**Investigation of possible pumpkin seeds and ginger effects on gastrointestinal nematode
infection indicators in meat goat kids and lambs**

**K.K. Matthews^{a,1}, D.J. O'Brien^{a*,2}, N.C. Whitley^b, J.M. Burke^c, J.E. Miller^d, and R.A.
Barczewski^a**

*^aDelaware State University, Department of Agriculture, 1200 N. Dupont Hwy, Dover DE, 19901,
USA,*

^bFort Valley State University, Cooperative Extension Program, Fort Valley, GA, 31030, USA

^cDale Bumpers Small Farms Research Center, USDA, ARS, Booneville, AR 72927, USA

*^dDepartment of Pathobiological Sciences, School of Veterinary Medicine and Departments of
Animal Science and Veterinary Science, Louisiana State University, Baton Rouge, LA 70803,
USA*

* Corresponding author. Present address: Virginia State University, Cooperative Extension, P.O.
Box 9081, Petersburg, VA 23806. Tel.: 1 (804) 524-6963. Fax: 1 (804) 524-5714.

Email address: dobrien@vsu.edu (D.J. O'Brien)

¹Tuskegee University, 205 Milbank Hall, Department of Agriculture and Environment Sciences, Tuskegee, AL 36088

² Virginia State University, Cooperative Extension, P.O. Box 9081, Petersburg, VA 23806

Abstract

In four experiments, 77 naturally-infected Boer crossbred kids and 28 artificially-inoculated Katahdin lambs were used to evaluate the effect of pumpkin seeds (Exp 1; 21 kids), ginger or pumpkin seed drench (Exp 2; 30 kids) and pumpkin seed oil (Exp 3 and 4: 28 lambs and 26 kids, respectively) on gastrointestinal nematode (GIN) indicators. In all experiments, kids and lambs were placed in individual pens and received pre-weighed rations of a commercially pelleted meat goat or sheep diet daily. In Exp 1, kids were supplemented with ground pumpkin seeds (PUM; $n = 10$) mixed into feed daily at a rate of 5 g/kg body weight (BW) or were not supplemented (CON; $n = 11$) for 21 days. In Exp 2, kids were orally drenched with water (CON; $n = 10$), 5 g pumpkin seed/kg BW (PUM; $n = 10$) or 3 g ginger/kg BW (GIR; $n = 10$) every other day for 42 days. In Exp 3, lambs were orally drenched with 2 ml/kg water (CON; $n = 7$), 2.0 ml/kg BW pumpkin seed oil once every 7 days (PUM1; $n = 10$), or 2.0 ml/kg BW pumpkin seed oil daily for 3 out of every 7 days (PUM2; $n = 11$) for 28 days. In Exp 4, kids were orally drenched with 2 ml/kg water (CON; $n = 13$), or 2.0 ml/kg BW pumpkin seed oil (PUM; $n = 13$) every other day for 35 days. In all experiments, BW, daily feed intake and blood and fecal samples were collected every 7 days. All animals in Exp 2 were harvested at a USDA-inspected abattoir and abomasal and small intestinal contents were collected for total worm counts. The FEC were similar for treatments in all experiments. Treatment influenced PCV ($P < 0.05$) only in Exp 1 and 4. In Exp 2, at harvest, there was a tendency ($P = 0.08$) for CON animals to have a higher number of total GIN than GIR-treated animals, but PUM-treated animals were intermediate. BW were similar for treatments in Exp 1, 2 and 3 while CON animals in Exp 4 had a greater BW than PUM-treated animals on day 7 only and were similar thereafter (treatment by day interaction, P

< 0.05). In these studies, pumpkin and ginger treatments administered were not effective in reducing FEC in meat goat kids or lambs.

Keywords: Internal parasites, meat goats, lambs, pumpkin, ginger

1. Introduction

A major hurdle in the U.S. small ruminant industry is production loss due to gastrointestinal nematodes (GIN), particularly the blood sucking abomasal GIN, *Haemonchus contortus* (Miller and Craig, 1996). Parasite infections, a major health problem in small ruminants, can hinder production due to reduced weight gains and increased mortality (Kaplan, 2004). The most common method used to control GIN infection is anthelmintic drug treatment. However, anthelmintic overuse and misuse has led to an increased prevalence of resistance in sheep and goat GIN (Mortensen *et al.*, 2003; Crook *et al.*, 2010). Anthelmintic resistance is now a global problem (Coles, 2005; Kaplan *et al.*, 2007; Howell *et al.*, 2008; Crook *et al.*, 2010), and has been reported for all three major classes of anthelmintics (Terrill *et al.*, 2001; Howell *et al.*, 2008; Crook *et al.*, 2010).

