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Ergot Alkaloids in Feedlot Diets: How Much is Too Much?

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Goals and Research Priorities

- Development of nutritional strategies to:
  1. Improve feed digestion efficiency and animal health
  2. Reduce environmental impact of beef cattle production
  3. Replace the use of antibiotics as growth promoters
- U of S Signature Areas of Research
  1. Agriculture, Energy and Mineral Resources for a Sustainable Future

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Cereal Grain Ergot

- Current allowable limits in cattle diets
  - Ergot sclerotia in feed grain samples = 0.4% (w/w)
  - Ergot alkaloids = 2-3 ppm in cattle diets (CFIA)
    - RG-8 Regulatory Guidance: Contaminants in Feed
- Ergot bodies extremely variable in alkaloid content
- Different alkaloids, different concentrations
- Some may have no alkaloids, others lots

Purplish ergot bodies produced by infection with fungus of the genera *Claviceps*

https://www.grainews.ca/2016/03/23/a-small-dose-of-ergot-is-harmful/

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Proposal - Contaminant Standards for Aflatoxins, Deoxynivalenol, Fumonisins, Ergot Alkaloids and *Salmonella* in Livestock Feeds

August 2017

Purpose

The Canadian Food Inspection Agency (CFIA) has embarked on a comprehensive change agenda to strengthen its foundation of legislation, regulatory programs and inspection approaches and tools. These directions set a context for the renewal of the federal *Feeds Regulations* (Regulations).

The goal of renewing the Regulations is to develop a modernized risk- and outcome-based regulatory framework for feeds which:

- safeguards feeds and the food production continuum;
- attains the most effective and efficient balance between fair and competitive trade in the market; and
- minimizes regulatory burden.

Modernization of the Regulations provides the opportunity to review feed controls, standards, labelling and other regulatory requirements. The purpose of this proposal is to review the standards for some biological contaminants that are known or reasonably foreseeable to be present in feeds:

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Issues

- Very little study of cereal ergot in any species
- Species differ in tolerance
  - Poultry > swine > sheep and cattle
- Most previous work – fescue ergot in USA
- BUT has different alkaloid types and concentrations
- Effects of individual alkaloids???
- Both concentrations and combinations of alkaloids present important

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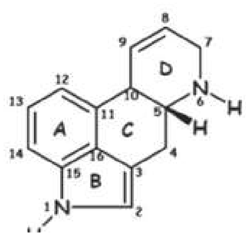
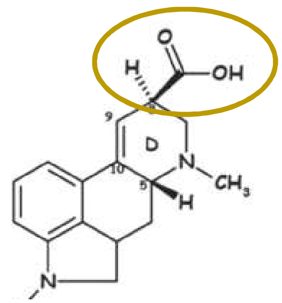
Chemical Structure Affects the Degree of Toxicity

