Effect of the Programmed Nutrition Beef Program on moisture retention of cooked ground beef patties and enhanced strip loins


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Effect of the Programmed Nutrition Beef Program on moisture retention of cooked ground 
beef patties and enhanced strip loins$^{1,2}$

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ABSTRACT:
This study evaluated the influence of the Programmed Nutrition Beef Program and exogenous growth promotants (ExGP) on water holding capacity characteristics of enhanced beef strip loins. Sixty, frozen strip loins, arranged in a 2 × 2 factorial treatment arrangement with dietary program serving as the first factor and use of ExGP as the second factor, were thawed, injected with an enhancement solution, and stored for 7 d. Loins from ExGP cattle possessed the ability to bind more ($P < 0.05$) water before pumping and bind less ($P < 0.05$) water after pumping and storage. Loin pH across treatments was similar ($P > 0.10$) before injection, but increased post-injection and after storage ($P < 0.01$). Treatments did not affect loin purge loss, steak cook loss, and expressible moisture ($P > 0.10$). The Programmed Nutrition Beef Program and use of ExGPs minimally impacted water holding capacity of enhanced frozen/thawed beef strip loins.

Keywords: Water-holding; Beef; Ractopamine; Feeding, Enhancement
1. Introduction

The goal of the beef industry is to produce a consistent, high quality product as efficiently as possible. Many different feedlot management strategies are employed to maximize efficiency including the utilization of different feed additives such as monensin (Rumensin; Elanco Animal Health, Greenfield IN) and tylosin (Tylan; Elanco Animal Health), and growth promoting technologies such as beta-adrenergic agonists and steroidal implants. Utilization of feed additives, implants, and beta-adrenergic agonists can greatly improve efficiency of beef production, but also can have negative consequences for beef quality (Winterholler et al., 2008). Beef palatability encompasses characteristics such as juiciness, tenderness, and flavor (Platter, Tatum, Belk, Scanga, & Smith, 2003), but water-holding capacity also impacts beef palatability. The ability of whole muscle or ground beef to retain moisture during storage and through processing is an important quality characteristic. It is established moisture loss from whole muscle products can impact the amount of salable product (Offer et al., 1989; Huff-Lonergan and Lonergan, 2005). Although cook yields of ground beef can be mostly dependent on fat content of the blend (Roth, McKeith, & Brewer, 1999), the ability of product to retain water during processing and cooking could also be important.

The Programmed Nutrition Beef Program (Alltech Inc., Nicholasville, KY) consists of two products that are designed to replace components of conventional feedlot diets. The Programmed Nutrition Beef Receiver is intended to be fed during the step-up period at the rate of 14 g•animal⁻¹•d⁻¹, while Programmed Nutrition Beef Finisher is fed for the remainder of the finishing period at a rate of 20 g•animal⁻¹•d⁻¹. Previous research by Phelps et al. (2014) reported the use of Programmed Nutrition Beef Program supplements in finishing feedlot diets decreased purge loss of strip loins aged 14 d compared to strip loins from steers fed a diet containing
conventional feedlot dietary components. Additionally, steaks from steers fed the Programmed Nutrition Beef Program supplements and steaks from steers that were not administered exogenous growth promotants (ExGP) had a decreased cook loss when compared to steaks from the conventional feedlot diet and administered ExGP, respectively. The objectives of this study were to evaluate influence of the Programmed Nutrition Beef Program and ExGPs on moisture retention of 85% lean ground beef patties, brine uptake and retention, objective water holding capacity, and Warner-Bratzler shear force (WBSF) of strip loins that were thawed from a frozen state and enhanced 110% with a salt/tripolyphosphate solution.

