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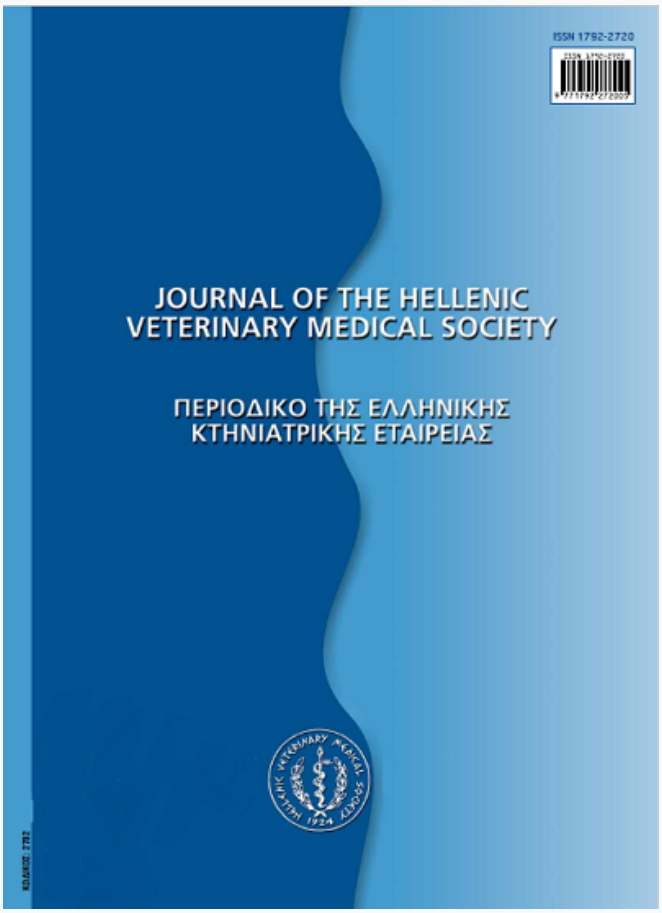

Effect of increased dietary fiber on hoof lesions of loose housed sows

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Effect of increased dietary fiber on hoof lesions of loose housed sows

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Επίδραση της πλούσιας σε κυτταρίνη διατροφής στις αλλοιώσεις των χηλών ομαδικά σταβλισμένων χοιρομητέρων

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ABSTRACT. Loose dry sow housing became mandatory in the European Union from January 2013 onwards. One of the major causes of injuries to sows' hooves and associated lameness is fighting on concrete/slatted flooring at grouping. Previous studies observed that in sows submitted to feed restriction, feed supplemented with dietary fiber reduced the time spent in the standing position and increased the time spent in the lying position. Therefore, we investigated the effect of increased levels of dietary fiber (7.2-7.5% crude fiber/kg dry matter) on the severity of hoof lesions of group housed sows in three Greek swine herds. The feet of 596 sows were initially examined for lesions upon their entry to the lactation facilities. Lesions scored included hoof hyperkeratinization, erosions or cracks and toe and dew claws overgrowths. When exiting the farrowing facilities they were offered recipes with increased dietary fiber throughout one or two subsequent gestations. Thirty-eight percent were re-examined for feet lesions during the first and sixty-two percent during the second lactation after initial examination. The proportion of sows with at least one lesion on any foot, at first scoring, was more than 95% in all herds. The most frequently and severely affected sites were the heel and the elongated toes and dew claws. The increased dietary fiber had no effect on lesion severity on any of the hoof sites considered.