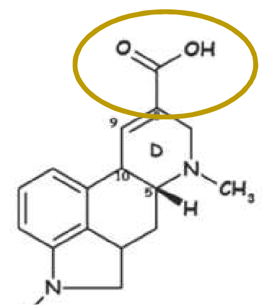
C8



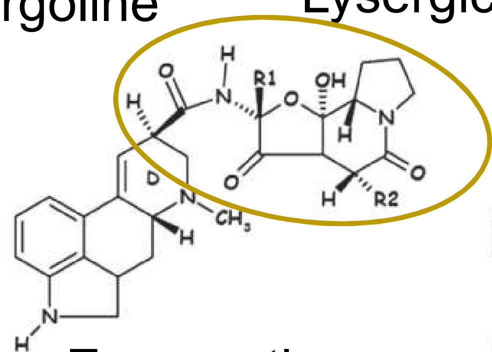
Ergoline



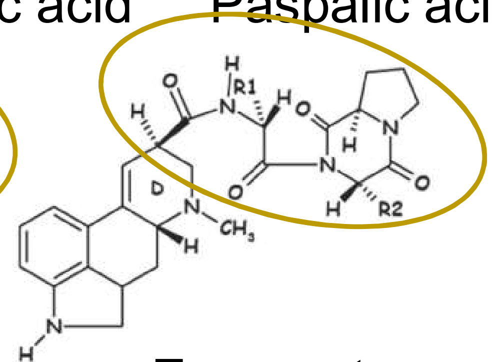
Lysergic acid



Paspalic acid



Ergopeptines



Ergopeptams

Occurrence of Ergot in Canada

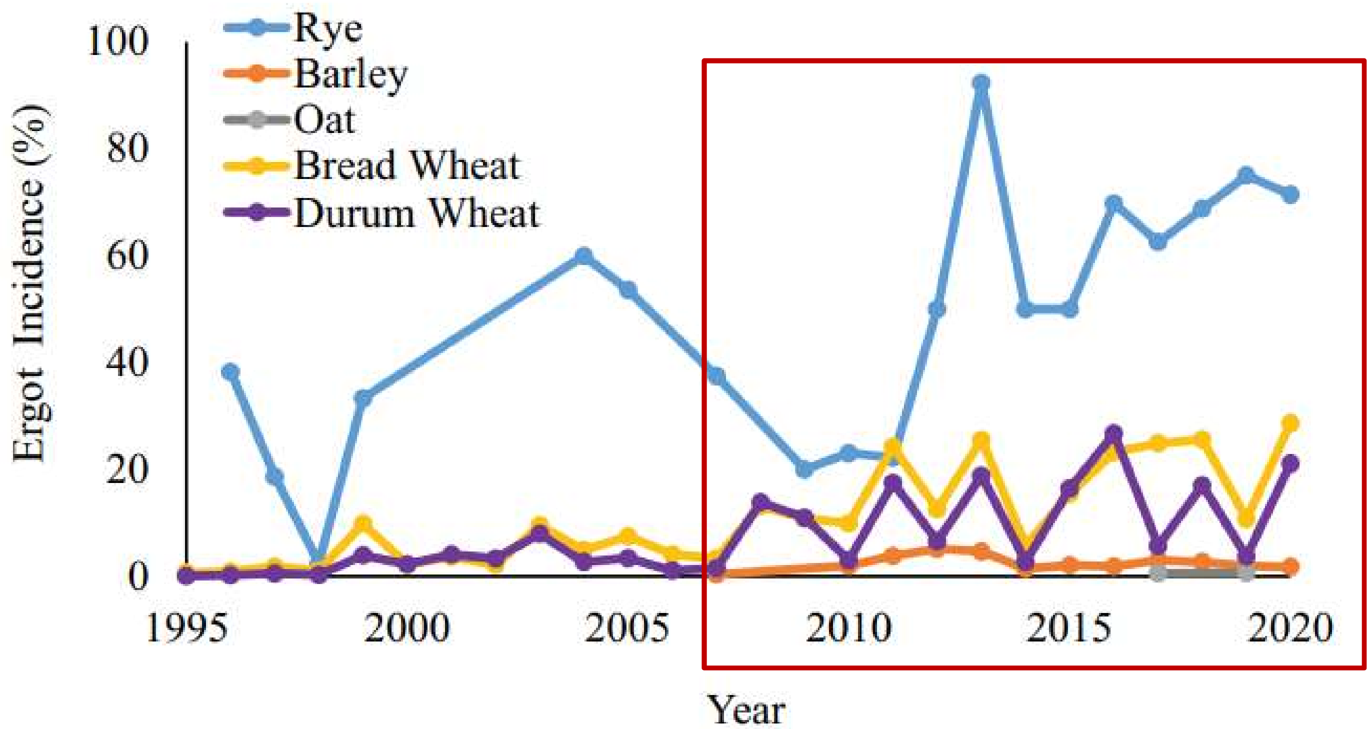


Figure. Annual ergot incidence (% of samples inspected in a year that contained ergot sclerotia) for Canadian cereal samples submitted to the Canadian Grain Commission Harvest Sample Program

Source: Canadian Grain Commission (2022a) and Walkowiak et al. (2022)

Why more ergot?

- Cool and wet conditions during flowering
- No-till seeding, lack of crop rotation
- Once established – difficult to eradicate
- Like any disease – keeps on spreading

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Clinical Signs

- Reduced growth performance
- Lameness that does not respond to standard treatment for foot rot
- Gangrene of the extremities
- Frostbite
- Frozen ears
- Loss of the tail end

Source: Dr. Manuel Aguilar-Vargas

Source: University of Calgary

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Studies

- **Study 1** - Rumen Simulation Technique (RUSITEC)
- **Study 2** - Effect of Increasing Levels of Ergot Alkaloids in the Diet of Feedlot Cattle
- **Study 3** - Effect of Continuous or Intermittent Feeding of Ergot Contaminated Grain in a Mash or Pelleted Form on the Performance of Feedlot Steers

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Study 1 - Rumen Simulation Technique (RUSITEC)

- Objective

  To determine the effect of ergot alkaloids on ruminal metabolism at toxic levels (20 ppm) with and without use of a mycotoxin deactivating product (Biomin® AA)

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RUSITEC Study

- Rumen digesta was collected from 4 cannulated cows
- The study consisted of **7 days of adaptation + 7 days of sampling**
- **2 RUSITEC** apparatuses with **8 fermentation vessels** each = 16 units (4/treatment)
- **4** Treatments with **90% concentrate**:10% silage diet (DM basis)

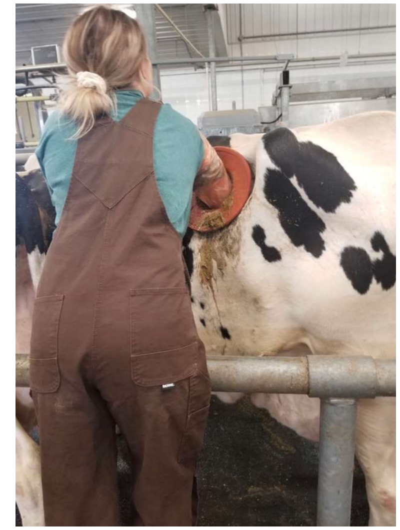
  1) 0.0 ppm of ergot (Control)

  2) 0.0 ppm of ergot + B

  3) 20.0 ppm of ergot

  4) 20.0 ppm of ergot + B

  - **B** = mycotoxin deactivating product (1 g/day/vessel)
  - All bags had 10 g diet DM ground to 2 mm



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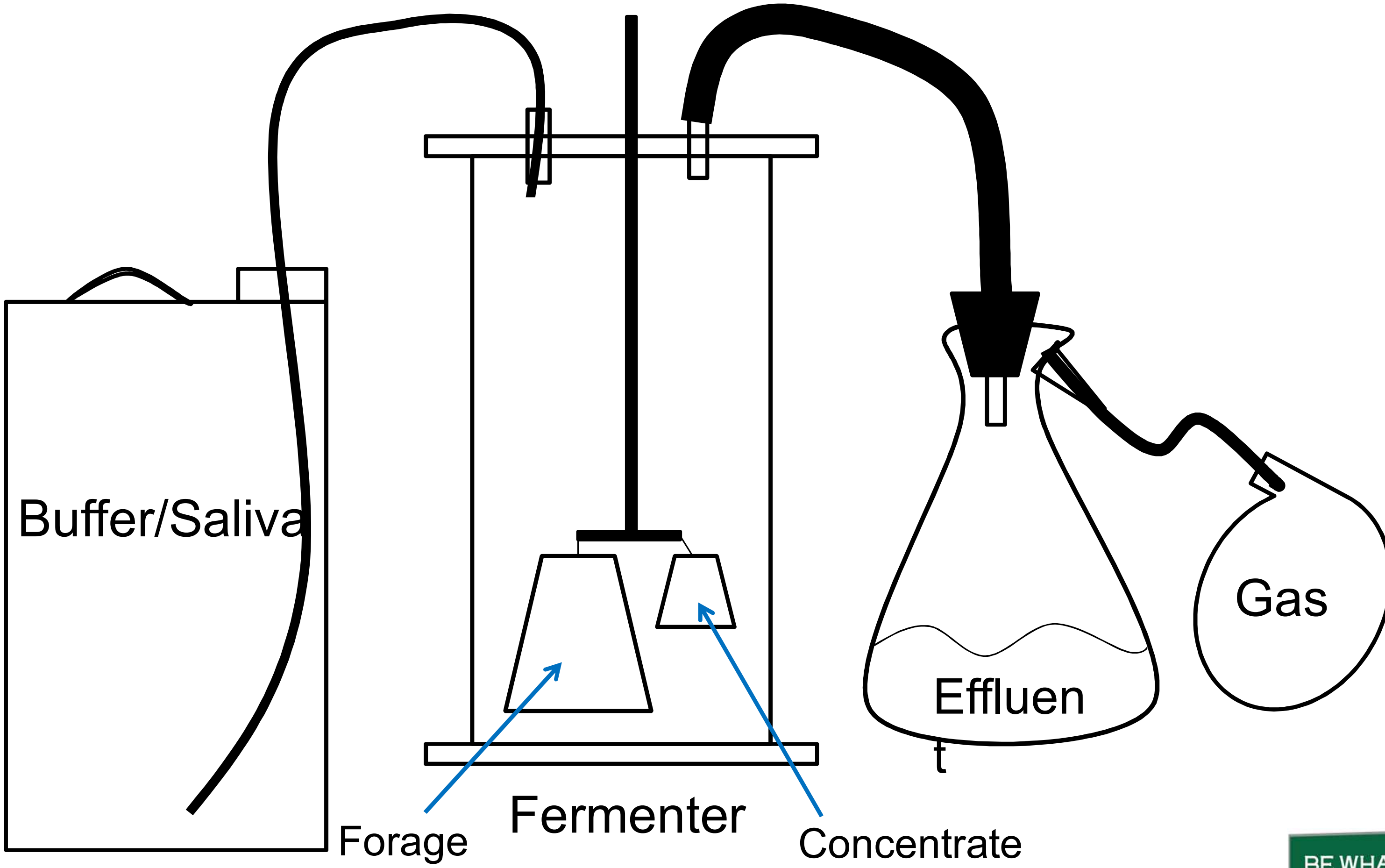
RUSITEC Study