Because GIN resistance to anthelmintics in small ruminants is well documented, alternative methods of control have been investigated. For instance, the seeds of squash (*Cucurbita moschata*), pumpkins (*Cucurbita maxima* and *pepo*) and many other vine crops are believed to contain a deworming compound called cucurbitacin and have been studied in lambs (Strickland *et al.*, 2009) with varying results. In addition, ginger (*Zingiber officinale*) has also been used as an anthelmintic purge for cattle, horses (Duval, 1997) and lambs (Iqbal *et al.*, 2006). Even though the effectiveness of these natural products is primarily anecdotal (Githiori *et al.*, 2006), the increasing incidence of anthelmintic resistance as well as the popularity of organically produced animals has led to renewed interest in alternative parasite control strategies.

It was therefore the objective of these experiments to determine the efficacy of fresh pumpkin seeds, a pumpkin seed drench, pumpkin seed oil or a ginger drench as natural means of parasite control in meat goat kids and lambs.

2. Materials and methods

2.1 Animals and procedures

All animal-related procedures were conducted in compliance with Delaware State University Institutional Animal Care and Use Committee guidelines. All animals were placed in individual 1.2 m x 1.2 m pens on solid concrete floors (day 0) and received pre-weighed rations of a commercially pelleted 15% CP meat goat feed (Southern States Inc., Richmond, VA) in Exp 1, 2 and 4 or a pelleted 16% CP sheep feed (Southern States Inc., Richmond, VA) in Exp 3 at approximately 3% of their BW daily but adjusted daily so that feed was supplied *ad libitum*. Water was supplied *ad libitum* and orts were measured weekly in all experiments except Experiment 3. In all experiments, BW was measured and fecal and blood samples were collected to determine FEC and PCV every 7 days. Feces were also pooled for coproculture in Exp 1, 2 and 4 to determine GIN genera according to Peña et al. (2002). Fecal egg counts were determined using the Modified McMasters technique (Whitlock, 1948). If PCV was < 15% in any experiment, animals were orally treated with moxidectin (0.2 mg/kg for lambs and 2 times the label sheep dose for goats) and removed from the study.

2.2 Experiment 1

Twenty-one naturally-infected female and castrated male Boer/Spanish crossbred meat goat kids, averaging 185.1 ± 1.9 days of age were randomly assigned to one of two treatments after accounting for initial FEC and BW. Goat kids were supplemented with ground pumpkin seeds (*Cucurbita pepo*; PUM; n = 10) mixed into the feed at a rate of 5 g/kg BW or were not

supplemented (CON; n = 11) daily for 21 days. One PUM-treated animal was dewormed and removed from this experiment on day 7 because of PCV below 15%.

2.3 Experiment 2

Thirty naturally-infected female and castrated male Boer/Kiko crossbred meat goat kids with a mean age of 144.4 ± 1.1 days were randomly assigned to one of three treatments based on initial FEC and BW. Kids were orally administered treatments of water (CON; n = 10), 5 g pumpkin (*Cucurbita pepo*) seed/kg BW (PUM; n = 10) or 3 g ginger (*Zingiber officinale*) /kg BW drench (GIR; n = 10) every other day for 42 days. Pumpkins (*Cucurbita pepo*) were purchased from Fifer Orchard in Dover, DE and seeds were removed, rinsed and air-dried for use in this study. The amounts of pumpkin seeds (5 g/kg BW) and ginger (3 g/kg BW) used was determined from previous studies evaluating the anthelmintic properties of these products (Strickland et al., 2009; Iqbal et al., 2006; Practical Farmers of Iowa, 2004). The pumpkin seed drench was prepared from an anecdotal method for the treatment of GIN in sheep by adding 500 – 600 g of ground pumpkin seeds in 3 l of water, simmering over low heat for 30 minutes, sieving to extract as much juice as possible after cooling, and then reducing over low heat to 150 – 200 ml (Duval, 1997) such that each animal in this treatment received a dosage of approximately 5 g pumpkin seed extract/kg BW. To have sufficient treatment, two batches were prepared at each dosing. The ginger drench was prepared by grinding 300 - 500 g of ginger in 100 ml of water, sieving and administering orally such that each animal in this treatment received a specific ml dosage of ginger extract/kg BW (determined such that each animal received an amount of extract equivalent to that produced from 3 g of ginger/kg BW), with doses determined weekly based on sampling day BW. Eight animals were dewormed and removed

from this experiment on days 14 (3 CON and 4 GIR) and 28 (1 GIR) because PCV declined below 15%.

