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EFFECT OF FEEDING DE-OILED WET DISTILLERS GRAINS PLUS SOLUBLES ON BEEF SHELF LIFE

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Abstract - This research was conducted to determine the effect of feeding de-oiled wet distiller's grains plus solubles (WDGS) on beef shelf life. Steers were fed one of seven dietary treatments: an all corn control, 35%, 50%, or 65% inclusion of WDGS, either full-fat or de-oiled. Fifteen low Choice carcasses were selected within each treatment (n = 105) and strip loins were obtained. Samples were aged 7 and 21 days and placed in retail display (RD) for 7 days. Composition and tenderness of beef was unaffected by dietary treatment. Finishing diet affected the C16:1 (greater for corn control and 35% de-oiled WDGS), C18:1T (greater for full-fat WDGS, intermediate for de-oiled WDGS and least for corn control), C18:2 and polyunsaturated fatty acids (PUFA) (greater for 65% de-oiled WDGS and all full-fat WDGS) content of beef. After 21 days of aging, and 5 days of RD de-oiled WDGS diets resulted in greater color stability (less discoloration, *P*<0.0001). De-oiled WDGS and 50% full-fat WDGS had less oxidation (*P*<0.0001). With prolonged aging periods and RD, feeding de-oiled WDGS has the potential to reduce oxidation compared to full fat WDGS and thus extend shelf life.

I. INTRODUCTION

Feeding wet distillers grains plus solubles (WDGS) is a common practice in the state of Nebraska as WDGS are a corn by-product from ethanol production that lowers production cost while providing great nutritional value and is widely available to producers. Previous research done at the University of Nebraska-Lincoln has found that feeding WDGS increases the PUFA content of beef, which in turn results in greater oxidation (1, 2). More recently, ethanol plants have been extracting soluble fats found in WDGS via centrifugation in order to maximize profits (3). It was reported that in 2012 over 50% of ethanol plants were removing the soluble fat portion of WDGS and this percentage continues to grow (4). Given the growing availability of de-oiled WDGS in the market, it is imperative to understand how these finishing diets will affect beef quality. Thus, the objective of this study was to evaluate how feeding de-oiled WDGS affected fatty acid profiles, lipid oxidation, and beef shelf life.

II. MATERIALS AND METHODS

A total of 336 steers were fed one of seven finishing diets: an all corn control (1:1 blend of dry-rolled and high moisture corn), 35%, 50%, or 65% inclusion of WDGS, either full-fat or de-oiled. All WDGS were from a single plant and steers were finished for 147 days. At harvest, fifteen low Choice carcasses were selected within each treatment (n = 105) and strip loins were obtained. Loins were vacuum packaged and aged for 7 and 21 days (0.5°C). After 7 day of aging, loins were fabricated into 2.54 cm steaks for visual discoloration and tenderness, and 1.27 cm steaks for fatty acid profile, proximate composition and lipid oxidation. The remaining portion of the loin was vacuum sealed and the same fabrication map was used at 21 days postmortem. At both aging periods, samples for visual discoloration, tenderness and thiobarbituric acid reactive substances (TBARS) were placed on foam trays and overwrapped with oxygen permeable film and placed under retail display conditions for four and seven days (2.7°C under white fluorescence lighting at 1000 to 1800 lux). Steaks used for fatty acid profile, proximate composition and zero day RD were vacuum packaged and frozen for further analysis (-80°C).

Visual discoloration was assessed daily during RD with a trained five-person panel. A percentage scale was used were 0% meant no discoloration and 100% meant complete discoloration.

Tenderness was measured via Warner-Bratzler Shear Force (WBSF). Samples were thawed (0.5°C) 24 hours prior to cooking and internal temperature was monitored with a thermocouple inserted in the geometric center of each steak. Steaks were cooked on Hamilton Beach grills until they reached an internal temperature of 35°C at which time they were flipped. The final internal temperature was 71°C. Cooked steaks were refrigerated for 24 hours and six cores were taken parallel to the muscle fiber and sheared using a portable Warner-Bratzler shear machine.

Fatty acid profiles were obtained via gas chromatography (5). Frozen samples, free of subcutaneous fat, were diced, flash frozen with liquid nitrogen and then powdered. Chromatography was done using a Chromopack CP-Sil (0.25 mm x 100 m) column with an injector temperature of 270°C and a detector temperature of 300°C. The head pressure was set at 40 psi with a flow rate of 1.0 ml/min. The fatty acids were identified by their retention times in relation to known standards and the percentage of fatty acids were determined by the peak areas in the chromatograph. Values were adjusted according to percent fat and values were converted to mg/100 tissue.