RUSITEC Study

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Ruminant Nutrition

OXFORD

AMERICAN SOCIETY OF ANIMAL SCIENCE

Effect of ergot alkaloids and a mycotoxin deactivating product on *in vitro* ruminal fermentation using the Rumen simulation technique (RUSITEC)

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Abstract

The rumen simulation technique (RUSITEC) was used to investigate the effect of ergot alkaloids (EA) and a mycotoxin deactivating product (Biomin AA; MDP) on nutrient digestion, ruminal fermentation parameters, total gas, methane, and microbial nitrogen production. Ruminal fermentation vessels received a feedlot finishing diet of 90:10 concentrate:barley silage (DM basis). Using a randomized complete block design, treatments were assigned ($n = 4$ vessels/treatment) within two RUSITEC apparatuses in a 2 × 2 factorial arrangement. Treatments included: (1) control (CON) diet (no EA and no MDP); (2) CON diet + 1 g/d MDP; (3) CON diet + 20 mg/kg EA; and (4) CON diet + 20 mg/kg EA + 1 g/d MDP. The study was conducted over 14 d with 7 d of adaptation and 7 d of sample collection. Data were analyzed in SAS using PROC MIXED including fixed effects of EA, MDP, and the EA×MDP interaction. Random effects included RUSITEC apparatus and cow rumen inoculum ($n = 4$). Ergot alkaloids decreased dry matter (DMD) ($P = 0.01$; 87.9 vs. 87.2%) and organic matter disappearance (OMD) ($P = 0.02$; 88.8 vs. 88.4%). Inclusion of MDP increased OMD ($P = 0.01$; 88.3 vs. 88.9%). Neutral detergent fiber disappearance (NDFD) was improved with MDP; however, an EA×MDP interaction was observed with MDP increasing ($P < 0.001$) NDFD more with EA diet compared to CON. Acetate proportion decreased ($P = 0.01$) and isovalerate increased ($P = 0.03$) with EA. Consequently, acetate:propionate was reduced ($P = 0.03$) with EA. Inclusion of MDP increased total volatile fatty acid (VFA) production ($P < 0.001$), and proportions of acetate ($P = 0.03$) and propionate ($P = 0.03$), and decreased valerate ($P < 0.001$), isovalerate ($P = 0.04$), and caproate ($P = 0.002$). Treatments did not affect ($P \geq 0.17$) ammonia, total gas, or methane production (mg/d or mg/g of organic matter fermented). The inclusion of MDP reduced ($P < 0.001$) microbial nitrogen (MN) production in the effluent and increased ($P = 0.01$) feed particle-bound MN. Consequently, total MN decreased ($P = 0.001$) with MDP. In all treatments, the dominant microbial phyla were Firmicutes, Bacteroidota, and Proteobacteria, and the major microbial genus was *Prevotella*. Inclusion of MDP further increased the abundance of Bacteroidota ($P = 0.04$) as it increased both *Prevotella* ($P = 0.04$) and Prevotellaceae_UCG-003 ($P = 0.001$). In conclusion, EA reduced OMD and acetate production due to impaired rumen function, these responses were successfully reversed by the addition of MDP.

- EA reduce DMD and alterd VFA profile, and reduced the microbial diversity
- Resposnse were reversed with MDP
- Overall little impact on ruminal fermentation

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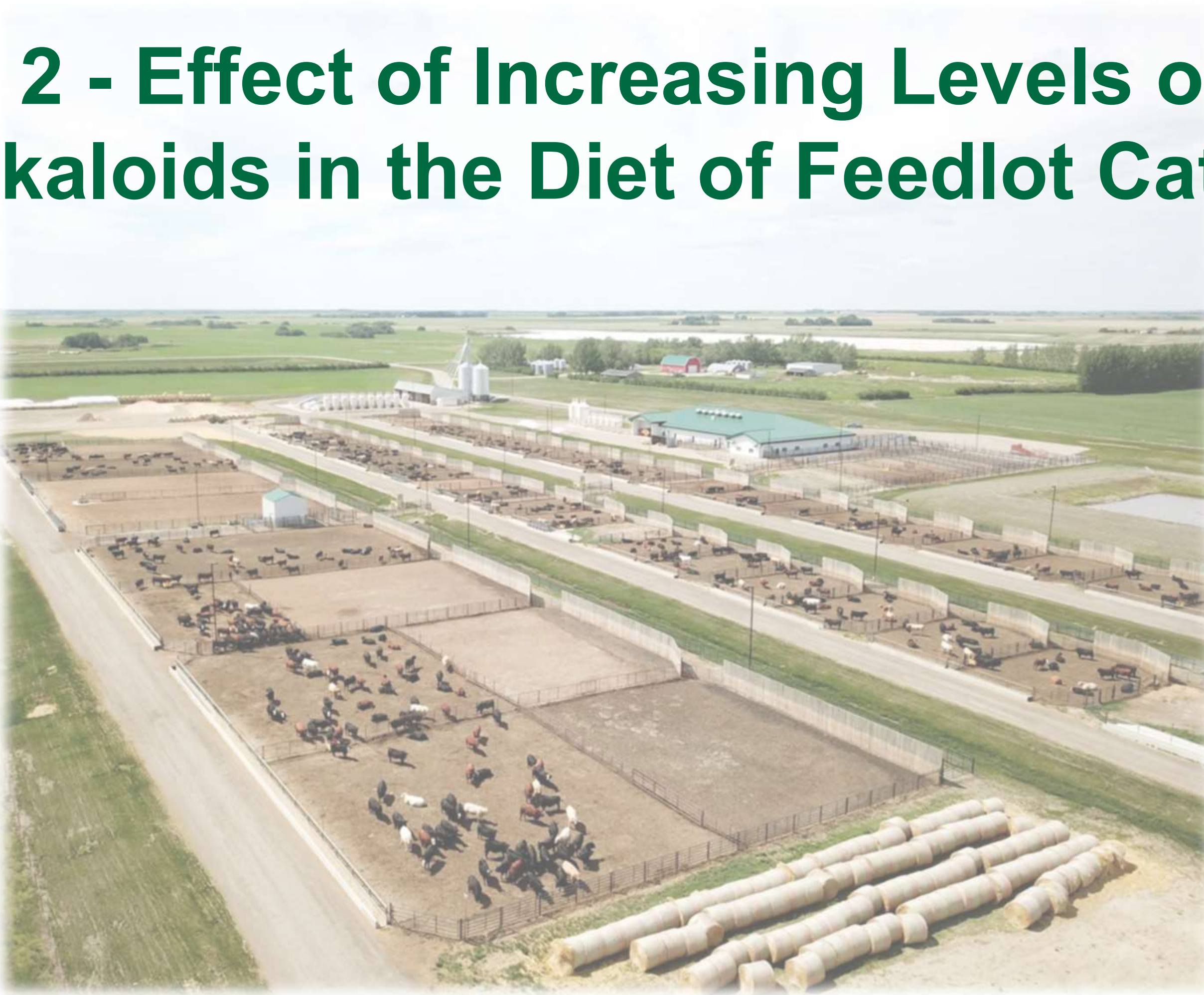
Study 2 - Effect of Increasing Levels of Ergot Alkaloids in the Diet of Feedlot Cattle



