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FOOD WASTE PRODUCTS IN DIETS FOR GROWING-FINISHING PIGS. EFFECT ON GROWTH PERFORMANCE, CARCASS CHARACTERISTICS AND MEAT QUALITY

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Key words: Food waste products, growing-finishing pigs, growth performance, carcass characteristics, meat quality.

The increased costs for the disposal of organic waste products in landfills, and governmental restrictions on such disposal, have led to increasing interest in using food waste products (FWP) in diets for animals. Successful use of organic waste products as feed is also of economical benefit for the pig farmers, because of low cost. Kornegay et al. (1965) reported that out-dated food products from grocery stores, leftovers from restaurants, hospitals and other institutions, waste from food processing plants and dairies, bakery products, and blood from slaughterhouses all were suitable for animal consumption. Some of the waste products may contain relatively high proportions of unsaturated fat, and may alter the fatty acid composition of the pig tissues. High proportions of unsaturated fatty acids in adipose tissue increase susceptibility to oxidation (Gray 1978). Feeding of kitchen waste to pigs has been a common practice in most countries (Bodá 1990). Many organic waste products, however, show great variation in chemical composition and nutritive value (Kornegay et al. 1965). In order to even out this variation, different waste products are mixed together as a liquid feed with a defined quality. The present study was carried out to determine the optimum dietary level of FWP in a wet feed mix with respect to 1) growth performance and carcass characteristics of growing-finishing pigs and 2) meat quality, including sensory quality.

Methods

Forty-eight crossbred [(Norwegian Landrace x Yorkshire) x (Norwegian Landrace x Duroc)] growing-finishing pigs (average 28.3 kg initial body weight and 104.7 kg final weight), were used to study the effect of adding food waste products (FWP) in diets. The treatments were comprised of six levels of FWP (0, 200, 400, 600, 800 and 1000 g kg^{-1} diet), in combination with a barley-soybean diet. The FWP consisted of, numbers as given as feed basis, food leftover products (324 g kg^{-1}), waste from pizza factory (47 g kg^{-1}), blood from a slaughterhouse (86 g kg^{-1}), waste from an ice cream factory (20 g kg^{-1}), dairy waste (92 g kg^{-1}), bakery wastes (122 g kg^{-1}), potato wastes (278 g kg^{-1}), dried egg meal (1.8 g kg^{-1}), soybean meal (8.3 g kg^{-1}), monocalcium phosphate (0.6 g kg^{-1}), amino acid-, mineral- and vitamin-premix[a] (1.0 g kg^{-1}), water (18 g kg^{-1}. PH=4.0. Fatty acid composition of the feed ingredients and of backfat trimmed from the loin muscle were analysed by GLC procedures as described by Tande & Aasoldsen (1992) for extracted/methylated samples. The acid methyl esters were determined on a Perkin Autosystem XL gas chromatograph with a WCOT Fused Silica column, 25 m (Middelburg, The Netherlands). The results are expressed as percentages of the total fatty acid composition. The loin muscle (*Longissimus dorsi*), was analysed for pH (Orion Model SA 720 with a Mlab 427 electrode), water content, fat content (extraction with chloroform:methanol (Blight & Dyer 1959)), drip loss, meat color and intramuscular fat content. A Minolta Chroma Meter CR-200 (8 mm viewing port, illuminant D_{65}) was used for measuring L* (lightness), a* (redness) and b* (yellowness) values in backfat and loin muscle. Fatty acid composition in backfat trimmed from the loin muscle was analysed by GLC procedures as described for feed samples. Thiobarbituric acid value (TBARS) and sensory quality (ISO 3972) was analysed on fresh samples and on samples stored for six months (-20°C, vakuumpacked in polyethylene). A trained ten-member panel evaluated the samples twice for 12 sensory attributes. Growth performance, carcass characteristics and sensory analyses were analysed using the GLM procedure of SAS. Level of significance was $P < 0.05$, unless stated otherwise.