2. Materials and Methods

2.1 Animals

Crossbred feedlot steers (initial BW 383 kg ± 30; \( n = 64 \) pens; 16 pens/treatment; 8 steers/pen) were blocked by body weight and subjected to a randomized complete block design with 2 × 2 factorial treatment arrangement. Steers were separated into a conventional finishing program treatment (CON) or Alltech Programmed Nutrition Beef Program treatment (PN; Table 1). Conventional diets contained monensin, tylosin, vitamins A and E, and supplemented trace minerals including copper sulfate, cobalt carbonate, ethlenediamine dihydriodide, manganous sulfate sodium selenite, and zinc sulfate. The Programmed Nutrition Beef Receiver portion of the diet was included in the total mixed ration for the first 21 d at a rate of 14 g\( \text{animal}^{-1} \cdot \text{d}^{-1} \). The Programmed Nutrition Beef Finisher was included in the total mixed ration at a rate of 20 g\( \text{animal}^{-1} \cdot \text{d}^{-1} \) for the final 154 d of the feeding period. The components of the Alltech Programmed Nutrition Beef Program diet were premixed into a ground corn carrier and subsequently blended into the total mixed ration. Both the Programmed Nutrition Beef Receiver and Finisher supplements contained a proprietary blend of organic trace elements, ascorbic acid,
Lactobacillus acidophilus fermentation product, Enterococcus faecium fermentation product, and selenium yeast. Additionally, Programmed Nutrition Beef Receiver included Aspergillus niger fermentation extract and Programmed Nutrition Beef Finisher included Aspergillus oryzae fermentation extract. Each diet was fed in conjunction with (EGP+) or in the absence of (EGP–) exogenous growth promotants (ExGP). Steers receiving ExGP were administered a Component E-S implant on d 1 of the study, reimplanted with Component TE-IS (Elanco Animal Health) on d 94, and fed ractopamine hydrochloride (RAC; Elanco Animal Health) at a rate of 400•d−1•steer−1 the final 28 d before harvest.

2.2 Loin collection

On d 175 of the study, animals were shipped 430 km to a commercial abattoir (Tyson Fresh Meats, Holcomb, KS) for harvest. After a 36-h chill, strip loins (Institutional Meat Purchase Specifications 180) were removed from the left side of 2 carcasses selected at random from each pen and were transported back to the Kansas State University Meats Laboratory. Loins were wet-aged for 14 d, 5 steaks were fabricated from the anterior portion of the Longissimus lumborum for another study (Phelps et al., 2014), and the remainder of the Longissimus lumborum was frozen at -40 ºC.

2.3 Loin Selection and Sampling

The posterior portion of the Longissimus lumborum of sixty frozen beef strip loins (n = 15 per treatment) were selected at random from the previous study (Phelps et al., 2014). For the injection study, loins selected were large enough to be injected (smallest loin = 0.58 kg), and also yielded 500 g of tissue for grinding. This resulted in a sample distribution that represented all 16 of the original weight blocks and 52 of the pens of the Phelps et al. (2014) study.

2.4 Loin processing and injection
Forty-eight hours prior to processing, strip loins were removed from the freezer and thawed at 2 ± 1 °C. Once thawed, all subcutaneous fat was removed from each loin, identified by loin number, and reserved for subsequent preparation of ground beef patties. From each trimmed loin, approximately 500 g of muscle was removed for grinding from the most anterior portion of each loin. Additionally, a 120-g sample was removed for measurement of expressible moisture (EM) and water binding ability (WBA) as described below. Before injection, pH was measured using a pH probe designed for use in meat (Model HI 99163; Hanna Instruments, Smithfield, RI) and loin sections were weighed. Loin sections were injected using a multi-needle injector (Model N50: Schröder Maschinenbau GmbH, Werther, Germany) with a brine solution (pH 7.95) which contained 5% sodium chloride and 3% sodium tripolyphosphate (Brifisol 85 Instant; BK Giulini Corp., Simi Valley, CA) to achieve a 0.5% sodium chloride and 0.3% sodium tripolyphosphate level within the muscle when pumped 10% over green weight. Following a 2-min rest period, loins were reweighed to ensure brine was assimilated to achieve 110% above green weight (average 111.14 ± 1.46%) and pH was recorded again before injected loins were vacuum packaged in 3-mm high-barrier vacuum pouches (Prime Source, Bunzyl Processor Division, Kansas City, MO). After storage for 7 d at 2 ± 1 °C, loins were removed from packages, patted dry, and re-weighed for purge loss calculations [{(injected weight - stored weight) / injected weight}] × 100. At this time, pH was measured, a 120-g sample was removed for expressible moisture and WBA analyses, and a 2.54-cm thick steak was fabricated for determination of WBSF.

2.5 Grinding

To formulate a ground beef blend that was 85% lean and 15% fat, analyzed fat percentages from proximate analysis were used to calculate a blend for each sample. Using a
table top grinder (Model KG-12-FS; Pro-Cut, Houston, TX), lean and fat for each sample were
ground separately through a 9.5-mm plate, blended together by hand, and then reground through
a 3.2-mm plate. Once ground, two 1.2-cm thick × 10.7-cm wide patties weighing 112 g were
formed from each sample.