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Study 2

Objective:

To define maximum concentrations of ergot alkaloids in the diet of feedlot steers and how increased levels of ergot alkaloids affect growth performance, health, and welfare parameters

Hypothesis:

Treatments containing less than 3 mg/kg of ergot alkaloids will impact cattle growth performance and health steers

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Study 2

- LFCE Feedlot
- 240 steers (15/pen)
- 4 diet treatments (4 pens/treatment)
    a) 0, 0.75, 1.5 or 3.0 ppm of diet DM (33 ppm Monensin)
- Backgrounding (84 d) – 60% barley silage:40% concentrate DM basis
- 4-week transition period
- Finishing (120 d) – 10% barley silage:90% concentrate DM basis

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Study 2 Timeline

Start — Backgrounding Period — Transition (28 d) — Finishing Period — End

DOF	
0 (Start)	BW
1	BW, Blood, Hair, Thermo, Flight Speed
21	BW, Fecal, Temp
42	BW, Blood, Hair, Thermo, Flight Speed
63	BW, Fecal, Temp
84	BW, Blood, Hair, Thermo, Flight Speed
112	BW, Blood, Hair, Thermo, Flight Speed
113	BW
140	BW, Fecal, Temp
168	BW, Blood, Hair, Flight Speed
189	BW, Blood, Hair, Thermo, Flight Speed, Fecal, Temp
210	BW, Blood
229	BW, Blood, Hair, Thermo, Flight Speed, Fecal, Temp
230 (End)	BW

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Study 2

Table. Performance parameters of backgrounding beef steers

	Ergot (ppm)					*P*-value		
Item	**0.00**	**0.75**	**1.50**	**3.00**	**SEM**	**Treat**	**Lin**	**Quad**
Shrunk initial BW, kg	273	273	274	273	0.4	0.43	0.53	0.13
Shrunk final BW, kg	359	358	352	353	2.1	0.04	0.03	0.32
Shrunk total BW gain, kg	85.7	85.1	79.0	79.7	2.12	0.03	0.02	0.38
DMI, kg/d	7.0	6.9	6.6	6.9	0.251	0.71	0.63	0.39
ADG, kg	1.00	0.98	0.90	0.95	0.021	0.04	0.10	0.05
G:F	0.143	0.136	0.137	0.139	0.0064	0.88	0.82	0.49

Study 2

	Start			Finishing Period				End
DOF	**112**	**113**	**140**	**168**	**189**	**210**	**229**	**230**
	BW	BW	BW	BW	BW	BW	BW	BW
	Blood		Fecal	Blood	Blood	Blood	Blood	
	Hair		Temp	Hair	Hair		Hair	
	Thermo			Flight Speed	Thermo		Thermo	
	Flight Speed				Flight Speed		Flight Speed	
					Fecal		Fecal	
					Temp		Temp	

Treatment with 3 ppm Ergot moved to Control diet

Strong signs of heat stress

- High respiratory rate
- Tongue out
- Drooling
- High body temperature
- Reduced DM intake

Ambient temperature above **20ºC**

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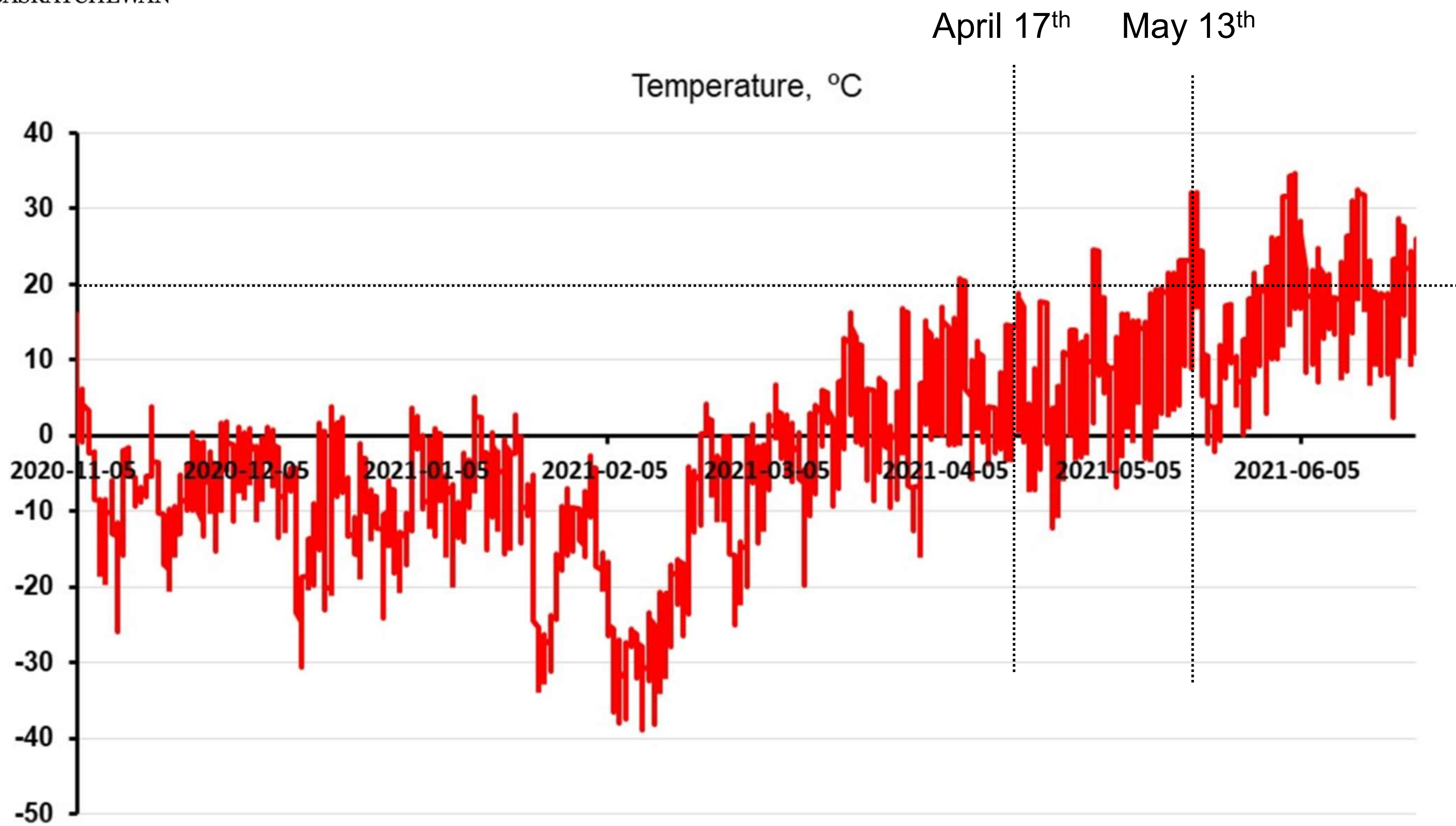

