Navigating The Post-Antibiotic Era In Commercial Poultry Nutrition

A Comprehensive Look At Gut Health Management Programs in Broiler Chickens Reared Under Commercial and Research Settings

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POULTRY INNOVATION PARTNERSHIP: INNOVATION SHOWCASE

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What is gut health?

Features > Nutrition and Feed Research

Nutritional strategies for optimizing poultry gut health

The latest research on nutritional strategies for broilers, layers and turkeys.

Features > Broilers Breeders Layers Turkeys

Guts of Growth: The continued story of antibiotic resistance

Where Canada stands and what else can be done.

Features > Business & Policy Trade

Gut Health Update: Coccidiosis control trends in Europe

Coccidiosis control trends in Europe

Features > Nutrition and Feed

Growth begins in the gut

Gut health research to lead to improved yeast-based feed products.

What is gut health?

Absence of pathogens

Low mortality

Absorption of nutrients

Efficient growth rate

Absence of s

Profitability

Intestinal integrity

Functioning barrier

State of overall health and well being

eight, crypt depth

"Intestines are fit for purpose"

(Bedford & Apajalahti 2021)

Why is the poultry industry focused on gut health?

Worldwide there is a concern that antibiotics used in human medicine are no longer as effective in the treatment of disease due to overuse in animal agriculture.

Poultry industry has been mandated to reduce and eliminate antibiotics.

Under Canadian regulations the majority of broilers are reared according to three gut health management programs.

1. Conventional (CON): Category III and IV antibiotics and avilamycin permitted
2. Raised without medically important antibiotics (RWMIA): Only avilamycin and Category IV antibiotics permitted (antibiotics not classified as important to human medicine)
3. Raised without the use of antibiotics (RWA): No antibiotics permitted from any category

Opportunities for "Gut Friendly" Diets

Diet composition

- Highly digestible ingredients
- Consistent composition
- Monitored for antinutritional factors
- All-vegetable, plant based ingredients

Ingredient usage

- Antibiotics
- Enzymes
- Probiotics
- Prebiotics
- Phytogenic feed additives
- Organic acids

Variations between research and commercial settings

- **Exposure to stress**
  - Heat stress
  - Stocking density
  - Extended periods of feed withdrawal
  - Water quality
- **Commercial feed mill**
  - Ingredient availability, price, and quality
- **Inability to reproduce field conditions**
  - Sanitary conditions

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Research hypothesis and objectives

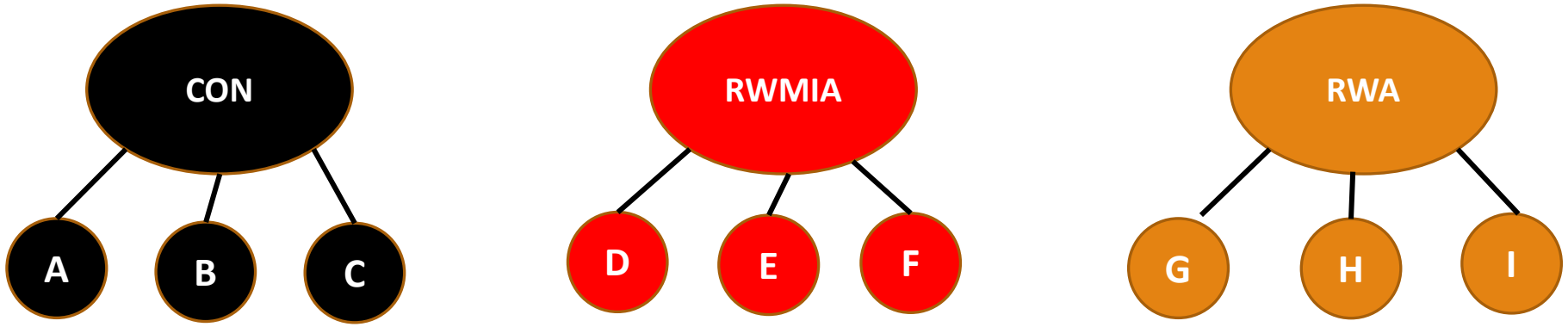
Hypothesis:

- Reducing or eliminating the use of antibiotics is not having negative impact on performance, bird health parameters, physiology, or diseases because gut health management programs are designed with a multifactorial approach using strategies proven to support the bird in the absence of antibiotics.

Objective:

- Benchmark growth performance and health parameters of broiler chickens reared on gut health management programs under commercial and research conditions.
- Measure impact on performance, gut physiology, intestinal morphology, plasma biochemical profiles, and tibia attributes.

