

A high dietary iodine increases thyroid iodine stores and iodine concentration in blood serum but has little effect on muscle iodine content in pigs

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Abstract

There is still iodine deficiency in many populations, which justifies efforts to increase this trace element in food such as milk, eggs and meat by fortifying compound animal feeds with extra iodine. The iodine requirement of growing pigs is in the order of 100–200 µg/kg feed (as a supplement) and the effects of this dosage range or higher on pork iodine concentration should be determined including the action of relevant iodine antagonists in feed, e.g., rapeseed. In three experiments on a total of 208 pigs [Pietrain × (Landrace × Large White)] the iodine concentration of meat (m. longissimus) – 71 samples –, blood serum – 100 samples – and of the thyroid – 100 samples – was analysed by intracoupled plasma-MS. In Experiment 1, 4 × 10 pigs received diets without or with rapeseed cake (0 and 3.2 mmol glucosinolates/kg diet) either with 125 or with 250 µg iodine/kg. In Experiment 2, the three groups with 46 pigs each were fed high iodine diets (1200 µg supplementary iodine/kg) without or with 100 or 150 g solvent extracted rapeseed meal/kg diet (0; 0.8 and 1.2 mmol glucosinolates/kg). In Experiment 3, 3 × 10 pigs received either 600 µg iodine/kg feed (1) or the 5-fold dosage (600 + 2400 µg iodine/kg diet) administered 7 days (2) or 18 days (3) before slaughtering. The group means of pork iodine content were in the relatively small range from 3 to 16 µg/kg, which contrasted to the enormously varying dosage range from 125 to 3000 µg iodine/kg diet. There was a certain iodine dosage effect in Experiment 3 when – in comparison to the control – a 3-fold higher meat iodine concentration resulted from a 5-fold higher diet iodine concentration. In Experiment 1 with the low iodine offer, rapeseed cake with glucosinolates decreased the serum iodine level whereas in Experiment 2 this did not happen due to higher iodine fed and lower glucosinolates exposure. The thyroid iodine reflected the dietary iodine better than blood serum iodine and the serum better than muscle. However, in Experiment 2, 1200 µg iodine/kg diet produced only half the serum iodine concentration than half as much dietary iodine in Experiment 3 (600 µg iodine/kg diet), which may result from rapid elimination of blood iodine and a higher urinary excretion by longer duration of feed withdrawal before blood sampling. The muscle of pigs has to be classified as a low iodine food. Thus, there are no possibilities to concentrate this trace element reproducibly in amounts relevant for human nutrition in pork.

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1. Introduction

There is still iodine deficiency in the German population justifying the use of iodized common salt in food processing and the household on the one hand and on the other

hand the efforts to increase concentrations of this trace element in milk, eggs and meat by fortifying compound animal feeds with extra iodine (Kaufmann & Rambeck, 1998; Rambeck, Kaufmann, Feng, Hollwich, & Arnold, 1997; Richter, 1995). In the past the iodine status of pigs was investigated with regard to iodine deficiency (Smith, 1915) often exacerbated by antithyroid compounds, e.g., glucosinolates of rapeseed feeds and hypothyroidism, as

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deficiency illness, was prevented by iodine addition to the diet (Devilat & Skoknic, 1971). Target of food iodine is the thyroid which has the ability to concentrate and store the trace element and synthesize thyroid hormones. The iodine status of growing pigs, taking account of food iodine supply and/or permissible antithyroid compounds, has been characterized by determining thyroid hormone concentration of blood serum (Mc Kinnon & Bowland, 1977; Spiegel, Bestetti, Rossi, & Blum, 1993), the thyroid iodine content (Schöne et al., 1990) and the iodine concentration of sows' serum and milk (Laurberg et al., 2002; Schöne, Leiterer, Hartung, Jahreis, & Tischendorf, 2001). There were some efforts to determine the iodine content of meat but the methods used up to the 1990s seemed to be less sensitive and specific. However, in the last decade the assay of iodine has improved (Fecher, Goldmann, & Nagengast, 1998; Leiterer, Truckenbrodt, & Franke, 2001) to allow the detection of the trace element in low iodine matrices.

The objective of present investigations was to analyze the muscle iodine content of pigs fed diets with defined amounts of iodine. Additionally, indicators of animal's iodine status, i.e., thyroid and serum iodine concentration, were established for the given food iodine supply. The iodine requirement of growing pigs is of the order of 100–200 µg/kg feed and this range and higher diet levels on pork iodine concentration were investigated. Since glucosinolates affect the iodine status, the role of these secondary plant metabolites was investigated by the inclusion of rapeseed feeds in the diets.