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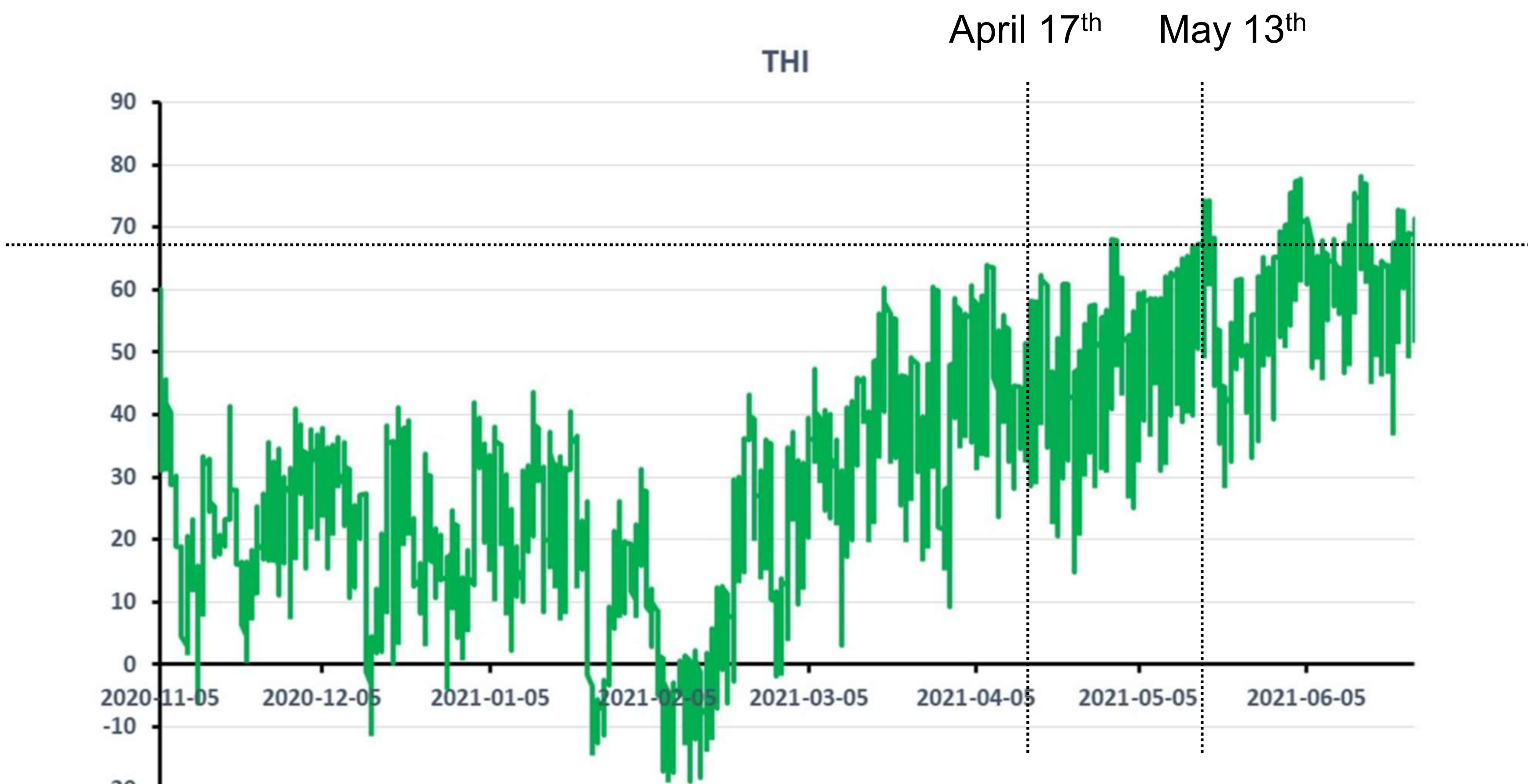