Proximate composition was done to determine fat, moisture and ash; protein was determined by difference. Ether extraction was used to quantify fat content. Moisture and ash were determined with a LECO thermogravimetric analyzer.

Lipid oxidation was determined with the TBARS protocol. Frozen samples, free of subcutaneous fat, were flash frozen in liquid nitrogen and powdered. Five grams of sample were used to conduct the TBARS protocol (6).

Statistical analysis was done with SAS. The experimental design was a 2x3+1 factorial where the main effects of dietary treatment, aging, RD, and their interactions were tested. The Proc Mixed procedure was used for repeated measures of visual discoloration. The Proc Glimmix procedure was used to evaluate all other variables measured. All means were separated with the LS MEANS statement and the TUKEY adjustment was used with an alpha level of 0.05.

III. RESULTS AND DISCUSSION

Proximate composition & Fatty acid profiles

Finishing diet had no effect on moisture (71.70%), fat (6.48%), protein (20.26%) or ash (1.56%) content in beef ($P > 0.05$). Differences were found in the C16:1, C18:1T, C18:2 and polyunsaturated fatty acids (PUFA) between dietary treatments. Palmitoleic acid (C16:1) was predominant in the corn control and 35% de-oiled WDGS ($P < 0.0001$) but no differences were found between 50% and 65% de-oiled WDGS and all full-fat WDGS diets (Figure 1).

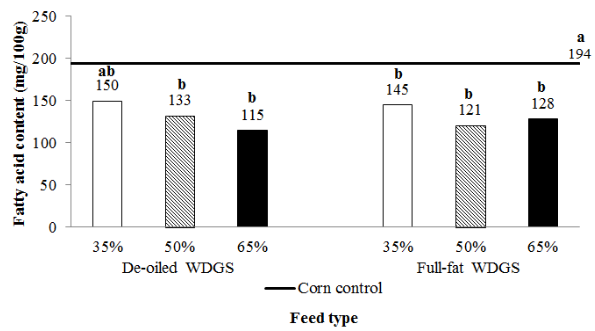

Figure 1. C16:1 differences among diets
Different superscripts indicate differences (P < 0.05)

Elaidic acid (C18:1T) content was lowest for the corn control, intermediate for all de-oiled WDGS, and greater for all full-fat WDGS diets (120.12 mg/100g, 185.13 mg/100g, and 250.93 mg/100g, respective average values; Figure 2). Linoleic acids (C18:2) were least for corn control and 35% de-oiled WDGS (177.70 mg/100 g and 227.16 mg/100 g, respectively), intermediate for 50% de-oiled WDGS (231.08 mg/100 g), and greatest for 65% de-oiled WDGS and all full-fat WDGS diets (287.89 mg/100 g, 294.87 mg/100 g, 279.78 mg/100 g and 301.36 mg/100 g, respectively; Figure 3).

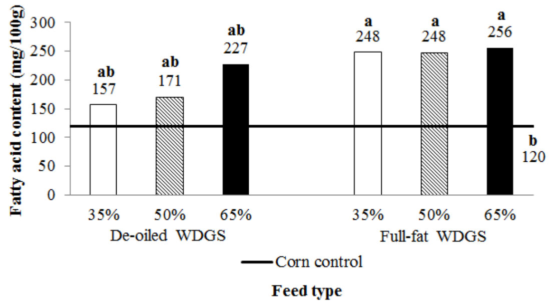

Figure 2. C18:1T differences among diets
Different superscripts indicate differences (P < 0.05)

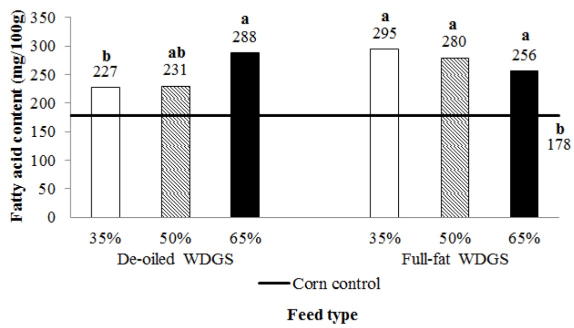

Figure 3. C18:2 differences among diets
Different superscripts indicate differences (P < 0.05)

The polyunsaturated fatty acid (PUFA) content was different (*P* = 0.0002) among diets, where beef from cattle fed the corn control had the least amount of PUFA's (223.98 mg/100 g), 35% and 50% de-oiled WDGS cattle were intermediate (273.77 mg/100 g and 273.84, respectively), and 65% de-oiled WDGS and the three full-fat WDGS cattle had the greatest amount of PUFA's (335.03 mg/100 g, 341.54 mg/100 g, 324.15 mg/100 g, and 347.79 mg/100 g, respectively; Figure 4).