2.6 Cooking and Warner-Bratzler shear force

All cooking and WBSF procedures were conducted according to the Meat Cookery and
Sensory Guidelines (AMSA, 1995). Ground beef patties were weighed before cooking and
cooked on a flat top grill (Model 106733; Walmart, Bentonville, AR) set to 132 °C. Patties were
turned at 1 min, turned again at 2 min, and then turned every 2 min until they reached an internal
temperature of 71 °C. A hypodermic needle thermometer consisting of a copper-constantan probe
connected to a Doric Trendicator 410A monitor (VAS Engineering; San Francisco, CA) was
used to monitor internal temperature. Patties were cooled at room temperature and once they
could be handled they were reweighed to determine cook loss [(precooked weight-cooked
weight)/precooked weight] ×100.

Prior to cooking, steaks were weighed and a thermocouple wire (30-gauge copper-
constantan; Omega Engineering, Stamford, CT) was inserted into the geometric center of each
steak to monitor internal temperature using a Doric Minitrend 205 monitor (VAS Engineering).
Steaks were cooked on electric, open-hearth Hamilton Beach grills (Indoor/Outdoor; Southern
Pines, NC) preheated to 204 °C. Steaks were turned when they reached an internal temperature
of 40 °C, removed from grills at 70 °C, and allowed to cool until they could be handled before
being reweighed to determine cook loss [(precooked weight-cooked weight)/precooked weight]
×100. Steaks were chilled for 24 h at 7 ± 1 °C, and six 1.27-cm cores were then removed from
each steak parallel to the muscle fiber. Cores were sheared once through the center using an
INSTRON Model 5569 testing machine (Instron, Canton, MA) with a Warner-Bratzler shear
head attached (100-kg compression load cell, crosshead speed of 250 mm/min).

2.7 Water binding ability and expressible moisture

The WBA of samples was measured by protein swelling analysis as described by
Pietrasik and Janz (2009) with a modification. The modification made was the 100-g sample of
muscle was cut into 0.5 × 0.5 × 0.5 cm pieces and then blended in a Waring blender (Waring
Products Division, Hartford, CT) with 300 mL of distilled water. The remainder of the procedure
was carried out as described by the authors.

Expressible moisture of samples was measured using the centrifugation method described
by Jauregui, Regenstein, and Baker (1981). A 5-g sample of muscle was weighed, placed in a 50
mL conical tube on top of 25 g of 4-mm glass beads, and centrifuged at 900 × g for 10 min. After
centrifugation, samples were removed from tubes and reweighed. Percent EM was calculated as

\[
\text{Percent EM} = \left(\frac{\text{initial weight} - \text{centrifuged weight}}{\text{initial weight}}\right) \times 100.
\]

2.8 Statistical analyses

Purge loss, cook loss, and WBSF data were analyzed as a randomized complete block
design with a 2 × 2 factorial arrangement. Dietary program and ExGP served as the main effects
and the animal weight block from Phelps et al. (2014) was the random effect. For loin pH,
expressible moisture, and WBA, data were analyzed as repeated measures using a randomized
complete block design with a 2 × 2 factorial treatment arrangement. Period served as the
repeated measure with loin (observational unit) as the subject and compound symmetry as
covariance structure. The PROC MIXED procedure of SAS (SAS Inst. Inc., Cary, NC) was
utilized and pair-wise comparisons between the least-squares means of the factor levels were computed using the PDIFF option of the LSMEANS statement. Differences were considered significant at $\alpha \leq 0.05$ and tendencies at $\alpha \leq 0.10$.

3. Results

3.1 Loin pH

Loin pH was recorded at three periods: before injection, after injection, and after 7-d of storage post injection (Table 2). There was no three-way interaction ($P = 0.55$) of dietary program $\times$ ExGP $\times$ period for pH. Also, the two-way interaction of dietary program $\times$ ExGP did not affect ($P = 0.39$) loin pH, but there was a tendency ($P = 0.10$) for a dietary program $\times$ period interaction to affect loin pH. Pre-injection, the pH of CON and PN loins was similar ($P = 0.75$), but post-injection PN loins had a greater ($P = 0.002$) pH than CON loins. Additionally, the post-injection pH of loins from both CON and PN loins increased ($P < 0.01$) by 0.37 and 0.32 units compared to their pre-injection pH, respectively. The pH recorded for both dietary treatments after 7 d of storage was similar to that recorded post-injection ($P > 0.15$); however, there was no difference ($P = 0.50$) in pH between the two dietary treatments after 7 d of storage. Also, pH data indicate an ExGP $\times$ period interaction ($P = 0.02$). Pre-injection pH was similar ($P = 0.88$) between EGP+ and EGP- loins. Post-injection pH of EGP- loins was greater ($P = 0.001$) than EGP+ loins, but pH recorded after 7-d of storage was similar ($P = 0.89$) between the two treatments. The pH of loins from the two dietary treatments differed with PN loins having a pH that was 0.04 units greater ($P = 0.02$) than CON loins. Additionally, there was a tendency ($P = 0.052$) for pH difference between the two ExGP treatments. Finally, as expected, period elicited an effect ($P < 0.01$) on the pH of loins. Before injection, the pH of loins was 5.53, and post-
injection pH was 0.32 units greater \( (P < 0.01) \). The pH recorded after 7 d of storage was comparable \( (P = 0.77) \) to post-injection pH.