Keywords: *dietary fiber, dry sows, hoof lesions, loose housing*

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ΠΕΡΙΛΗΨΗ. Από τον Ιανουάριο του 2013, είναι υποχρεωτικός σε όλες τις χώρες μέλη της Ευρωπαϊκής Ένωσης ο ομαδικός σταβλισμός των εγκύων χοιρομητέρων. Μια από τις κύριες αιτίες αλλοιώσεων στις χηλές και της συσχετιζόμενης με αυτές χωλότητας των χοιρομητέρων είναι ο ανταγωνισμός μεταξύ τους κατά την ομαδοποίηση σε κελιά με σχαρωτό δάπεδο. Προηγούμενες μελέτες έδειξαν ότι χοιρομητέρες που διατρέφονται με περιορισμένη ποσότητα σιτηρεσίου, αφιερώνουν λιγότερο χρόνο της ημέρας σε όρθια στάση και περισσότερο χρόνο σε ανάπαυση (ξαπλωμένες) στην περίπτωση που το σιτηρέσιό τους περιείχε υψηλό ποσοστό κυτταρίνης. Για το λόγο αυτό διερευνήθηκε η πιθανή επίδραση του υψηλού ποσοστού κυτταρίνης του σιτηρεσίου ξηρής περιόδου στην ένταση των αλλοιώσεων των χηλών ομαδικά σταβλισμένων χοιρομητέρων τριών ελληνικών εκτροφών. Αρχικά εξετάστηκαν και οι αλλοιώσεις βαθμονομήθηκαν στις χηλές 596 χοιρομητέρων εντός των θαλάμων τοκετών. Οι αλλοιώσεις που βαθμονομήθηκαν αφορούσαν αλλοιώσεις υπερ-κερατινοποίησης, διαβρώσεις ή ρωγμές και υπερ-αναπτύξεις των δακτύλων και των επικουρικών χηλών. Ακολούθως οι χοιρομητέρες διατράφηκαν κατά τη διάρκεια της επόμενης ή των δύο επόμενων κυήσεων με σιτηρέσιο με αυξημένο ποσοστό κυτταρίνης. Τριάντα οκτώ τοις εκατό επανεξετάστηκαν κατά τη διάρκεια της πρώτης και εξήντα δύο τοις εκατό κατά τη διάρκεια της δεύτερης γαλουχίας μετά την πρώτη εξέταση. Κατά την πρώτη εξέταση, το ποσοστό των χοιρομητέρων με τουλάχιστον μία αλλοίωση σε οποιοδήποτε άκρο ήταν μεγαλύτερο του 95% σε όλες τις εκτροφές. Οι συχνότερες και εντονότερες αλλοιώσεις εντοπίζονταν στο βολβό των χηλών καθώς και στο μέγεθος των δακτύλων και των επικουρικών χηλών. Η χορήγηση σιτηρεσίου με υψηλό ποσοστό κυτταρίνης δεν επηρέασε την ένταση των αλλοιώσεων σε κανένα ανατομικό τμήμα των χηλών.

Λέξεις κλειδιά: *κυτταρίνη σιτηρεσίου, χοιρομητέρες σε ξηρή περίοδο, αλλοιώσεις χηλών, ομαδικός σταβλισμός*

INTRODUCTION

Concern regarding food production from animals is increasingly focused on the quality of the final product, the production methods and the environmental implications. In response to pressure from welfare organizations and food distribution chains promoting good animal welfare to consumers, loose dry sow and gilt housing in intensive pig production became mandatory in the European Union from January 2013 onwards (European Council Directive 2001/88/EC). Pregnant sows are typically fed a restricted, concentrated diet to avoid obesity, but this management practice results in behavioral problems which indicate that sows are hungry (Meunier-Salaün et al., 2001). The inclusion of increased amounts of dietary fiber, which is a provision of the EU Directive, is likely to reduce hunger of restricted-fed pregnant sows due to a reduced assimilation of energy derived from starch at the expense of greater amounts of energy derived from short-chain fatty acids due to microbial fermentation of non-starch polysaccharides (Serena et al., 2009) in the large intestine. This change in energy assimilation may result in less variation in glucose and insulin during the day (de Leeuw et al., 2004, 2005a,b). Furthermore, rations rich in fiber more rapidly activate the satiety center in the brain of sows through dilatation of the stomach wall and slow down the digestion of ingredients by reducing the rate of gastrointestinal passage. As a consequence, restricted-fed animals may be for a shorter period of time in the stress condition caused by the feeling of hunger (Che et al., 2011).

From the available various types of loose sow systems (Nielsen, 2008) the one with static groups of sows with free-access non-locking stalls (i.e. one feeding and resting crate per sow) is dominant in Greek herds because, compared to other group housing systems, the capital cost at conversion to this system is lower. In this system, sows are fed simultaneously dropping feed once or several times per day into the individual feed trough of each sow. This practice entails relatively high risk of aggression and competition around feeding because dominant sows can steal feed and interrupt feeding of others. Baxter (1986) found that during feeding, 65% of all

aggression was initiated by pigs at a trough against an approaching pig, while much of the remainder was between pigs feeding simultaneously. Under commercial situations, competition over access to food is heightened by food restriction (Love et al., 1999).