At the end of the study, all remaining animals were harvested at a USDA-inspected abattoir. The abomasum and small intestine were tied off and removed, stored in zippered bags on ice until content collection the same day. Contents were collected into 3000 ml tap water, mixed well and two 150 ml aliquots were collected, mixed with 100 ml of 10% formalin and stored until GIN counting at Louisiana State University. Abomasal and small intestinal worm counts were conducted according to procedures described by Shaik et al. (2006).

2.4 Experiment 3

Twenty-eight female and castrated male Katahdin lambs at approximately 300 days of age were dewormed orally with moxidectin (0.2 mg/kg) and levamisole (6 mg/kg) and kept in a barn with concrete floors, limited straw bedding and no access to pasture to minimize possible re-infection. Following a 21-day dewormer withdrawal period, lambs were artificially inoculated twice, two days apart, with a 2 ml larval inoculation containing approximately 750 L3 *H. contortus*. Treatments were administered approximately 45 days after inoculation. Treatments consisted of one dose of a commercially available pumpkin (*Cucurbita maxima*) seed oil (PUM; 100% Certified Organic Pumpkin Seed Oil, Swanson Health Products, Fargo, ND) and water (CON) over 28 days. Lambs treated with pumpkin seed oil were further divided into two groups. In the PUM1 group lambs were administered the pumpkin seed oil drenched at a rate of 2.0 ml/kg (equivalent to 5 g pumpkin seeds/kg BW; n = 10) once every week (7 days) or water on days when PUM2 lambs were treated. Lambs in the PUM2 group were administered the pumpkin seed oil drenched at the rate of 2.0 ml/kg (equivalent to 5 g pumpkin seeds/kg BW; n = 11) divided equally over 3 doses in one week (3 out of 7 days) such that their total dose was

equivalent to the dose that was given in the PUM1 group. In the CON (n = 7) group, lambs were drenched with water on the same day as the PUM2 group. One lamb from the PUM1 group was removed and another from the PUM2 group was dewormed and removed on day 21 due to PCV < 15%.

2.5 Experiment 4

Twenty-six naturally-infected female and castrated male Boer/Kiko crossbred meat goat kids at 166.4 ± 1.0 days of age were placed in one of two treatments based on initial BW and FEC. Treatments consisted of one dose of a commercially available pumpkin seed oil (PUM; 100% Certified Organic Pumpkin Seed Oil, Swanson Health Products, Fargo, ND) or water (CON) drench. Kids in the PUM group were administered the pumpkin seed oil drenched orally at a rate of 2.0 ml/kg (equivalent to 5 g pumpkin seeds/kg BW; n = 13) or an equivalent amount of water (CON; n = 13) every other day for 35 days. Two meat goat kids from the PUM group were dewormed and removed from the experiment on days 7 and 14 due to PCV < 15%.

2.6. Statistical analysis

Data from animals dewormed were totally removed from all analyses. For all experiments, BW, average daily feed intake per week, PCV and FEC data were analyzed using the MIXED procedure of SAS (SAS Institute, Carey, NC) for repeated measures. Pen was the experimental unit and class variables included treatment, pen and day; the model tested main effects and the interaction of treatment and day; pen(trt) was the random term and day was repeated (Littell et al., 1998). All FEC data were log transformed: $\ln(\text{FEC} + 1)$ for analysis and inferences were made on transformed data but untransformed least squares means are presented. For Exp 2, day 0 FEC was used as a covariate in all analyses. Abomasal and small intestinal worm count data were analyzed using the GLM procedure of SAS.