### 3.2 Purge loss, cook loss, and WBSF

For purge loss, steak cook loss, and ground beef cook loss there was no two-way interaction of dietary program \( \times \) ExGP (Table 3; \( P > 0.34 \)). Also, the main effect of dietary program did not affect purge loss, steak cook loss, and ground beef cook loss \( (P > 0.35) \).

Additionally, the ExGP effect did not impact purge loss or steak cook loss \( (P > 0.23) \), but there was a tendency \( (P = 0.08) \) for ExGP use to affect ground beef cook loss with ground beef patties from the EGP- tending to have a cook loss 1.06\% greater than the EGP+ treatment.

Warner-Bratzler shear force was measured on strip loin steaks fabricated from enhanced loins (Table 3). There was a tendency \( (P = 0.06) \) for a dietary program \( \times \) ExGP interaction to affect shear force. Dietary program influenced \( (P = 0.05) \) WBSF of steaks from enhanced loins.

The shear force of steaks from PN loins was 0.15 kg less \( (P = 0.05) \) than the shear force of steaks from CON loins. The use of ExGP during the finishing phase did not impact \( (P = 0.54) \) shear force of steaks fabricated from enhanced loins.

### 3.3 Expressible moisture and water binding ability

There was no dietary program \( \times \) ExGP \( \times \) period interaction for EM or WBA (Table 4; \( P > 0.36 \)). The two-way interactions of dietary program \( \times \) ExGP or dietary program \( \times \) period did not affect EM or WBA (Table 5; \( P > 0.84 \)). The ExGP \( \times \) period interaction did not impact \( (P = 0.13) \) EM, but did influence WBA \( (P < 0.01) \). Before injection, EGP+ loins had greater \( (P = 0.01) \) WBA compared to EGP- loins. After loins were injected and stored EGP- loins had a
greater \((P < 0.01)\) WBA than EGP+ loins. Finally, the main effects of dietary program and ExGP did not impact EM or WBA \((P > 0.21)\).

4. Discussion

Beef palatability is influenced by many attributes, including tenderness, marbling, texture, juiciness, and flavor profile (Miller, Carr, Ramsey, Crockett, & Hoover, 2001). These attributes can be influenced by a wide range of factors, including genetics, age, diet, pre-harvest management, and post-mortem processing (Hocquette, et al., 2012). Although the amount of marbling often influences juiciness the most (O’Quinn et al., 2011), water holding capacity of beef may also play a role in a consumer’s beef eating experience (Winger & Hagyard, 1994). Intrafiber water content has been suggested to impact meat tenderness (Currie & Wolfe, 1980) and could potentially impact overall palatability of beef. In addition to influencing palatability, poor water holding capacity of products can result in loss of salable weight for processors and retailers (Huff-Lonergan and Lonergan, 2005).

Water holding capacity of beef and other meat products is largely influenced by pH (Honikel, 2004). When meat reaches its isoelectric point the net charge of proteins is zero. This effectively decreases the amount of water held between proteins as a result of the close association between positively and negatively charged protein moieties. When the pH of meat is transitioned away from its isoelectric point, water holding capacity improves (Aberle et al., 2003). The increase in meat pH following the use of phosphates in brine solutions is well documented (Smith, Simmon, McKeith, Bechtel, & Brady, 1984; Robbins et al., 2002; Wicklund et al., 2005). In the present study, the common increase in pH due to brine injection was duplicated. Loin pH recorded post-injection and after 7 d of storage were increased by 0.32 and
0.33 pH values, respectively when compared to pH recorded prior to injection. Similar to the present study, Wicklund et al. (2005) reported increases in muscle pH (0.32 units) when beef strip steaks were enhanced with a brine containing phosphates. Pietrasisk and Janz (2009) reported a smaller pH increase of 0.23 units in enhanced beef Semitendinosus steaks compared to non-enhanced steaks, while Robbins et al. (2002) observed that pH values of enhanced beef rounds were 0.28 units greater compared to non-enhanced rounds. Finally, Grobbel, Dikeman, Hunt, & Milliken (2008) reported that pH of enhanced Longissimus, Semitendinosus, and Triceps brachii steaks were 0.3, 0.2, and 0.2 units higher, respectively, compared to non-enhanced steaks. The current data also indicate that the ExGP × period interaction, dietary treatment, and ExGP treatment affected pH. When examining the differences closely, the differences in pH are all less than 0.10, which presumably would have a relatively small biological effect on water holding characteristics. Therefore, any treatment differences in water binding characteristics, cook loss, WBSF post-injection and storage occurred independent of pH.

