several reports (Bailey et al., 1956; Walker, 1959; Hartman et al., 1961; Manners and Stevens, 1972) showing that the specific activity of mucosal lactase in the small intestine of the pig is high at birth but begins to decline by about 2 weeks of age and 6 weeks of age is similar to the low levels normally found in mature pigs.

In conclusion, these results suggest that all of the treatments produced similar ADG and ADFI except for maize starch, which was inferior. These results also suggest that dextrin was utilized as effectively as lactose, sucrose, glucose and could substitute lactose in part for weanling pigs.

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STRESZCZENIE

Wartość pokarmowa dekstryny jako źródła węglowodanów dla prosiąt odsadzonych w 21 dniu życia

Przeprowadzono dwa doświadczenia, w których porównywano wartość pokarmową dektryny z innymi węglowodanami celem określenia optymalnego stosunku laktoza:dekstryna, jaki można zastosować w dietach dla prosiąt odsadzonych w 21 dniu życia. W każdym doświadczeniu, 80 prosiąt, o m.c. 6,43±0,18 kg w doświadczeniu 1 i 6,93±0,19 kg w doświadczeniu 2 rozdzielono do 20 grup (4 prosięta/grupa; 5 grup/doświadczenie), stosując układ kompletnych bloków losowych. W doświadczeniu 1 dekrytynę stosowano w grupie kontrolnej, w pozostałych skrobię kukurydzianą lub jeden z 3 cukrów (laktozę, glukozę, sacharozę), w doświadczeniu 2 laktozę i dekstrynę w różnym stosunku (100:0, 75:25, 50:50, 25:75, i 0:100).

W doświadczeniu 1 prosięta z grupy otrzymującej skrobię kukurydzianą pobierały najmniej paszy (ADFI) oraz miały najniższe dzienne przyrosty (ADG: P<0,05). W ciągu drugiego tygodnia doświadczenia ADG prosiąt grupy kontrolnej oraz otrzymujących w diecie laktozę, glukozę lub sacharozę były lepsze (P<0,05) niż prosiąt otrzymujących skrobię kukurydzianą. W trzecim tygodniu po odsadzeniu ADFI przez prosięta wszystkich grup doświadczalnych były lepsze (P<0,05) niż przez kontrolne. W ciągu całego doświadczenia nie stwierdzono różnic w ADFI i ADG pomiędzy grupami, jednak wykorzystanie paszy (FCR) przez prosięta grupy kontrolnej było lepsze (P<0,05) niż z pozostałych grup. W ciągu pierwszych 14 dni po odsadzeniu (faza I) nie stwierdzono różnic w strawności energii brutto (GE), suchej masy (DM), białka ogólnego (CP) oraz popiołu (CA) między grupami, w trzecim tygodniu (faza II) strawność GE i CP była wyższa w grupie prosiąt otrzymujących sacharozę niż w pozostałych.

W doświadczeniu 2 nie stwierdzono różnic między grupami w ADFI, ADG, i FCR. W ciągu pierwszych 14 dni po odsadzeniu (faza I) strawność GE była większa (P<0,05) w grupie prosiąt otrzymujących tylko laktozę niż laktozę i dekstrynę w stosunku 25:75; wartości w pozostałych grupach były pośrednie.