Hoof lesions, which are very common among sows (Pluym et al., 2011), were associated with lameness (Anil et al., 2007) and increased risk of culling (Engblom et al., 2007). Lameness is an animal-based welfare indicator (Welfare Quality®, 2009) which reduces the productivity of a pig unit by reducing sow longevity and the number of pigs produced per sow per year due to increased involuntary culling rate of sows (Anil et al., 2005; Engblom et al., 2008). One of the major causes of injuries to the hooves is fighting on concrete/slatted flooring at grouping. Even after the dominance hierarchy is established, grouped sows will continue to fight if they have to compete for access to feed or are stressed by a perpetual feeling of hunger. Before the implementation of the EU Directive, fighting was controlled by the use of individual stalls. After implementation and without proper managerial adjustments it is reasonable to expect that the importance of feet lesions and associated lameness for longevity and welfare of grouped sows will increase (Anil et al., 2007; Fitzgerald et al., 2012).

Cassar et al. (2008) observed that the time spent lying was increased in sows submitted to feed restriction when supplemented with bulky food. A reduction in standing activity has been reported when different fiber components were included in the diet, such as chopped straw, wheat bran and corn cob (Robert et al., 1997). Che et al. (2011) reported a beneficial effect of increasing plant cell wall content in the gestation diet of multiparous sows, expressed as a reduction in the time spent in the standing position and an increase in the time spent in the lying position. Lately, Jensen et al. (2012) reported that restricted-fed with increased fiber sows exhibited reduced feeding motivation during the night but not during the daytime. Evidently, if diets rich in dietary fiber have a calming effect on restricted- and competitively-fed sows, they may prevent the induction or worsening of hoof lesions and associated lameness. Therefore, in this study we investigated the effect of increased levels of dietary fiber on the severity of feet lesions of group housed sows in three Greek swine herds.

MATERIALS AND METHODS

Study population

The studied herds were farrow-to-finish herds with 350 (A), 190 (B) and 800 (C) sows, respectively. The herds had different genetics coded as line 1 (A, B) and 2 (C). The dry sow units of these herds met the official requirements and the herds were granted compliance with the Directive by the veterinary authorities before initiation of the study. The dry sows were loose housed in static groups of 8-12 with free-access to non-locking stalls on combinations of concrete and slatted flooring, as required by the Directive. They were fed by an automated feeding system a total of 2.6-2.8 kg of typical dry sow diets containing 12.6-12.8 MJ metabolizable energy (ME) and 4.6-4.8% crude fiber per kg dry matter (DM). The latter was given either in one meal at 07:00 h (herds B and C) or was split in half and offered in two meals at 07:00 and 16:00 h (herd A). All herds operated on weekly farrowing schedules. For participation in the study the only criterion was the owners' written consent. Neither the health status of the sows' feet nor the frequency of mobility disorders was considered for herd selection. The authors declare that the study was conducted in farms which complied with the current laws concerning the protection of animals kept for farming in the European Union (European Council Directive 98/58/EC concerning the protection of animals kept for farming).

Study design

At the beginning of the study, when sows entered the lactation facilities, their feet were examined for lesions by three farm employees. The training of employees to recognize, characterize and score feet lesions was done by two of the authors (LM and LL). It involved an initial session at the University's

Clinics where the different anatomical sites of the foot were identified and also representative lesions on feet obtained from the slaughterhouse were characterized and scored. Training was repeated on each farm. Each sow's data was recorded on specially developed sheets. Those sheets were collected on a monthly basis from two of the authors (LM and ET). During the visits the authors cross-checked the data by examining a random sample of 20% of the sheets and rescoring the sows. The scoring system was described in detail elsewhere (Lisgara et al., 2015). Briefly, the medial and lateral toes of each foot were individually examined for lesions and scored when sows were lying down (the ventral surface) or standing up (the dorsal surface) in the farrowing crate. Lesions recorded included heel hyperkeratinization, erosions or cracks and toe and dew claws overgrowths. Five hoof anatomical sites were examined, the heel (soft keratinized epidermis on the ventral surface of the hoof towards the posterior end, HL), the sole (hard keratinized epidermis anterior to the heel on the ventral surface of the hoof including the junction between heel and sole, SL), the white line (junction between sole and wall, WL), the wall (hard keratinized epidermis on the dorsal surface of the hoof, WA) and the coronary band (CB). The scoring system applied was based on "Zeugenklauwencheck", a scoring system developed in The Netherlands (Pluym et al., 2011) and the Zinpro® Feet First method (Feet First® Team, 2010) with some modifications. Scoring of lesions of the epidermis involved a severity scale ranging from 0 to 2 where score 0 was given to hooves with no lesions or very small superficial cracks of the epidermis, score 1 was assigned to serious lesions in the epidermis not extended into the corium and score 2 was assigned to severe lesions with serious and deep cracks extended into the corium or subcutis. For toes (TL) and dew claws (DCL), score 0 was assigned to toes and dew claws with normal length, score 1 to extended toes and dew claws touching the floor when the animal was standing, and score 2 to overgrown and twisted or cracked toes and dew claws. For the coronary band, lesion score was 0 when healthy and 1 when any lesion was observed.