Water binding ability measures the capacity of muscle to assimilate and retain additional water. In the current study, the WBA of EGP+ loins was greater than EGP- loins prior to enhancement and storage. After enhancement, WBA of EGP+ loins were less than EGP- loins. Because there were no differences in purge loss, the WBA data may indicate EGP+ were incapable of retaining additional moisture after they were enhanced 110%. Pietrasik and Janz (2009) found that freezing greatly reduced the WBA of meat and injection with a 1.5% phosphate solution increased WBA over injection with a 0.5% phosphate solution. Since all meat was frozen and the same brine solution was utilized on all loins, these factors can be eliminated as contributing to the ExGP difference. It is feasible that increased WBA of EGP+ loins was due to an increase in cross-sectional areas of type IIA and type IIX fibers as reported by Phelps et al.
Offer and Trinick (1983) stated that the majority of water present in meat is located within myofibrils, and these authors demonstrated that the degree of swelling by myofibrils observed after injecting brine solution was similar to the amount of water retained by the muscle. Therefore, since EGP+ loins possessed greater muscle fiber cross-sectional area as reported by Phelps et al. (2014), they likely possessed more myofibrils with which to bind the brine solution.

Previously, Phelps et al. (2014) reported that fresh loins from PN Beef Program supplemented steers had less purge loss during storage and also lost less weight during cooking compared to their CON counterparts. Additionally, the authors observed similar moisture retention properties for loins from cattle produced without ExGPs compared to those from cattle produced with ExGPs. The moisture retention advantages observed by Phelps et al. (2014) were expected to be duplicated in the meat systems examined in the present study. Data in this study indicate that when loins from all pre-harvest treatments were subjected to needle-injection enhancement, there are no differences in purge loss or cook loss. Numerous studies indicate that enhancement of fresh meat can affect both purge loss and weight loss during cooking. In a study in which purge loss was compared between non-enhanced and enhanced beef and bison steaks, Pietrasik, Dhanda, Shand, and Pegg (2006) reported that enhanced steaks lost 0.97% more purge than non-enhanced steaks. In contrast, Pietrasik and Janz (2009) reported that enhanced Semitendinosus steaks lost less purge than non-enhanced samples. McGee, Henry, Brooks, Ray, & Morgan (2003) reported that injecting beef round roasts with a brine decreased weight loss during cooking by 7.65% compared to non-injected controls, while Pietrasik and Shand (2005) reported injection of Semimembranosus roasts decreased weight loss during cooking by 11.9%.

When compared to the Phelps et al. (2014) results, the lack of purge and cook loss differences of enhanced loins and steaks in the current study may be a function of freezing and
thawing of the loins prior to enhancement. Expressible moisture, which is greatly related to
moisture retention during storage and cooking, was unaffected by treatment before or after
enhancement. This could indicate that freezing/thawing may have masked the fresh meat
treatment related differences in moisture retention properties that were observed by Phelps et al.
(2014). Boles and Swan (2002) reported that beef inside rounds that were frozen prior to
injection retained 1% more brine solution than fresh injected rounds. The authors concluded that
the disruption of the protein structure due to freezing (Polymendis, 1978) allowed for increased
brine uptake. Pietrasik and Janz (2009) found that when frozen/thawed meat was stored 7 d post-
injection, expressible moisture was drastically improved when compared to frozen/thawed meat
stored 1 d post injection. Since Phelps et al. (2014) did not measure expressible moisture prior to
freezing, it is impossible to determine the effect of freezing/thawing on this water holding
characteristic.

