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A comparison of the effect of soybeans roasted at different temperatures versus calcium salts of fatty acids on performance and milk fatty acid composition of mid-lactation Holstein cows

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ABSTRACT

To evaluate the effect of soybeans roasted at different temperatures on milk yield and milk fatty acid composition, 8 (4 multiparous and 4 primiparous) mid-lactation Holstein cows (42.9 ± 3 kg/d of milk) were assigned to a replicated 4 × 4 Latin square design. The control diet (CON) contained lignosulfonate-treated soybean meal (as a source of rumen-undegradable protein) and calcium salts of fatty acids (Ca-FA, as a source of energy). Diets 2, 3, and 4 contained ground soybeans roasted at 115, 130, or 145°C, respectively (as the source of protein and energy). Dry matter intake (DMI) tended to be greater for CON compared with the roasted soybean diets (24.6 vs. 23.3 kg/d). Apparent total-tract digestibilities of dry matter, organic matter, and crude protein were not different among the treatments. Actual and 3.5% fat-corrected milk yield were greater for CON than for the roasted soybean diets. Milk fat was higher for soybeans roasted at 130°C than for those roasted at either 115 or 145°C. No differences were observed between the CON and the roasted soybean diets, or among roasting temperatures, on feed efficiency and nitrogen concentrations in rumen, milk, and plasma. Milk from cows fed roasted soybeans had more long-chain fatty acids and fewer medium-chain fatty acids than milk from cows fed Ca-FA. Compared with milk from cows fed the CON diet, total milk fat contents of conjugated linoleic acid, *cis*-9,*trans*-11 conjugated linoleic acid, *cis*-C18:2, *cis*-C18:3, and C22:0 were higher for cows fed the roasted soybean diets. Polyunsaturated fatty acids and total unsaturated fatty acids were greater in milk from cows fed roasted soybean diets than in milk from cows fed CON. Concentrations of C16:0 and saturated fatty acids in milk fat were greater for CON than for the roasted soybean diets. Cows fed roasted soybean diets had lower atherogenic and thrombogenic indices than cows fed CON. Milk fatty acid composition did not differ among different roasting temperatures. In summary, results showed that cows fed CON had higher DMI and milk yield than cows fed roasted soybean diets. Among different roasting temperatures (115, 130, and 145°C), soybeans roasted at 115°C led to higher milk production and lower DMI. Cows fed roasted soybeans, regardless of the roasting temperature, had more unsaturated fatty acids in milk. Using roasted soybeans in dairy cow rations could, therefore, improve the health indices of milk for human nutrition.
Key words: roasted soybeans, calcium salts of fatty acids, milk fatty acids

INTRODUCTION

Fats and oils have been included in diets for dairy cows for many years, principally to increase the energy density of the diet in an attempt to increase energy intake by high-yielding cows. More recently, lipids were included in the diet of lactating dairy cows in an attempt to alter the fatty acid composition of milk fat and improve its nutritional properties. Conjugated linoleic acid is a fatty acid that naturally occurs in foods derived from ruminants, with *cis*-9,*trans*-11-CLA (rumenic acid) the predominant isomer of CLA (more than 82% of total CLA) in dairy products (Dilzer and Yeonhwa, 2012). Conjugated linoleic acid could be beneficial for human health because of its anticarcinogenic properties (Dilzer and Yeonhwa, 2012). For this reason, increasing the CLA content of milk may enhance the perceived healthfulness of milk and milk products, and increase the consumption of CLA by humans. Vegetable oils in dairy cow diets generally increase the CLA concentration of milk (Dhiman et al., 2000). However, vegetable oils may alter populations of fiber-digesting microbes in the rumen and reduce fat content in milk, and therefore, they are not usually used in dairy diets (Jenkins and Harvatine, 2014).

The use of processed oilseeds is one possible solution to increase CLA without adversely affecting the

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rumen microbes. Whole soybeans are a good source of protein and energy for dairy cows. Processed soybeans have been generally considered as a source of protein, and several heat-treating processes have been used to increase proportions of RUP in the seeds (Faldet and Satter, 1991; Faldet et al., 1992; McNiven et al., 1994). Roasting and extruding are the most common heat processing techniques applied to whole soybean seeds. Faldet and Satter (1991) reported that cows fed roasted soybeans had higher milk production than those fed extruded soybeans. During the extrusion process, oil vesicles in the soybean seed are damaged. By making the oil more readily available in the rumen, extrusion may then decrease fat content of milk in the same way as feeding free oil (Faldet and Satter, 1991). Although several studies have determined the effects of extruded soybeans on milk fatty acid composition (Chouinard et al., 1997b; Solomon et al., 2000), few studies are available on the effect of roasted soybeans on milk fatty acid profile (Mohamed et al., 1988; Tice et al., 1994).