3. Results

In all experiments, FEC were similar for treatments and averaged 4555 ± 371 , 3396 ± 750 , 604 ± 104 epg and 2404 ± 246 epg for Exp 1, 2, 3, and 4, respectively (Figures 1, 2, 3 and 4). Fecal egg counts in Exp 1 were greatest (day effect, $P < 0.01$) on day 0 compared to day 7, 14, and 21 (Fig. 1). In Exp 2, days 35 and 42 FEC were similar but less (day effect, $P < 0.01$) than FEC on days 0, 7, 14, 21 and 28 while day 0 FEC was greater ($P < 0.01$) than FEC on day 7 and 14 (Fig. 2). Fecal egg counts in Exp 3 significantly decreased (day effect, $P < 0.03$) over time until day 21 and then were similar among treatments for the rest of the study (Fig. 3). Day 0 FEC in Exp 4 was greater (day effect, $P < 0.0001$) than all other days measured while day 7 FEC was similar to day 14 but greater ($P < 0.02$) than days 21, 28, and 35. Also, day 14 FEC was greater ($P < 0.02$) than day 28 but similar to days 21 and 35 (Fig. 4).

Packed cell volume was greater (treatment effect, $P < 0.01$) in the PUM-treated kids (37.8 ± 1.6) compared to those in the CON group (33.1 ± 1.7) in Exp 1. In addition, PCV was greatest (day effect, $P < 0.01$) on day 0 compared to days 7, 14, and 21 while day 14 was greater ($P < 0.04$) than day 21 (Fig. 1). Packed cell volume was similar among treatments in Exp 2 (Fig. 2) and 3 (Fig. 3) and averaged 27.5 ± 0.6 and $31.6 \pm 0.3\%$, respectively. In Exp 3, day 0 PCV was similar to day 7, 21, and 28, and day 14 was greater (day effect, $P < 0.02$) than both days 0 and 7 (Fig. 3). Packed cell volume in Exp 4 was greater (treatment by day interaction, $P < 0.04$) in PUM-treated animals compared to CON animals on days 7, 21, and 35 (Fig. 4). In addition, there was a tendency ($P = 0.05$) for PCV on day 28 to be greater for PUM-treated animals.

On day 0 in Exp 1, CON group fecal samples consisted of 6% *Haemonchus contortus* and 94% *Trichostrongylus* spp. while the PUM group had 2% *H. contortus* and 98% *Trichostrongylus* spp. By day 21, the CON group had 46% *H. contortus* and 54%

Trichostrongylus spp. while the PUM group had 28% *H. contortus* and 72% *Trichostrongylus* spp. The genera of parasite larvae identified from eggs present in the pooled fecal samples collected from CON and PUM-treated animals at each sampling in Exp 4 included primarily *H. contortus* and *T. colubriformis*. The predominant GIN genus at each sampling was *H. contortus* with the only exception on day 35, when *T. colubriformis* was predominant in the PUM-treated animals only (Table 1).

In Exp 2, the predominant GIN genus at each sampling was *H. contortus* (averaging 87%, 94% and 90% for PUM, GIR and CON groups, respectively). Abomasal worms identified after slaughter were *H. contortus*, *Trichostrongylus axei* and *Teladorsagia* spp. There was a tendency ($P = 0.08$) for CON animals to have a higher number of GIN than GIR-treated animals, but PUM-treated animals were intermediate at slaughter (Table 2). There was also a tendency for CON animals to have a higher number of adult male ($P = 0.07$), adult female ($P = 0.09$), and total *H. contortus* ($P = 0.07$) compared to GIR-treated animals with PUM-treated animals being intermediate (Table 2). Worms identified in the small intestine included *Trichostrongylus colubriformis*, *Nematodirus* spp., *Cooperia curticei*, and *H. contortus* and *Teladorsagia* spp. from the abomasum. The total number of small intestinal worms was similar among treatments, with a mean of 38.3 ± 12.3 , 5.0 ± 17.4 and 33.0 ± 10.7 for CON, GIR and PUM-treated kids, respectively.

In Exp 1, 2 and 3, BW were not influenced by treatment with means of 24.4 ± 0.5 , 18.7 ± 0.2 and 33.0 ± 0.5 kg, respectively (Fig. 5 and 6). In Exp 3, BW averaged 32.7 ± 1.8 , 33.2 ± 1.8 and 33.2 ± 2.1 kg for CON, PUM1 and PUM2 groups, respectively. There was a day effect on BW for all experiments with natural variations noted. In Exp 4, CON animals had a greater (treatment by day interaction effect, $P < 0.05$) BW than PUM-treated animals on day 7 only and

were similar thereafter (Fig. 7). In Exp 1, 2 and 4, feed intake followed body weight as would be expected with means of 515 ± 26.0 , 640 ± 14.0 and 520 ± 17.2 g/day, respectively (Figures 5, 6, and 7).