Experimental design – Commercial setting



starter (d 0-14), grower (d 15-28), finisher (d 29-harvest)

BW, FI, FCR, mortality, condemnations were recovered from processing data

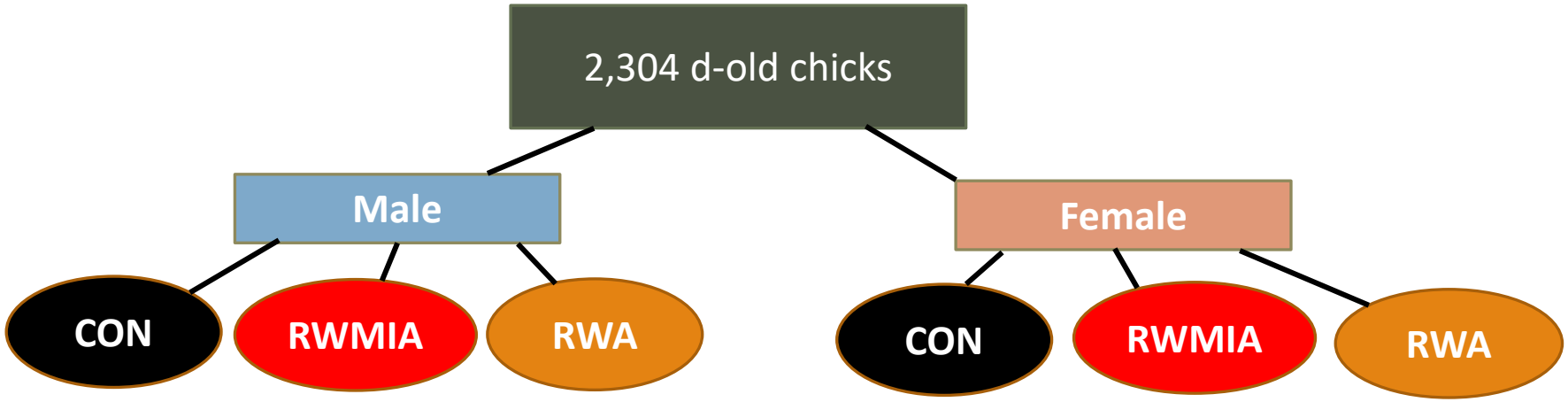
↓

At d 28, 8 birds per farm collected for analysis, 6 flocks (R) per farm

↓

GLIMMIX with program (P) as fixed effect, farm (F), F(P), R(F) as a random effect

Experimental design – Research setting



starter (d 0-14), grower (d 15-28), finisher (d 29-42)

n=8, sex and program combination (48 birds per pen)

BW, FI, FCR at d 14, d 28, d 42, and overall

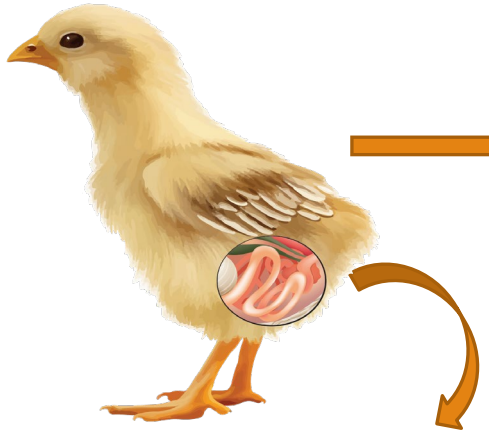
At d 28 and d 41 sample collection for analysis

ANOVA analysis with sex, program, and associated interactions

Table 1: Guidelines for ingredient inclusion (%) among gut health management programs

	Starter (0-14 d)			Grower (15-28 d)			Finisher (29 d- market)		
Program	CON	RWMIA	RWA	CON	RWMIA	RWA	CON	RWMIA	RWA
Corn products	35-50	45-55	50-55	35-55	55-60	55-60	45-55	52-66	60-65
Wheat products	15-25	8-10	7.5	15-28	10-13	9	20-30	10-15	9
Animal products	3-8	3-5	0	3-8	3-6	0	3-8	3-6	0
Plant protein meals	20-25	25-30	33-35	15-25	19-20	22-25	9-15	16-20	20-23
Animal Vegetable lipid blend	0-5	0-2	0	0-5	0-3	0	0-5	0-3	0
Vegetable oil	0	0	1-2	0	0	2-2.5	0	0	2-3
Feed enzymes	+	+	+	+	+	+	+	+	+
n-Butyric acid	-	0.11	0.12	-	0.04	0.06	-	0.04	0.04
Probiotic supplement	-	+	+	-	+	+	-	-	-
Feed additives mixture	-	-	+	-	-	+	-	-	+
Calculated provisions									
Crude protein %	21.50	22.00	21.50	19.50	19.00	18.00	17.50	17.50	17.50
AME, kcal/kg	2970	3025	3000	3035	3035	3125	3100	3125	3200
Calcium %	1.00	1.00	0.90	0.94	0.94	0.91	0.90	0.90	0.88
Available phosphorus %	0.50	0.50	0.50	0.45	0.45	0.44	0.44	0.44	0.44
dig Lysine %	1.17	1.23	1.25	1.02	1.02	1.05	0.85	0.85	0.96