Results and discussion

Increasing dietary levels of FWP reduced (linear, $P < 0.001$) average daily intake of feed on a dry matter basis (ADFI), and ADFI was significantly lower when pigs were fed the diets with 600 g kg^{-1} FWP or more. Dietary addition of FWP gave a linear reduction in fat firmness ($P < 0.02$). Meat area in cutlet, lean percentage and meat score in carcass were not affected ($P > 0.10$) by dietary level of FWP. The FWP had no adverse effect on growth performance of growing-finishing pigs when used in moderate levels (200 - 500 g kg^{-1}). The results of the meat quality measurements are shown in Table 1. The pH in the meat, water content, and fat content in the loin muscle were not affected by the dietary FWP levels. However, the level of FWP affected drip loss (quadratic, $P < 0.05$), with the lowest and highest drip losses for the control diet and the FWP80 diet, respectively. Increasing dietary levels of FWP reduced (linear, $P < 0.01$) fat firmness, and L*-values of backfat. Both subcutaneous fat and loin meat from pigs fed the highest levels of FWP had a darker colour than the pigs fed the control diet. The a* and b*-value of subcutaneous fat and loin were not affected by the FWP levels. The dietary FWP level did not influence TBA value on fresh samples or samples stored for six months. The TBA values after six months of storage (average 270.8) were higher ($P < 0.001$) than the TBA values for fresh samples (average 187.2). The increased TBA values after six months of storage indicated considerable oxidation in the samples, but still there were no differences among the dietary treatments.

Increasing dietary levels of FWP linearly increased the proportions of C14:0, C16:0, C16:1, C18:1, C20:5 (EPA) and C22:6 (DHA) in the diet, while the proportions of C18:0 and C18:2 decreased. The daily intake of unsaturated fatty acids increased with increasing dietary levels of FWP. Dietary FWP exerted a marked effect on the fatty acid composition of the backfat, as shown in Table 1. The proportion of saturated fatty acids (SAFA) in backfat decreased (linear, $P< 0.001$) and the proportion of polyunsaturated fatty acids (PUFA) increased (quadratic, $P < 0.03$) with increasing FWP levels. The proportion of PUFA was significantly higher ($P < 0.05$) for the diets with 400 g kg^{-1} or more FWP, compared to the diets with less than 400 g kg^{-1} FWP. The results show that fatty acid composition in backfat is influenced by the fatty acid composition of the diet. Influence of dietary fatty acids on fatty acid composition in pork has been reported previously in several studies. Øverland et al. (1996) and Kjos et al. (1999) showed that increasing dietary levels of fish fat increased the proportions of polyunsaturated fatty acids (PUFA) in intramuscular fat and in subcutaneous fat. In a study with Iberian pigs, Cava et al. (1997) showed that acorns in the diet significantly increased the proportion of PUFA in lard and muscle. Hertzman et al. (1988) found that the content of C22:6 (DHA) in pork fat may serve as an indicator of the amount of polyunsaturated marine dietary fat. They also showed that a proportion of marine fatty acids in pork fat higher than 0.5% may be critical for meat quality by increasing rancidity of the meat. In the present study, the proportion of marine fatty acids in backfat

increased with increasing dietary levels of FWP, and ranged from 0% to 0.76%. Only the FWP100 group had a level that exceeded 0.5%. Kirchheim et al. (1998) fed 0%, 25% and 50% sterilized food leftovers in the diet to growing finishing pigs, and found no effect of diet on meat pH, L* values of subcutaneous fat, drip loss or content of intramuscular fat. As in the present study, they found that increasing dietary levels of food leftovers increased the proportions of these fatty acids in subcutaneous fat.
None of the sensory attributes were affected by the dietary treatments in either fresh or stored loin muscle (results not shown). It was not possible to make statistical comparisons on the effect of storage time on the sensory attributes. However, six months' storage gave numerically higher intensities for rancid odour, off-odour, rancid taste, and off-taste. These observations were supported by the higher values of TBA values found in the samples after six months of storage. As in the present study, Westendorf et al. (1998) found no adverse effect on sensory quality of pig meat by dietary inclusion of food leftovers or cafeteria food waste. Diets causing increased proportions of unsaturated fatty acids in the depot lipids could be expected to increase susceptibility to lipid oxidation (Gray 1978). However, although the proportions of unsaturated fatty acids in the backfat of pigs fed FWP in the present study were significantly higher than those fed the control diet, no appreciable differences in TBA values or sensory attributes were found among treatments.

Conclusions: FWP has a potential as a feedstuff for growing-finishing pigs when used in moderate levels in well balanced diets. Optimal dietary inclusion level of FWP was in the range of 200 to 500 g kg^{-1} diet, and these levels did not influence feed intake, daily gain, feed:gain ratio or carcass characteristics.