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3 ppm Ergot treatment

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3 ppm Ergot treatment

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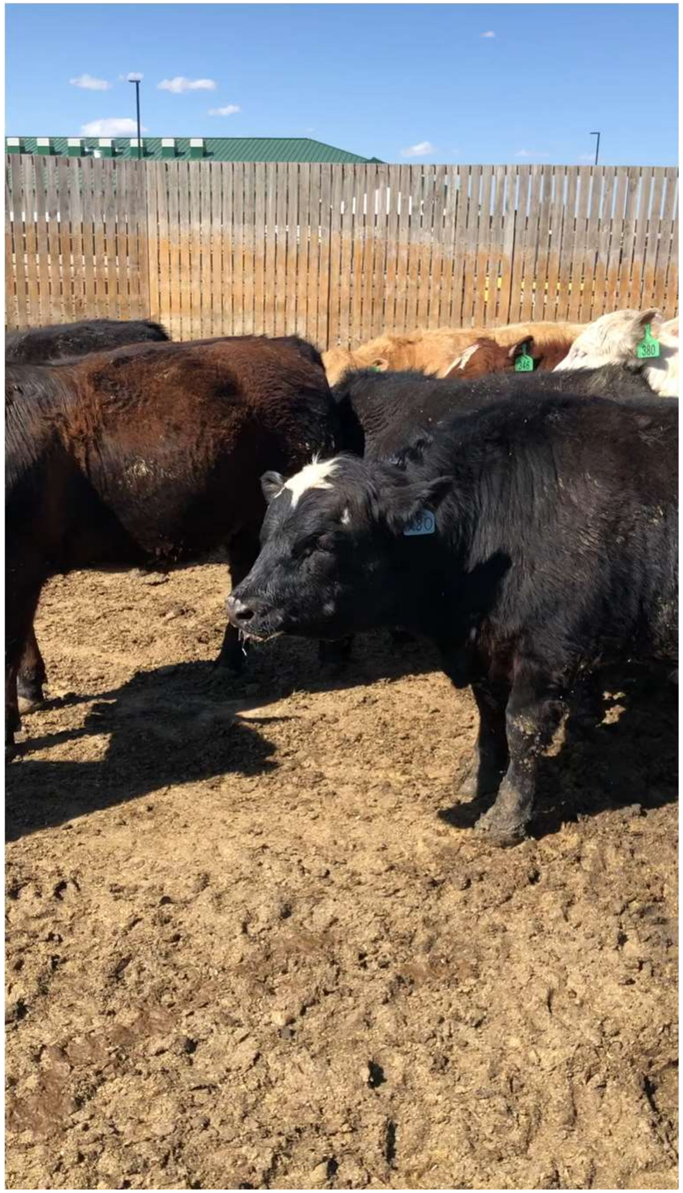

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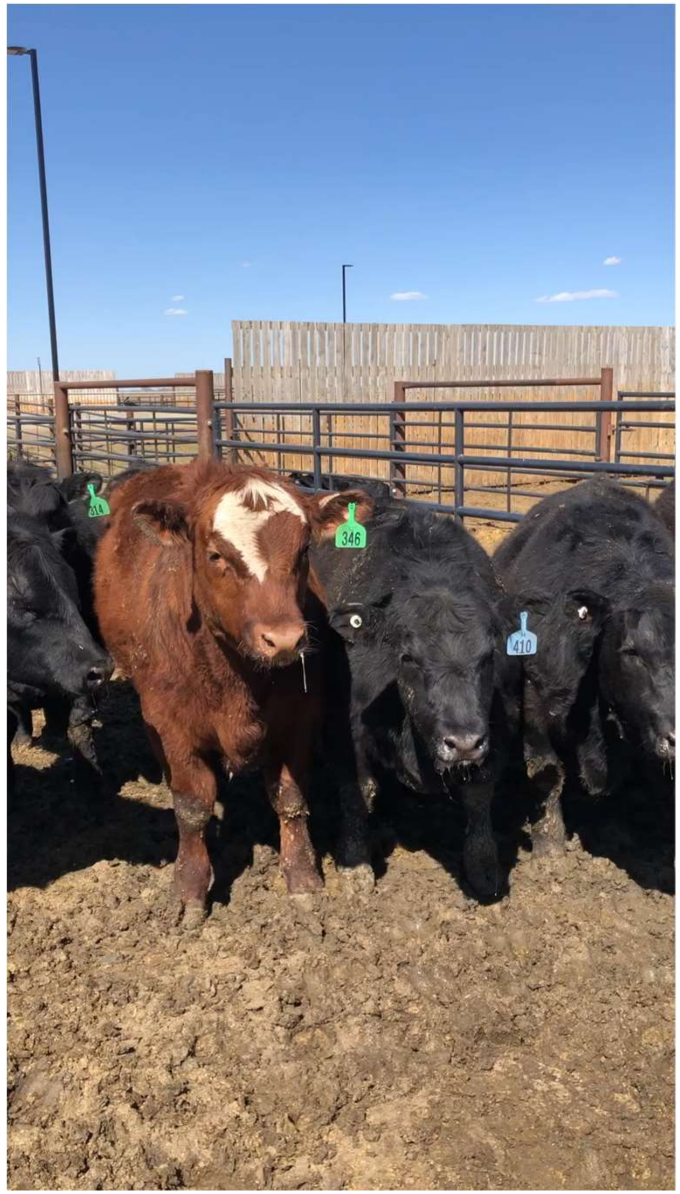

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Control treatment

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Control treatment

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Study 2

Table. Average body temperature of beef steers throughout the study

	Ergot (ppm)					*P*-value				
	0.00	0.75	1.5	3.00	SEM	Trt	Period	Trt*Day	Lin	Quad
Body temperature, ºC	39.2	39.3	39.3	39.5	0.1	< 0.01	< 0.01	0.36	< 0.01	0.49

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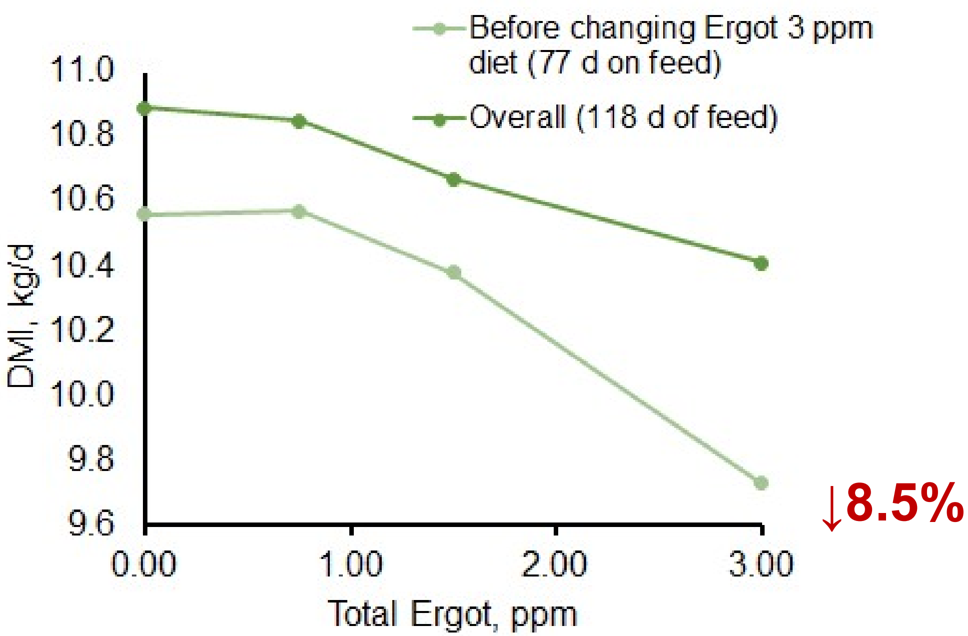
Study 2