Enhancement of beef cuts with brine solutions has become a more common production
practice to alleviate tenderness issues (McGee et al., 2003). Regardless of treatment, average
reduction in shear force compared to Phelps et al. (2014) reported values were 13.0 N for all
steaks. Although it must be acknowledged the reduction in shear force of the enhanced steaks
may also be a function of freezing. Robbins et al. (2002) reported shear force of enhanced
Semimembranosus steaks was 0.52 kg lower than non-enhanced controls. In a study on the
enhancement of beef chuck muscles, Molina, Johnson, West, & Gwartney (2005) found needle
injection reduced WBSF of oven-roasted Complexus and Subscapularis steaks and grilled
Triceps brachii steaks compared to non-injected controls by 11.7, 12.7, and 9.9 N, respectively.
Also, Grobbel et al. (2008) examined the enhancement of Longissimus lumborum,
Semitendinosus, and Triceps brachii steaks and reported needle injection decreased WBSF by
1.73, 1.25, and 1.25 kg, respectively compared to non-injected controls. In contrast to the results of Phelps et al. (2014), the data in the present study indicated that enhanced CON steaks were 1.5 N more tender than enhanced PN steaks. Miller et al. (2001) reported that consumers can distinguish between tenderness classifications at WBSF values of 0.30 kg, suggesting that differences in tenderness between the enhanced CON and PN within the present study are unlikely to be detectable by consumers.

The greatest improvement in shear force from the Phelps et al. (2014) values due to enhancement was seen in EGP+ steaks, but there were no shear force differences for pre-harvest use of ExGP versus not using ExGP when loins were enhanced. Enhancement reduced the shear force of EGP+ by 15.2 N compared to values reported by Phelps et al. (2014). Brooks et al. (2010) reported enhancement of strip loins from cattle fed zilpaterol hydrochloride reduced shear force by 0.27 kg. The greater reduction in shear force in the present study compared to Brooks et al. (2010) may have been influenced by freezing and thawing of loins prior to enhancement. As stated before, ice crystals formed during freezing can disrupt protein structure. Two studies (Hiner, Madsen, & Hankins, 1945; Shanks, Wulf, & Maddock, 2002) report lower WBSF of steaks frozen prior to cooking compared to steaks cooked fresh. The combined effects of moisture enhancement and freezing may have caused a much greater reduction in shear force.

Since Phelps et al. (2014) detected differences in fresh steak cook loss due to dietary program or ExGP use, effect of treatments on cook loss from ground beef patties was examined. In contrast to the fresh steak data, there were no differences in moisture loss during cooking of ground beef patties. Two mechanisms could be responsible for this finding. First, as indicated throughout this paper, the cellular disruption events associated with freezing/thawing the meat may have negated the increased moisture retention associated with EGP- and PN treatments.
reported by Phelps et al. (2014). This can be inferred by the fact that all treatment groups had similar expressible moisture percentages prior to pumping, therefore indicating they have similar water binding capacity. The second mechanism responsible for lack of moisture retention differences could be that fat was added to each sample to achieve the same final fat blend. Roth et al. (1999) found that reduced-fat patties possessed more water and less fat in the raw and cooked state than high-fat patties. More importantly, the authors reported that cook loss percentage mirrored fat content of the blend rather than water content of the blend. This would indicate that water binding is more important for ground beef blends made with a lower fat content, and the differences reported by Phelps et al. (2014) may have been masked by adding additional fat to the lean.

5. Conclusion

Injection of frozen/thawed beef loins with 0.5% sodium chloride and 0.3% sodium tripolyphosphate increased loin pH by up to 0.32 units after 7-d of storage. As expected, enhanced steaks had improved WBSF when compared to values reported by Phelps et al. (2014) fresh steaks, but no large differences in WBSF were detected between dietary programs and use of ExGP once steaks were enhanced. Expressible moisture analysis revealed that both before and after injection, there was no differences in treatments to hold water. This finding is reflected in the lack of pre-harvest treatment differences for purge loss and cook loss from ground beef and enhanced steaks during cooking. Although not measured, freezing of the meat may have influenced results in this study, thus warranting further investigation of the impact of freezing on water holding capacity of beef from cattle supplemented PN Beef Program supplements.
Table 1. Diets (dry basis) for steers fed conventional feedlot diets† or Alltech Programmed Nutrition Beef Program‡

<table>
<thead>
<tr>
<th>Ingredient, %</th>
<th>Conventional</th>
<th>Alltech</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet corn gluten feed</td>
<td>35.00</td>
<td>35.00</td>
</tr>
<tr>
<td>Steam-flaked corn</td>
<td>53.55</td>
<td>53.56</td>
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<tr>
<td>Ground wheat straw</td>
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<td>7.00</td>
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<td>Feed additive premix</td>
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<td>-</td>
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<tr>
<td>Mineral/vitamin supplement</td>
<td>2.29</td>
<td>2.23</td>
</tr>
<tr>
<td>Programmed Nutrition supplement</td>
<td>-</td>
<td>2.21</td>
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</table>

†Conventional diets included vitamin A at 2,200 IU/kg; vitamin E at 22 IU/kg; copper sulfate to provide 10 mg/kg Cu; cobalt carbonate to provide 0.15 mg/kg Co; ethylenediamine dihydriodide to provide 0.5 mg/kg I; manganous sulfate to provide 60 mg/kg Mn; sodium selenite to provide 0.3 mg/kg Se; zinc sulfite to provide 60 mg/kg Zn on a dry matter basis; as well as 300 mg•animal⁻¹•d⁻¹ of monensin and 90 mg•animal⁻¹•d⁻¹ of tylosin (Elanco Animal Health; Greenfield, IN).