Acknowledgements: The experiment was sponsored by the Norwegian Meat Cooperative, Oslo, Norway, the Norwegian Research Council, Oslo, Norway, the Ministry of Agriculture, Oslo, Norway, and the Ministry of Environment, Oslo, Norway.

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Table 1. Effect of FWP on chemical and physical parameters of loin muscle and fatty acid composition of backfat (g 100 g^{-1} of total fatty acids).

	C	FWP20	FWP40	FWP60	FWP80	FWP100	SEM[1]	Linear	Quadratic	Cubic
No. of pigs	7	8	8	6	7	7	-	-	-	-
Drip loss, %	3.23^{g}	3.95^{gh}	3.79^{gh}	3.51^{gh}	4.15^{h}	3.58^{gh}	0.200	NS	0.05	NS
Fat lightness, L*[2]	79.10^{g}	79.31^{g}	78.81^{g}	77.95^{gh}	76.58^{h}	75.77^{h}	0.683	0.001	NS	NS
Meat lightness, L*[2]	60.59^{g}	59.20^{gh}	59.98^{gh}	58.92^{gh}	58.12^{gh}	57.81^{h}	0.740	0.003	NS	NS
TBA value[3], fresh sample	189.0	186.0	182.9	196.2	185.0	222.8	21.10	NS	NS	NS
TBA value[3], after six months	240.9	234.4	275.6	281.8	266.1	287.0	21.60	NS	NS	NS
C14:0	1.38^{c}	1.50^{c}	1.75^{d}	2.01^{e}	2.11^{ef}	2.25^{f}	0.061	0.001	NS	NS
C16:0	25.10^{c}	24.63^{c}	24.07^{cd}	23.20^{d}	23.13^{d}	22.97^{d}	0.353	0.001	NS	NS
C16:1	2.13^{c}	2.10^{c}	2.26^{c}	2.31^{cd}	2.34^{d}	2.42^{d}	0.084	0.001	NS	NS
C18:0	14.87^{c}	14.44^{c}	12.68^{d}	11.40^{de}	11.21^{de}	10.26^{e}	0.572	0.001	NS	NS
C18:1, n-9	40.06	40.00	39.85	39.71	40.52	40.81	0.496	NS	NS	NS
C18:1, n-7	2.66^{c}	3.04^{d}	2.99^{d}	3.06^{d}	2.86^{cd}	2.88^{cd}	0.093	NS	0.003	0.06
C18:2, n-6	10.62^{c}	11.27^{cd}	12.64^{de}	14.07^{e}	13.79^{e}	13.88^{e}	0.551	0.001	0.04	NS
C18:3, n-3	0.89^{c}	0.94^{d}	1.08^{de}	1.25^{e}	1.21^{e}	1.20^{e}	0.049	0.001	0.01	0.09
C22:5, n-3 (DPA)	0.08	0.05	0.09	0.08	0.12	0.08	0.052	NS	NS	NS
C22:6, n-3 (DHA)	0.00^{c}	0.00^{c}	0.28^{de}	0.21^{d}	0.37^{de}	0.46^{e}	0.059	0.001	NS	NS
C22:6, n-9	0.09	0.05	0.05	0.18	0.02	0.10	0.038	NS	NS	NS
Σ C22:5 and C22:6, n-3	0.08^{c}	0.05^{c}	0.37^{d}	0.29^{cd}	0.50^{d}	0.54^{d}	0.084	0.001	NS	NS
SAFA	42.00^{c}	41.18^{cd}	39.32^{de}	37.66^{e}	37.30^{e}	36.71^{e}	0.844	0.001	NS	NS
MUFA	46.00	46.29	46.22	46.27	46.89	47.29	0.549	(0.05)	NS	NS
PUFA	11.98^{c}	12.54^{c}	14.45^{d}	16.06^{d}	15.81^{d}	15.99^{d}	0.588	0.001	0.03	NS

Values in LSMEAN. [1] Standard error of the mean. [2] L* = Degree of lightness, 0 = black, 100 = white. [3] TBA value ranging from 50 to 400. TBA value of fat tissue with an oily taste is in the range 150 - 200, TBA value of rancid fat tissue is higher than 200. [c, d, e g, h] Different letter indicates significant difference among dietary treatments ($P < 0.05$).