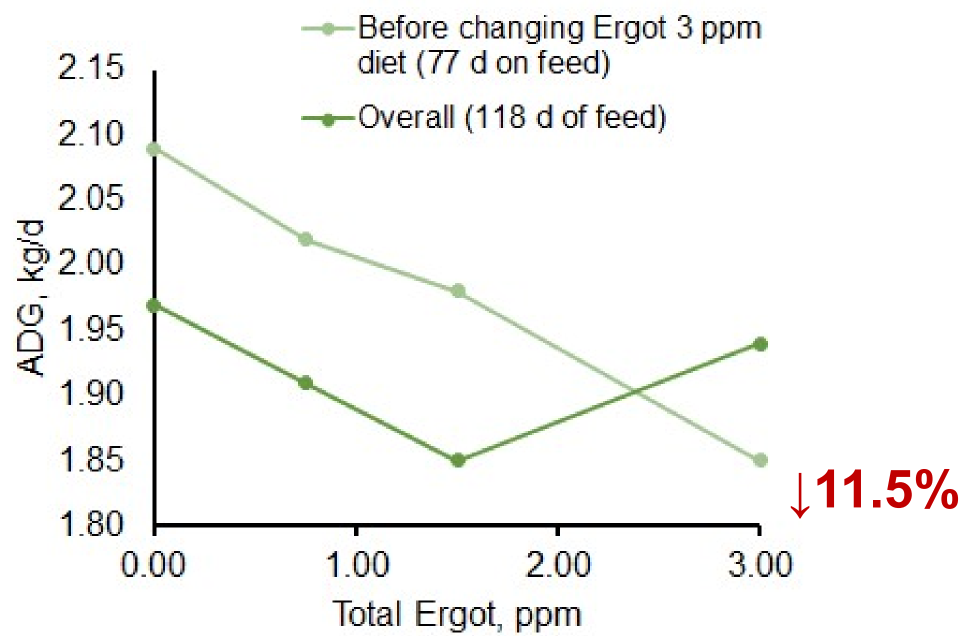
Table. Performance parameters of finishing beef steers

Item	Ergot (ppm)				SEM	*P*-value		
	0.00	0.75	1.50	3.00		Treat	Lin	Quad
Shrunk initial BW, kg	400	404	393	395	2.5	0.04	0.05	0.56
Shrunk BW, kg (P3)	567	563	548	541	6.2	0.04	0.01	0.67
Shrunk final BW, kg	627	624	604	621	6.5	0.10	0.37	0.05
Shrunk total BW gain, kg (P3)	167	159	155	146	4.6	0.05	0.01	0.80
Shrunk total BW gain, kg	223	220	211	226	3.6	0.04	0.56	0.02
DMI, kg/d (P3)	10.6	10.6	10.4	9.7	0.310	0.15	0.04	0.46
DMI, kg/d	10.9	10.9	10.7	10.4	0.286	0.53	0.16	0.89
ADG, kg (P3)	2.09	2.02	1.98	1.85	0.051	0.04	0.01	1.00
ADG, kg	1.97	1.91	1.85	1.94	0.039	0.19	0.69	0.05
G:F (P3)	0.192	0.191	0.198	0.191	0.0064	0.79	0.94	0.50
G:F	0.181	0.177	0.180	0.187	0.0040	0.38	0.20	0.28

Study 2

Finishing period





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Study 2

Table. Blood serum parameters and hair cortisol of beef steers

	Ergot (ppm)					P-value				
	0.00	0.75	1.50	3.00	SEM	Trt	Day	Trt*Day	Lin	Quad
Hair Cortisol, pg/mg	5.68	6.33	6.41	5.77	1.36	0.81	<0.001	0.25	0.96	0.35
Blood Cortisol, nmol/L	63.0	68.0	63.1	64.5	8.71	0.84	<0.001	0.78	0.98	0.81
Haptoglobin, µg/mL	185.6	182	177.6	192.8	28.27	0.83	<0.001	0.83	0.64	0.45
Prolactin, ng/mL	37.1	34.4	34.9	36.5	6.01	0.99	0.02	0.33	0.94	0.83
BUN, mg/100 mL	10.9b	12.0a	10.9b	12.0a	0.68	<0.001	<0.001	0.28	0.04	0.73
TAG, mmol/L	0.273	0.263	0.277	0.255	0.0193	0.29	<0.001	0.23	0.23	0.46
Total protein, g/100 mL	7.32	7.25	7.32	7.26	0.126	0.89	<0.001	0.66	0.77	0.98
Globulin, g/100 mL	3.74	3.66	3.82	3.73	0.147	0.7	<0.001	0.62	0.83	0.73
Cholesterol, mg/100 mL	104	105	100	104	3.3	0.22	<0.001	0.008	0.83	0.33
Albumin, g/100 mL	3.54	3.54	3.47	3.50	0.048	0.11	<0.001	0.04	0.10	0.23
Alkaline phosphatase, U/L	165	163	168	149	9.0	0.04	<0.001	0.03	0.02	0.11
GGT, U/L	14.4	16.3	16.5	15.2	1.79	0.49	<0.001	0.35	0.76	0.15
AST, U/L	91.6	87.4	87.1	81.4	6.58	0.05	0.02	0.01	0.01	0.96
ALT, U/L	27.5	26.8	25.2	24.7	1.41	0.05	<0.001	0.01	0.01	0.40

Study 2

Table. Carcass characteristics and liver abscess incidence of beef feedlot steers

Item	Ergot (ppm) 0.00	0.75	1.50	3.00	SEM	*P*-value Treat	Lin	Quad
Hot carcass weight, kg	374a	371ab	358b	366ab	3.4	0.04	0.08	0.05
Dressing percentage, %	59.4ab	59.7a	59.6a	58.5b	0.21	0.01	0.01	0.02
Back fat thickness, mm	13.2	14.2	13.5	12.7	0.66	0.42	0.36	0.28
Rib-eye area, cm^2	86.5	88.4	87.1	87.7	1.35	0.83	0.83	0.80
Marbling score	390ab	411a	362b	390ab	8.4	0.01	0.40	0.21
Lean meat yield, %	55.9b	56.6b	56.4b	57.6a	0.18	<0.01	<0.01	0.54
Quality grade, %								
AAA, %	64.4	73.3	65.0	73.3	-	0.56	-	-
AA, %	32.2	20.0	26.7	11.7	-	0.07	-	-
A, %	3.4	1.7	3.3	11.7	-	0.10	-	-
B4, %	0.0	5.0	5.0	3.3	-	0.97	-	-
Abscessed livers, %	38.3	40.0	51.7	33.3	-	0.20	-	-
Severely abscessed, %	36.7	36.7	45.0	33.3	-	0.59	-	-