‡The Alltech diet included Programmed Nutrition Receiver in the total mixed ration for the first 21 days at the rate of 14 g•d⁻¹•steer⁻¹ which contained: zinc proteinate to provide 10.7 mg/kg Zn; manganese proteinate to provide 7.1 mg/kg manganese; cobalt proteinate to provide 1.2 mg/kg cobalt; copper proteinate to provide 2.9 mg/kg copper; calcium iodate to provide 0.6 mg/kg iodine; selenium yeast to provide 0.31 mg/kg selenium on a dry matter basis as well as ascorbic acid, *Aspergillus oryzae* fermentation product, *Lactobacillus acidophilus* fermentation product, and *Enterococcus faecium* fermentation product. Thereafter, Programmed Nutrition Finisher was included in the total mixed ration at the rate of 20 g•d⁻¹•steer⁻¹: 10.7 mg/kg Zn; manganese proteinate to provide 7.1 mg/kg manganese; cobalt proteinate to provide 1.2 mg/kg cobalt; copper proteinate to provide 2.9 mg/kg copper; calcium iodate to provide 0.6 mg/kg iodine; selenium yeast to provide 0.31 mg/kg selenium on a dry matter basis as well as ascorbic acid, *Aspergillus niger* fermentation product, *Lactobacillus acidophilus* fermentation product, and *Enterococcus faecium* fermentation product. Both supplements were premixed into a ground corn carrier and subsequently blended into the total mixed ration.
<table>
<thead>
<tr>
<th></th>
<th>Conventional</th>
<th>Alltech PN</th>
<th>P – value</th>
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<tr>
<td></td>
<td>EGP-</td>
<td>EGP+</td>
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<td>pH Pre-injection</td>
<td>5.53</td>
<td>5.52</td>
<td>0.03</td>
</tr>
<tr>
<td>pH Post-injection</td>
<td>5.85</td>
<td>5.76</td>
<td></td>
</tr>
<tr>
<td>pH After storage</td>
<td>5.86</td>
<td>5.83</td>
<td></td>
</tr>
</tbody>
</table>

† Conventional diets included vitamin A at 2,200 IU/kg; vitamin E at 22 IU/kg; copper sulfate to provide 10 mg/kg Cu; cobalt carbonate to provide 0.15 mg/kg Co; ethylenediamine dihydriodide to provide 0.5 mg/kg I; manganous sulfate to provide 60 mg/kg Mn; sodium selenite to provide 0.3 mg/kg Se; zinc sulfate to provide 60 mg/kg Zn on a dry matter basis; as well as 300 mg·animal⁻¹·d⁻¹ of monensin and 90 mg·animal⁻¹·d⁻¹ daily of tylosin (Elanco Animal Health; Greenfield, IN).
‡ The Alltech diet included Programmed Nutrition Receiver in the total mixed ration for the first 21 days at the rate of 14 g·animal⁻¹·d⁻¹ which contained zinc proteinate to provide 10.7 mg/kg Zn; manganese proteinate to provide 7.1 mg/kg manganese; cobalt proteinate to provide 1.2 mg/kg cobalt; copper proteinate to provide 2.9 mg/kg copper; calcium iodate to provide 0.6 mg/kg iodine; selenium yeast to provide 0.31 mg/kg selenium on a dry matter basis; as well as ascorbic acid, *Aspergillus oryzae* fermentation product, *Lactobacillus acidophilus* fermentation product, and *Enterococcus faecium* fermentation product. Thereafter, Programmed Nutrition Finisher was included in the total mixed ration at the rate of 20 g·animal⁻¹·d⁻¹ which contained zinc proteinate to provide 10.7 mg/kg Zn; manganese proteinate to provide 7.1 mg/kg manganese; cobalt proteinate to provide 1.2 mg/kg cobalt; copper proteinate to provide 2.9 mg/kg copper; calcium iodate to provide 0.6 mg/kg iodine; selenium yeast to provide 0.31 mg/kg selenium on a dry matter basis; as well as ascorbic acid, *Aspergillus niger* fermentation product, *Lactobacillus acidophilus* fermentation product, and *Enterococcus faecium* fermentation product. Both supplements were premixed into a ground corn carrier and subsequently blended into the total mixed ration.
§ Exogenous growth promotants included Component ES implant administered on d 1 of the experiment, Component TE-IS at reimplant, and ractopamine hydrochloride (Optaflexx) fed at 400 mg/animal daily for the final 28 d before harvest (all products from Elanco Animal Health).
1 Recorded following injection after a 2 min rest.
2 Recorded after 7 d of storage.
Table 3. Purge loss of injected beef *Longissimus lumborum*, cook loss of injected beef *Longissimus* steaks and ground beef, and Warner-Bratzler shear force (WBSF) from steers fed conventional diets† or Alltech Programmed Nutrition Beef Program‡ with and without exogenous growth promotants§