4. Discussion

The results of all four experiments indicate that ground pumpkin seeds, pumpkin seed drench and pumpkin seed oil administered to meat goat kids and lambs were not effective in reducing FEC under the conditions of these studies. The seed of squash, pumpkins and many other vine crops is believed to contain a potential anthelmintic compound, known as cucurbitacin, which has been studied in lambs (Strickland et al., 2009). Previously, Strickland and colleagues (2009) found that FEC were significantly reduced after two weeks when pumpkin seeds were mixed in feed at a rate of 0.33 g/kg BW and fed to lambs for 21 days. In Exp 1 of the current study, researchers observed that goat kids in the PUM-treated group were sorting through feed and leaving behind a substantial amount of orts each week (indicated by greater feed intake for CON compared to PUM-treated animals from d 7 – 14 and d 14 – 21). From this, it was concluded that an alternative means of administering the pumpkin seeds might be more effective in ensuring that kids consumed an amount necessary to see a reduction in FEC. Therefore, a pumpkin seed drench (Exp 2) and pumpkin seed oil (Exp 3 and 4) were tested in meat goat kids and/or Katahdin lambs to determine its efficacy in reducing FEC. A preliminary study conducted at Delaware State University had indicated that a single pumpkin seed drench (as used in Exp 2) was effective in preventing a rise in FEC (decreased by 11%) while untreated animals experienced a 56% increase after 7 days (unpublished data). However, the pumpkin seed drench administered in Exp 2 was not effective in reducing FEC in meat goat kids. It should be noted, however, that no kids in this group were dewormed while 3 kids from the CON group and 5 from

the GIR group were dewormed and removed from the study (leaving 7 and 5 kids, respectively in these treatment groups). Though FEC were similar among treatments, no pumpkin-treated animals exhibited clinical signs of infestation (diarrhea, bottle jaw, and anemia/low PCV) and were therefore not dewormed. This may suggest that the pumpkin seed drench could provide some tolerance to parasite infection and further investigation might be beneficial.

The overall ineffectiveness of the pumpkin seed treatments in the current study may be related to the cucurbitacin content, which was not measured in these experiments. Future research should evaluate the cucurbitacin content of different pumpkin strains/products as this may produce varying research results.

In addition to pumpkin seeds, ginger has previously been used as an anthelmintic in lambs (Iqbal et al., 2006). Phytochemical reports have shown that the main constituents of ginger are gingerols, shogaols, zingerone and paradol (Ghayur and Gilani, 2005); however, it is not known which of these constituents may have potential anthelmintic properties. Iqbal and colleagues (2006) examined the efficacy of a single dose of ginger administered as an aqueous extract or a powder in lambs and concluded that the extract (3 g/kg BW) was more effective in controlling parasite infections than the powder. The 3 g/kg dose extract and powder were able to reduce FEC ten days post-treatment by 66% and 24%, respectively (Iqbal et al., 2006). In the present study, FEC over time was not influenced by treatment when ginger was administered as a drench of similar doses in Exp 2. The difference in results could be due to differences in preparation of the ginger treatment used in this study. In addition, differences in the proportion of GIN genera present could also play a role in the effect of treatment; larval data for Exp 2 indicated that the predominant species present was *H. contortus*, but Iqbal et al. (2006) indicated that animals in their study were infected with a mix of GIN species including *H. contortus*,

Trichostrongylus axei, *Trichostrongylus colubriformis*, *Oesophagostomum columbianum*, *Strongyloides papillosus* and *Trichuris ovis*.

5. Conclusions

Due to reports of increased anthelmintic resistance in sheep and goats and the growing popularity of sustainably-raised meat products, producers are drawn to alternatives to chemical dewormers. However, under the conditions of this study, pumpkin seeds, a pumpkin seed drench, pumpkin seed oil and a ginger drench was not an effective treatment for GIN infestation in meat goat kids and lambs.

Acknowledgements

Funding was supported by a Northeast Sustainable Agriculture Research and Education (NESARE; LNE08-269) grant. The authors thank graduate students Elizabeth Crook and Jenna Warren and undergraduate students Jarvis Scott and Kevin Beaudoin as well as Delaware State University's College of Agriculture and Related Science Dean, Dyremple Marsh and farm technician, Lee Dulin, for support and assistance with this research project.