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Study 3 - Effect of continuous or intermittent feeding of ergot contaminated grain in a mash or pelleted form on the performance of feedlot steers

Agriculture and Agri-Food Canada Agriculture et Agroalimentaire Canada

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Hypothesis

It was hypothesized that:

- **Cattle fed the ergot supplement pellet would experience reduced symptoms compared to mash form**
- **Cattle fed the ergot diet continuously would experience greater symptoms than when fed the ergot diet intermittently**

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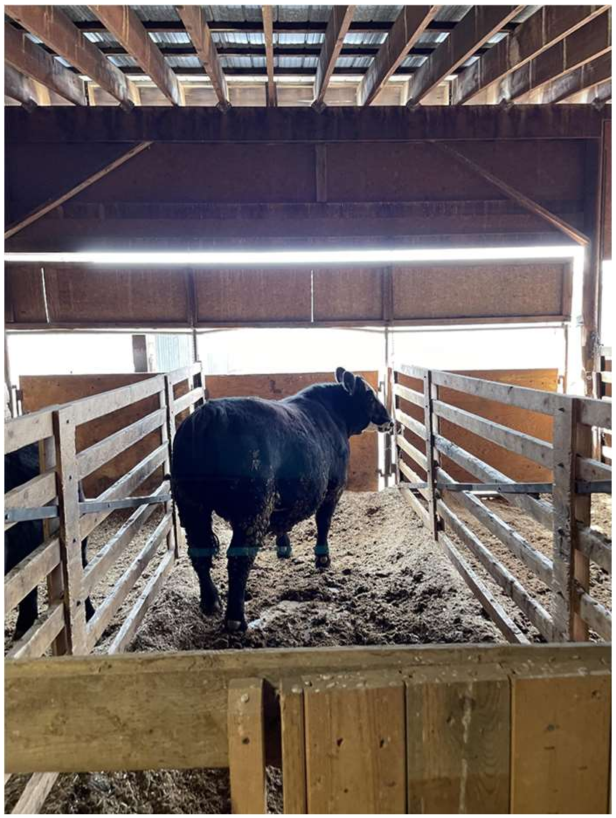
Study 3



- 60 black Angus cross steer calves
- 300 ± 29.4 kg BW
- 84-day backgrounding (60% silage:40% concentrate)
- 125-day finishing phases (10% silage:90% concentrate)
- Calves weighed every 21 days

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Study 3

- Steers were individually housed and randomly assigned to 4 different treatments (15/treatment)
- Treatments include:
  - 1) Control ration (CON; no ergot added)
  - 2) Continuous ergot mash (CEM; fed continuously at 2 ppm)
  - 3) Intermittent ergot mash (IEM; fed at 2 ppm)
  - 4) Intermittent ergot pellet (IEP; fed at 2 ppm)

Ergot Diet ↓	Control Diet ↓	Control Diet ↓
Week 1	**Week 2**	**Week 3**

3 – Week Intermittent Feeding Period

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Study 3



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Study 3

- 7.6% ↓ DMI
- 18.6% ↓ weight gain

Growth performance of backgrounding steers

	Treatments					*P*-value	
	Control	Ergot Continuous	Ergot Intermittent Mash	Ergot Intermittent Pellet	SEM	Trt	Ctrl vs. Ergot
Shrunk initial BW, kg	289	288	290	289	7.37	0.99	0.97
Shrunk final BW, kg	366	350	354	351	9.4	0.62	0.20
Shrunk total BW gain, kg	77.3	61.7	64.6	62.3	4.73	0.08	**0.01**
DMI, kg/d	8.05a	7.31b	7.48ab	7.55ab	0.182	0.03	**0.01**
ADG, kg	0.980	0.735	0.770	0.741	0.0563	0.08	**0.01**
Gain:Feed	0.142	0.130	0.134	0.130	0.0051	0.27	0.07

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Study 3

- 10.0% ↓ DMI
- 10.1% ↓ weight gain

Growth performance of finishing steer

	Treatments					*P*-value	
	Control	Ergot Continuous	Ergot Intermittent Mash	Ergot Intermittent Pellet	SEM	Trt	Ctrl vs. Ergot
Shrunk initial BW, kg	446	414	426	419	8.5	0.07	0.01
Shrunk final BW, kg	671a	618b	648ab	628b	11.5	**0.01**	**0.004**
Shrunk total BW gain, kg	225.2a	202.5b	221.7ab	208.7ab	5.66	**0.02**	**0.03**
DMI, kg/d	11.05a	9.95b	10.26ab	9.96b	0.253	**0.01**	**0.001**
ADG, kg	1.80a	1.62b	1.77ab	1.67ab	0.045	**0.02**	**0.04**
Gain:Feed	0.161	0.163	0.173	0.168	0.0034	0.07	0.09

Study 3

	Treatments					*P*-value	
	Control	Ergot Continuous	Ergot Intermittent Mash	Ergot Intermittent Pellet	SEM	Trt	Ctrl vs. Ergot
Body temperature, ºC	39.4	39.7	39.7	39.6	0.05	<0.01	<0.01

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Takehome Messages

- Ergot has little impact on ruminal fermentation
- Steers fed increasing levels of ergot had lower DMI, ADG, and a lower dressing %
- Steers fed 3.0 ppm ergot had strong symptoms of heat stress when ambient temperature was >20ºC
- Ergor alkaloids caused increased body temperature (~ ↑0.3ºC)
- **Intermittent** feeding showed similar results to **continuous**
- **Pelleting** was **not** an effective method of reducing ergot toxicity
- Maximum ergot level for feedlot cattle **≤1.0 ppm**

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Next steps

- Look at strategies to reduce the toxicity of ergot
- Investigate the impact of ergot in cold vs. warm climate
- Investigate the impact of **R- vs. S-epimers** (thought to be biologically inactive)

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BCRC
Beef Cattle Research Council

Since 1874 Alberta Beef

SCA Saskatchewan Cattlemen's Association

NSERC CRSNG

Government of Saskatchewan
Ministry of Agriculture

Agriculture and Agri-Food Canada Agriculture et Agroalimentaire Canada

THANK-YOU

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