Following the exit from the farrowing facilities and until service, the sows were offered a total of 4.0-4.5 kg daily of dry sow feed. Thereafter, the daily amount of feed was 2.6-2.8 kg until 90 days and 3.2-3.5 kg from day 91 to 107 of gestation. The feed contained 12.6-12.8 MJ ME and 7.2-7.5% crude fiber/kg DM, and was given either in one or two daily meals. To maintain the energy density of the diet we added appropriate amount of fat (either vegetable fat or lard) in the recipes. During the monthly visits to the herds feed samples were obtained from the feed dispensers and appropriately analyzed in order to quickly correct any deviations from the above target values. The fiber sources used in diet formulations were wheat bran (approximately 11% crude fiber), sunflower meal (approximately 26% crude fiber) and distilled dried grain with solubles (DDGS – approximately 9% crude fiber). Approximately in one third of the sows the feet lesions were rescored when they were in lactation after one gestation. In the remaining sows, the lesions were rescored when they were in lactation after two gestations. During gestations they were offered diets with increased dietary fiber.

Statistical analysis

All statistical analyses were performed using Stata 13.1 (Stata Statistical Software. College Station, TX) and interpreted for significance at the 5% level. The total score for the four feet for each anatomical site considered was obtained by adding the respective scores of hooves, toes and dew claws. Therefore, for all anatomical sites except the coronary band, the total score for the four feet ranged from 0 to 16; for the coronary band, the total score varied between 0 and 8. The medians of total scores for each site considered before and after gestations on diets with increased crude fiber were compared with the Wilcoxon matched-pairs sign-rank test. In order to compare the severity of lesions on each hoof site considered before and after one or two gestations on diets with increased crude fiber we

used seven mixed-effect ordinal logistic regression models in GLAMM (Rabe-Hesketh et al., 2005; Rabe-Hesketh and Skrondal, 2008). In these models the score on the anatomical site considered was the dependent variable whereas the dietary status (before or after dietary fiber increase), the foot (front or rear), the toe (medial or lateral), the sow parity and the farm of sow origin were the independent variables. The latter four variables were forced in the models in order to control for their likely confounding effects because it was shown that lesion severity depended on age and differed between rear and front feet, lateral and medial toes and among herds (Lisgara et al., 2014; 2015). Furthermore, a random-effect term for sow, a random-effect term for foot nested within sow and a random-effect for toe nested within foot were included in order to account for repeated scoring on the same animal, foot and toe.

Results

In total 596 sows, 147 of which on herd A, 113 on herd B, and 336 on herd C were initially scored and subsequently re-scored after one (227/596, 38.1%) or two (369/596, 61.9%) gestations on fiber enriched diets. The proportion of sows with at least one lesion on any foot, at first scoring, was very high and similar among herds with 142/147 (96.6%), 111/113 (98.2%) and 328/336 (97.6%) affected sows in herds A, B and C, respectively. The medians of the total scores, by anatomical site, at the first and second scoring are presented in Table 1. For neither anatomical hoof site they differed significantly. The HL, the TL and the DCL were the most frequently and severely affected sites. Overall, 84.2 % (502/596), 57.9% (345/596) and 75.6% (451/596) of the studied sows had at least one lesion on the HL, TL and DCL respectively, at first scoring. After one or two gestations on the fiber enriched diets, the respective proportions of affected sows were 85.6% (510/596), 59% (352/596) and 76.7% (457/596) for HL, TL and DCL. The increased dietary fiber had no effect on lesion severity on any of the hoof anatomical sites considered (lowest P-value for DCL was 0.13).