2. Materials and methods

The samples originated from 3 experiments with a total of 208 pigs [Pietrain × (Landrace × Large White)]: Experiment 1 with 4 × 10 male-castrated pigs, Experiment 2 with 3 × 46 pigs – one half of them female and one half male castrated, Experiment 3 with 3 × 10 male-castrated pigs. The performance and further results have been published (Richter, Bargholz, Leiterer, & Lüdke, 2002; Schöne, Tischendorf, Leiterer, Hartung, & Bargholz, 2001; Weiß, Quanz, & Schöne, 2004).

In Experiments 1 and 2, the number of samples for the iodine determination was restricted: Experiment 1 – the iodine concentration in meat (*m. longissimus*) in each second sample (5 per group); Experiment 2 – 10 serum and 10 thyroid samples and 7 muscle samples per group.

2.1. Diets and procedure in the experiments

In Experiment 1 (Table 1), the four groups of 10 pigs each received two diets – one diet without, one diet with 150 g rapeseed press cake/kg diet (0 or 3.2 mmol glucosinolates/kg diet), which were supplemented either with 125 (groups 1 and 3) or with 250 µg iodine/kg (groups 2 and 4). In Experiment 2, the three groups with 46 pigs each were fed high iodine diets (1.2 mg supplementary iodine/kg) without or with 100 or 150 g solvent extracted rapeseed

meal/kg diet (0; 0.8 and 1.2 mmol glucosinolates/kg). In Experiment 3, 3 × 10 pigs received either 600 µg iodine/kg feed (1) or an additional dosage of 2400 µg iodine/kg diet one week (2) or 18 days (3) before slaughter.

The glucosinolate concentration of rapeseed press cake used in the diet of Experiment 1 (Table 1) was 21.2 mmol/kg; that of rapeseed meal (Experiment 2) 10 mmol/kg (basis air dry matter). In Experiment 1, the lower iodine dosage tested was similar to the 140 µg iodine per kg diet recommended by the National Research Council NRC (1998). Basal diets had iodine concentrations below the detection limit of <20 µg/kg. Iodine was provided as KI bound to casein which was found to be highly stable. In the diets added iodine dosages were confirmed analytically.

The design and protocols of the animal experiments were approved by the Official Commission for Animal Experimentation (permission of Thuringian Ministry of Health and Welfare, dated 18 March 1991). In Experiments 1 and 3, pigs were held in individual pens in the Thuringian animal nutrition research unit Remderoda. Experiment 2 took place in the climatized pig barn with pens for 2 pigs each at the Hessian farm-animal-research station Neu-Ulrichstein (Weiß et al., 2004).

The pigs were weighed at the beginning, once fortnightly and at the end of experiment, determined by the recommended body-weight. Feed mixtures were offered *ad libitum* and feed intake was recorded as difference between the daily weight of the feed offered and refused. Pigs were slaughtered after 12 (Experiments 1 and 3) or 24 h (Experiment 2) feed withdrawal in the abattoir in Jena, Germany. Classification of leanness was done by backfat and *m. longissimus* measurement at the 13th/14th rib region with a Fat-O-Meater (PG 200, Giralda-Opto-Elektronik, Aichach, Germany).

The thyroids were removed at slaughter, weighed and frozen in polyethylene bags at –20 °C. Blood was sampled from the anterior vena cava on the penultimate day after a 12 h fasting period. Blood samples were transferred to glass tubes, centrifuged after 2 h for 15 min at 1600 and the serum was frozen at –20 °C until analysed.

The meat sample of 150–200 g was cut from the pork chop (left carcass half) *m. longissimus*, which had been transported to the meat laboratory after retaining and chilling the carcass overnight. The sampling position was standardized at transition from the breast to the lumbar region (last rib). The weighed samples consisting of pure muscle without attached fat or connective tissue were cut in cubes, freeze-dried at –20 °C, freeze-dried and finely ground.

2.2. Analyses

In the experiments, the dry matter, crude protein, ether extract, crude fibre and ash content was determined in feed ingredients as well as diets (Bassler & Buchholz, 1993). Glucosinolates of rape feeds were determined by HPLC with sinigrin as internal standard (European Community, 1990). The iodine content of diets and lyophilized meat samples was analysed using intracoupled plasma-mass

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