Mention of trade names or commercial products in this manuscript is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture (USDA, an equal opportunity provider and employer).

References

- Coles, G.C. 2005. Anthelmintic resistance-looking to the future: a UK perspective. *Res. Vet. Sci.* 78, 99–108.
- Crook, E.K., O'Brien, D.J., Barczewski, R.A, Whitley, N.C., McCrea, B.A., 2010. Use of the fecal egg count reduction test and larval development assay to characterize anthelmintic

- resistance in gastrointestinal nematodes of small ruminants in the Mid-Atlantic U.S.
Master's thesis: Delaware State University. Dover. DE.
- Duval J. 1997. The control of internal parasites in cattle and sheep. Retrieved November 10, 2011 from <http://eap.mcgill.ca/publications/EAP70.htm>
- Ghayur, M. N. and Gilani, A. H. 2005. Pharmacological basis for the medicinal use of ginger in gastrointestinal disorders. *Dig. Dis. Sci.* Oct;50 (10):1889-97.
- Githiori, J.B., Athanasiadou S., and Thamsburg, S.M. 2006. Use of plants in novel approaches for control of gastrointestinal helminthes in livestock with emphasis on small ruminants. *Vet. Parasitol.* 139, 308-320.
- Howell, S.B., Burke, J.M., Miller, J.E., Terrill, T.H., Valencia, E., Williams, M.J., Williamson, L.H., Zajac, A.M., Kaplan, R.M., 2008. Prevalence of anthelmintic resistance on Sheep and goat farms in the southeastern United States. *J. Am. Vet. Med. Assoc.* 233, 1913-1919.
- Iqbal Z, Lateef, M., Akhtar, M.S., Ghayur, M.N., Gilani, A.H., 2006. In vivo anthelmintic activity of ginger against gastrointestinal nematodes of sheep. *J. Ethnopharmacol.* 106, 285-287.
- Kaplan, R.M., Vidyashankar, A.N., Howell, S.B., Neiss, J.M., Williamson, L.H., Terrill T.H., 2007. A novel approach for combining the use of in vitro and in vivo data to measure and detect emerging moxidectin resistance in gastrointestinal nematodes of goats. *Int. J. Parasitol.* 37 (7), 795-804.
- Littell, R. C., Henry, P. R., Ammerman, C. B., 1998. Statistical analysis of repeated measures data using SAS procedures. *J. Anim. Sci.* 76, 1216-1231.

- Miller, J.E., Craig, T.M., 1996. Use of anthelmintic combinations against multiple resistant *Haemonchus contortus* in Angora goats. *Small Rumin. Res.* 19, 281–283.
- Mortensen, L.L., Williamson, L.H., Terrill, T.H., Kircher, R., Larsen, M., Kaplan, R.M., 2003. Evaluation of prevalence and clinical implications of anthelmintic resistance in gastrointestinal nematodes of goats. *J. Am. Vet. Med. Assoc.* 23, 495–500.
- Peña, M. T., Miller, J. E., Fontenot, M. E., Gillespie, A. Larsen, M., 2002. Evaluation of *Duddingtonia flagrans* in reducing infective larvae of *Haemonchus contortus* in feces of sheep. *Vet. Parasitol.* 103, 259 – 265.
- Practical Farmers of Iowa. Alternative parasite management – Are we there yet? 2004.
<http://practicalfarmers.org/farmer-knowledge/research-reports/2004/alternative-parasite-management-are-we-there-yet/>
- SAS/STAT® Software: Changes and Enhancements through Release 6.11. 1996. SAS Inst, Inc, Cary, NC.
- Shaik, S. A., Terrill, T. H., Miller, J. E., Kouakou, B., Kannan, G., Kaplan, R. M., Burke, J. M., Mosjidis, J., 2006. *Sericea lespedeza* hay as a natural deworming agent against *Haemonchus contortus* infection in goats. *Vet. Parasitol.* 139, 150-157.
- Strickland, V.J., Krebs G.L., Potts, W., 2009. Pumpkin kernel and garlic as alternative treatments for the control of *Haemonchus contortus* in sheep. *Anim. Prod. Sci.* 49, 139-144.
- Terrill, T. H., Kaplan, R. M., Larsen, M., Samples, O. M., Miller, J. E., Gelaye, S., 2001. Anthelmintic resistance on goat farms in Georgia: efficacy of anthelmintics against gastrointestinal nematodes in two selected goat herds. *Vet. Parasitol.* 97, 261-268.