<table>
<thead>
<tr>
<th>Item</th>
<th>Conventional</th>
<th>Alltech PN</th>
<th>P - value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EGP-</td>
<td>EGP+</td>
<td>SEM</td>
</tr>
<tr>
<td>Purge loss†, %</td>
<td>1.31</td>
<td>1.51</td>
<td>1.45</td>
</tr>
<tr>
<td>Steak cook loss‡, %</td>
<td>22.89</td>
<td>21.02</td>
<td>23.28</td>
</tr>
<tr>
<td>Ground beef cook loss‡, %</td>
<td>23.36</td>
<td>21.72</td>
<td>22.89</td>
</tr>
<tr>
<td>WBSF, N</td>
<td>20.9</td>
<td>19.0</td>
<td>18.0</td>
</tr>
</tbody>
</table>

†Conventional diets included vitamin A at 2,200 IU/kg; vitamin E at 22 IU/kg; copper sulfate to provide 10 mg/kg Cu; cobalt carbonate to provide 0.15 mg/kg Co; ethylenediamine dihydriodide to provide 0.5 mg/kg I; manganous sulfate to provide 60 mg/kg Mn; sodium selenite to provide 0.3 mg/kg Se; zinc sulfate to provide 60 mg/kg Zn on a dry matter basis; as well as 300 mg/animal daily of monensin and 90 mg/animal daily of tylosin (Elanco Animal Health; Greenfield, IN).

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fermentation product, *Lactobacillus acidophilus* fermentation product, and *Enterococcus faecium* fermentation product. Both supplements were premixed into a ground corn carrier and subsequently blended into the total mixed ration.

§ Exogenous growth promotants included Component ES implant administered on d 1 of the experiment, Component TE-IS at reimplant, and ractopamine hydrochloride (Optaflexx) fed at 400 mg/animal daily for the final 28 d before harvest (all products from Elanco Animal Health).

1 \[\frac{\text{pumped weight} - \text{stored weight}}{\text{pumped weight}} \times 100.\]

2 \[\frac{\text{pre-cook weight} - \text{cooked weight}}{\text{pre-cook weight}} \times 100.\]
Table 4. Expressible moisture and water binding ability of beef strip loins from steers fed conventional diets† or Alltech Programmed Nutrition Beef Program‡ with and without exogenous growth promotants§ before injection and after 7 d of storage.

<table>
<thead>
<tr>
<th>Item</th>
<th>Conventional</th>
<th>Alltech PN</th>
<th>SEM</th>
<th>Program</th>
<th>ExGP</th>
<th>Period</th>
<th>ExGP × Period</th>
<th>P – value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expressible moisture¹, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before injection</td>
<td>11.12</td>
<td>10.03</td>
<td>10.84</td>
<td>10.36</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After storage</td>
<td>10.20</td>
<td>11.36</td>
<td>10.75</td>
<td>10.85</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water binding ability², %</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Before injection</td>
<td>19.86</td>
<td>31.64</td>
<td>20.42</td>
<td>28.88</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After storage</td>
<td>32.79</td>
<td>25.61</td>
<td>34.21</td>
<td>25.49</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹Conventional diets included vitamin A at 2,200 IU/kg; vitamin E at 22 IU/kg; copper sulfate to provide 10 mg/kg Cu; cobalt carbonate to provide 0.15 mg/kg Co; ethylenediamine dihydriodide to provide 0.5 mg/kg I; manganous sulfate to provide 60 mg/kg Mn; sodium selenite to provide 0.3 mg/kg Se; zinc sulfate to provide 60 mg/kg Zn on a dry matter basis; as well as 300 mg·animal⁻¹·d⁻¹ of monensin and 90 mg·animal⁻¹·d⁻¹ of tylosin (Elanco Animal Health; Greenfield, IN).

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¹[(Initial weight-cenrifuged weight)/initial weight] × 100.

²Calculated as 300-(11.43 × supernatant volume).
Literature Cited