Different roasting temperatures have been applied to increase the proportions of RUP when roasted soybeans are fed to lactating cows (Faldet et al., 1992). However, little consideration has been given to the effect of different roasting temperatures on the fatty acid composition of milk fat. Application of heat during roasting might protect fat from microbial biohydrogenation in the rumen (Abdi et al., 2013), by denaturing the protein matrix surrounding the fat droplets (Khorasani et al., 1992) or by binding peroxides of UFA with amino groups of proteins (Abel-Caines et al., 1998), and thus increasing the concentrations of PUFA in milk. Another common source of fat in dairy ration is calcium salts of FA (**Ca-FA**). Few studies are available comparing Ca-FA and roasted soybeans on cow performance and milk fatty acid composition, and we are aware of no studies considering the effect of roasting temperature on milk fatty acid profile.

The objectives of this study were (1) to determine whether roasting soybeans, as well as roasting temperature, could affect the fatty acid composition of milk fat, (2) to compare effects of roasted soybeans with those of Ca-FA on CLA content and fatty acid profile of milk, and (3) to investigate the effect of soybeans roasted at different temperatures and compare their effect with that of Ca-FA on the performance of dairy cows.

MATERIALS AND METHODS

The study was conducted under protocols previously approved by the Animal Care and Use Committee of the Iranian Council of Animal Care (1995). The experiment was conducted at the Farm Animal Research and Teaching Unit of Isfahan University of Technology in the region of Lavark near Najaf-Abad, Iran.

Experimental Design, Cow Management, and Treatments

Eight lactating Holstein cows were used in a duplicated 4 × 4 Latin square design consisting of 21-d periods, of which 16 d were used as the adaptation period followed by 5 d for sampling and data collection. Four multiparous (third parity, 90 ± 18 DIM, BW = 631 ± 33 kg, milk production = 44.2 ± 3.9 kg/d; mean ± SE) and 4 primiparous (95 ± 12 DIM, BW = 548 ± 32 kg, milk production = 41.8 ± 1.8 kg/d; mean ± SE) Holstein cows were used in the experiment. Cows within square were randomly assigned to dietary sequences arranged to minimize carryover effects. Throughout the experiment, each cow was housed in a box stall (4 × 4 m) in a roofed barn with open sides. Each box stall was bedded with clean wood shavings refreshed twice daily. Each stall had a concrete feed bunk and automatic water troughs.

Dietary treatments included treatment 1, a TMR containing Ca-FA and lignosulfonate-treated soybean meal (**SBM**) as a control diet (**CON**); treatment 2, a TMR containing soybeans roasted at 115°C (**RS115**); treatment 3, a TMR containing soybeans roasted at 130°C (**RS130**); and treatment 4, a TMR containing soybeans roasted at 145°C (**RS145**). Ingredient composition and chemical composition of the diets are presented in Tables 1 and 2. The forage to concentrate ratio was 40:60 on a DM basis, with corn silage and chopped alfalfa hay as the forage components. Prior to feeding, alfalfa hay was chopped with a theoretical length of 30 mm using a harvesting machine with screen size regulator (Golchin Trasher Hay Co., Isfahan, Iran). Corn silage was used from the silo and sampled on a weekly basis for DM content, and its inclusion in the TMR was adjusted accordingly. Dry matter content of corn silage samples was determined after drying at 60°C in a forced-air oven for 48 h (Faldet et al., 1992). Barley and corn grains were ground using a hammer mill with 3-mm screen size (model 5543 GEN, Isfahan Dasht, Isfahan, Iran). In diets 2, 3, and 4, soybeans roasted at 115, 130, or 145°C were included at the expense of SBM, lignosulfonate-treated SBM, and Ca-FA used in diet 1. Soybeans were roasted for 10 min and immediately cooled after roasting by horizontal cooler (Bisotun Co., Isfahan, Iran). The roasted soybeans were ground by passing them through a hammer mill (model 55, Gehl Company, West Bend, WI) with a 9-mm screen size. The geometric mean particle size of ground soybeans was then calculated using the dry-sieving technique