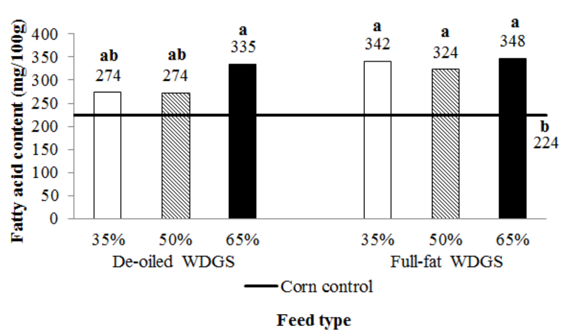

Figure 4. Polyunsaturated fatty acid differences among diets
Different superscripts indicate differences (P < 0.05)

Visual discoloration

Dietary treatment had no effect on discoloration in samples aged for 7 days (*P* > 0.05). After 21 days of aging, discoloration was significant at 5 days of RD (*P* < 0.0001) and all samples surpassed 50% discoloration by day 7 of RD (Table 1). At day 5 RD, meat from the corn control had the most discoloration (20.03%) and was as equally discolored as 50% de-oiled WDGS and 65% full-fat WDGS (15.42% and 14.98%, respectively). At day 6 RD, 65% full-fat WDGS had the most discoloration (50.30%) followed by 65% and 50% de-oiled WDGS (40.20% and 39.50%, respectively). By day 7 RD, 65% full-fat and 65% de-oiled WDGS showed the most discoloration (76.72% and 69.88%, respectively) while 35% de-oiled WDGS presented the least discoloration (52.98%).

Table 1. Discoloration (%) of strip loin steaks (*L. dorsi*) aged 21 days at days 5, 6 & 7 retail display (*P* < 0.0001)

	Days on retail display		
Dietary Treatment	5	6	7
35% De-oiled WDGS	4.35^{c}	17.75^{d}	52.98^{d}
50% De-oiled WDGS	15.42^{ab}	39.50^{b}	67.75^{b}
65% De-oiled WDGS	9.38^{bc}	40.20^{b}	69.88^{ab}
35% Full-fat WDGS	4.48^{c}	25.83^{c}	67.67^{b}
50% Full-fat WDGS	11.95^{bc}	31.30^{c}	57.30^{cd}
65% Full-fat WDGS	14.98^{ab}	50.30^{a}	76.72^{a}
Corn control	20.03^{a}	31.77^{c}	60.60^{c}

$^{a-d}$ Means in the same column with different superscripts are different (*P* < 0.05)

Lipid oxidation

Lipid oxidation, measured by TBARS, indicated there was an age x RD interaction, where increased oxidation rate was seen with increased aging. Dietary treatment had an effect on lipid oxidation (*P* < 0.0001; Table 2). The corn control was found to have the greatest amount of oxidation (1.98 mg/kg), and was not statistically different from 35% full-fat WDGS (1.78 mg/kg) and 65% full-fat WDGS (1.78 mg/kg). These oxidation measures suggest that all de-oiled

WDGS diets and the 50% full-fat WDGS diet had less oxidation than the corn control and several of the full-fat WDGS.

Table 2. TBARS dietary treatment means

Dietary Treatment	Mean
35% De-oiled WDGS	1.12[c]
50% De-oiled WDGS	1.13[c]
65% De-oiled WDGS	1.21[bc]
35% Full-fat WDGS	1.78[ab]
50% Full-fat WDGS	1.18[c]
65% Full-fat WDGS	1.78[ab]
Corn control	1.98[a]
SEM	0.14
P-value	<0.0001

[a - c] Means in the same column with different superscripts are different ($P < 0.05$)

Tenderness

There was an increase in tenderness from 7 to 21 days of aging ($P < 0.0001$) and, as RD progressed ($P < 0.0001$), dietary treatment had no effect on WBSF ($P = 0.57$).

IV. CONCLUSION

At 7 days of aging, dietary treatment had no effect on RD discoloration and all samples had an increase in oxidation regardless of the treatment. However, at 21 days of aging, feeding de-oiled WDGS had less oxidation compared to the corn control and several of the full-fat WDGS treatments. Feeding de-oiled WDGS resulted in decreased PUFA content in comparison to a full-fat WDGS finishing diet which proved to extend beef shelf life at longer aging periods.

De-oiled WDGS are currently the feed of choice in Nebraska for beef finishing diets. The removal of the soluble oil fraction of WDGS is not only advantageous to ethanol plants as they maximize profits, it is especially positive for the local and export market of beef given its extended shelf life. It would now be interesting to study the addition of antioxidants to further extend beef shelf life of cattle finished with de-oiled WDGS.

ACKNOWLEDMENTS

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