Whitlock, H. V.,1948. Some modifications of the McMaster helminth egg-counting technique and apparatus. J. Counc. Sci. Ind. Res. 21, 177–180

Fig. 1.

Least squares means and standard errors of gastrointestinal nematode eggs per gram of feces (A) and packed cell volume (B) for meat goat kids treated with pumpkin seeds (PUM; n = 9) or not (CON; n = 11) over a 21-day period in Exp 1.

Fig. 2.

Least square means and standard errors of gastrointestinal nematode eggs per gram of feces (A) and packed cell volume (PCV; B) for meat goat kids treated with a pumpkin seed drench (PUM; n = 10), ginger drench (GIN; n = 5) or water (CON; n = 7) every other day over a 42-day period in Exp 2.

Fig. 3.

Least square means and standard errors of gastrointestinal nematode eggs per gram of feces (A) and packed cell volume (PCV; B) for lambs drenched with pumpkin seed oil once weekly (PUM1; n = 9), three times weekly (PUM2; n = 10), or water (CON; n = 7) over a 28-day period in Exp 3.

Fig. 4.

Least square means and standard errors of gastrointestinal nematode eggs per gram of feces (A) and packed cell volume (PCV; B) for meat goat kids drenched with pumpkin seed oil (PUM; n = 11) or water (CON; n = 13) every other day over a 35-day period in Exp 4.

* Indicates significance for PCV at $P < 0.05$

+ Indicates a tendency for PCV at $P = 0.05$

Fig. 5.

Least squares means and standard errors of body weights (BW; A) and feed intake (B) for meat goat kids treated with pumpkin seeds (PUM; $n = 9$) or not (CON; $n = 11$) over a 21-day period in Exp 1.

* Indicates significance for feed intake at $P < 0.02$

Fig. 6.

Least square means and standard errors of body weights (BW; A) and feed intake (B) for meat goat kids treated with a pumpkin seed drench (PUM; n = 10), ginger drench (GIN; n = 5) or water (CON; n = 7) every other day over a 42-day period in Exp 2.

Fig. 7.

Least square means and standard errors of body weights (BW; A) and feed intake (B) for meat goat kids drenched with pumpkin seed oil (PUM; $n = 11$) or water (CON; $n = 13$) every other day over a 35-day period in Exp 4.

* Indicates significance for BW at $P < 0.05$

⁺ Indicates significance for feed intake at $P < 0.04$

[§] Indicates a tendency for feed intake $P < 0.10$

Table 1. Larval Identification of meat goat kids drenched with pumpkin seed oil (PUM) or water (CON) every other day over a 35-day period in Exp 4.

Day	CON			PUM		
	<i>Haemonchus contortus</i>	<i>Trichostrongylus colubriformis</i>	Other	<i>Haemonchus contortus</i>	<i>Trichostrongylus colubriformis</i>	Other
0	81%	14%	5%	62%	7%	31%
7	80%	15%	5%	71%	25%	4%
14	71%	9%	20%	48%	28%	24%
21	73%	10%	17%	57%	25%	18%
28	65%	9%	26%	57%	9%	34%
35	67%	11%	22%	43%	54%	3%

Table 2. Least square means of gastrointestinal nematodes recovered from abomasums of meat goat kids treated with a pumpkin seed drench (PUM), ginger drench (GIR) or water (CON) every other day over a 42-day period in Exp 2.

Adult Nematodes	CON	PUM	GIR	S.E.M.
Abomasum total	1857	869	549	238
<i>H. contortus</i> total	1276	580	312	166
Adult male	481	176	123	67
Adult female	665	301	162	91
L5 male	39	33	6	7
L5 female	28	4	0	7
L4	39	42	12	16
L3	24	24	9	9
<i>T. axei</i> total	509	266	219	65
Adult male	258	123	138	31
Adult female	209	80	60	29
L5 male	13	16	3	4
L5 female	6	6	3	3
L4	15	33	12	8
L3	8	8	3	3
<i>O. circumcincta</i> total	72	23	18	23
Adult male	40	8	18	12
Adult female	32	15	0	11