Discussion

An ideal dry sow feeding regime should induce satiety, reduce competition and be operational in low cost and simple housing systems. The modification of dietary components to formulate a high-fiber diet is likely to partly help achieving the above objectives. Those dietary components should be cheap and widely available, have less or no negative impact on other nutrient utilization efficiency, have good palatability and have high water holding capacity. Moreover, they should not have any anti-nutritional effect or any negative effect on animal production. Feeding pregnant sows with high fiber diets had considerable effect on their behavior. Studies showed that inclusion of sugar-beet pulp (Brouns et al., 1997), wheat bran and cobs (Roberts et al., 1993) or straw (Fraser, 1975) in sow diets increased feeding time, reduced activity and feeding motivation. However, the internal heat production is higher from fiber-rich diets than from starch or fat (Stahly and Cromwell, 1986). Therefore, in temperate climates, and especially when the external temperature greatly exceeds the thermo-neutral zone of sows, diets with very high amount of crude fiber may cause discomfort and reduce sow appetite to levels less than those needed to meet the energy requirements for maintenance and optimum productivity.

In this study, we increased the dietary fiber almost 50% higher than the crude fiber of typical dry sow rations. The productivity of the sows was unaffected (data not shown) but the increased dietary fiber, at the percentage used in this study, had no effect on the severity of feet lesions recorded on any of the anatomical sites considered. Almost every sow examined in the herds had at least one feet lesion. The most frequent and severe lesions were on the heel, the overgrown toes and dew claws. Likewise, other studies also recorded extremely high frequency of feet lesions in sows (Anil et al., 2007; Pluym et al., 2011). The high prevalence of feet lesions may be linked with the intensive farming of sows on concrete floors, with minimal or no bedding, and the selection towards highly productive sows and fast growing pigs in today's swine industry

(Anil et al., 2007; Cameron, 2012). Location (Anil et al., 2007, 2008) and severity (Pluym et al., 2011) of the lesions might determine whether a sow will show overt lameness or not. Additionally, hoof lesions may permit entry of infection that might spread upwards, affecting joints and other tissues (Penny et al., 1965). Therefore, prevention should include measures to discourage the development of hoof lesions. Factors affecting the prevalence and severity of hoof lesions may include housing, nutrition, management of infectious agents and pig related features such as hoof and foot conformation (Kroneman et al., 1993; Cameron, 2012). Regarding housing, higher incidence of hoof problems in sows housed on partially slatted concrete floors, as those in the studied herds, than in sows on straw-bedding or solid concrete floors has already been reported (Holmgren et al., 2000). The space between slats, roughness of the surface, and edge design are crucial factors in deciding the extent of injury (Boon and Wray, 1989). Though housing conditions on the farm are crucial as immediate causes for the development of feet lesions, many nutritional aspects and especially the availability of trace minerals may also act as predisposing factors because it is vital in developing the feet structure and integrity Tomlinson et al., 2004, van Riet et al., 2013).

Concluding remarks

Under the conditions of this study, there was no association between increased dietary fiber in dry sow rations during one or two gestations and the severity of sow hoof lesions. In herds where sows suffer high frequency of hoof problems, other nutritional and managerial changes for dry sows should be likely prioritized over increased dietary fiber.

CONFLICT OF INTEREST STATEMENT

There are no conflicts of interests professionally or financially with this manuscript that the co-authors are aware of.

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Table 1. Median (range) of the total score of hoof lesions recorded on all feet of 596 sows of three Greek herds, by anatomical hoof site considered, before and after one or two gestations on a diet enriched in crude fiber.

Anatomical hoof site	Median (range) of total score		P-value*
	Before	After	
Sole	1(0-6)	1(0-8)	0.6
Heel	3(0-14)	4(0-16)	0.3
White line	0(0-10)	1(0-12)	0.2
Wall	1(0-9)	2(0-11)	0.4
Coronary band	0(0-3)	0(0-3)	0.5
Toe length	1(0-8)	2(0-10)	0.3
Dewclaw length	2(0-11)	3(0-12)	0.6

* P-value of the Wilcoxon matched-pairs sign-rank test.

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