Broiler chickens
28 days of age



→ **Bled for plasma d 28 & d 41** → Electrolytes, minerals, proteins, carbohydrates, lipid, enzymes

Euthanized, weighed, & necropsied for:

Organ weight

Myopathy evaluation ← **Breast weight**

De-fleshed left tibia (weight, length, diameter) → Tibia ash content

Intestine samples → Jejunal histomorphology

Ceca digesta → Digesta SCFA

At 41 days of age: Euthanized, weighed, & necropsied for:

Breast weight → Myopathy evaluation

De-fleshed left tibia (weight, length, diameter) → Tibia ash content

Ceca digesta → Digesta SCFA

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Performance results – Commercial settings

Table 2:Effect of gut health management programs on growth performance, mortality, and condemnations of broiler chickens from hatch to market weight

Program[1]	Body weight kg/bird	Feed intake kg/bird	FCR	Mortality %	Condemnations %
CON	3.05±0.13	5.34±0.19	1.75±0.03	4.80±1.10	0.55[b]±0.07
RWMIA	2.78±0.13	4.73±0.20	1.72±0.03	5.41±1.14	1.10[a]±0.15
RWA	2.77±0.15	4.89±0.25	1.71±0.04	7.05±1.34	0.80[ab]±0.14
P-value	0.299	0.151	0.629	0.538	0.021

*LSMeans reported ± SEM

[1]Gut health management program: CON, some medically important antibiotics (MIA) allowed; RWMIA, raised without MIA; RWA, raised without antibiotics.

[a,b]Means within a column with no common superscripts differ significantly ($P < 0.05$).

Bean-Hodgins, L., M. Mohammadigheisar, A. M. Edwards, C. Wang, S. Barbut, and E. G. Kiarie. 2022. Comparative impact of conventional and alternative gut health management programs on growth performance and breast meat quality in broiler chickens raised in commercial and research settings. J. Appl. Poult. Res. 31: 100228

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Performance results- Research settings

Table 3: Effect of gut health management programs and sex on growth performance and mortality of broiler chickens

	Program[1]				Sex			*P*-value		
Item	CON	RWMIA	RWA	SEM	Male	Female	SEM	Program	Sex	Program*Sex
Starter d 0-14										
Body weight (BW), kg/bird	0.35^{b}	0.39^{a}	0.40^{a}	0.004	0.37^{b}	0.39^{a}	0.003	<0.001	0.003	0.419
BW gain, kg/bird	0.31^{b}	0.35^{a}	0.36^{a}	0.01	0.33^{b}	0.35^{a}	0.01	<0.001	0.002	0.331
Feed intake, kg/bird	0.43^{b}	0.46^{a}	0.46^{ab}	0.01	0.43^{b}	0.45^{a}	0.01	0.002	0.004	0.173
FCR, kg/kg	1.38^{a}	1.31^{b}	1.23^{c}	0.02	1.31	1.30	0.02	<0.001	0.871	0.618
Grower d 15-28										
Body weight (BW) kg/bird	1.30	1.30	1.30	0.01	1.33^{a}	1.26^{b}	0.01	0.887	<0.001	0.472
BW gain, kg/bird	0.95^{a}	0.91^{ab}	0.89^{b}	0.01	0.96^{a}	0.87^{b}	0.01	<0.001	<0.001	0.811
Feed intake, kg/bird	1.48	1.46	1.45	0.02	1.52^{a}	1.40^{b}	0.01	0.064	<0.001	0.419
FCR, kg/kg	1.49^{b}	1.54^{a}	1.55^{a}	0.01	1.51^{b}	1.54^{a}	0.01	<0.001	0.004	0.743
Finisher d 29-42										
Body weight (BW), kg/bird	2.64	2.65	2.64	0.04	2.80^{a}	2.49^{b}	0.01	0.817	<0.001	0.467
BW gain, kg/bird	1.34	1.36	1.34	0.03	1.46^{a}	1.23^{b}	0.01	0.666	<0.001	0.480
Feed intake, kg/bird	2.51	2.48	2.53	0.06	2.27^{b}	2.30^{a}	0.02	0.201	<0.001	0.252
FCR, kg/kg	1.80^{a}	1.75^{b}	1.81^{a}	0.01	1.77	1.80	0.01	0.003	0.085	0.684
Overall d 0-42										
BW gain, kg/bird	2.60	2.61	2.60	0.04	2.76^{a}	2.45^{b}	0.01	0.823	<0.001	0.459
Feed intake, kg/bird	4.42	4.39	4.43	0.07	4.67^{a}	4.16^{b}	0.02	0.653	<0.001	0.236
FCR[2], kg/kg	1.69	1.68	1.70	0.01	1.70	1.70	0.01	0.100	0.956	0.787
Cumulative mortality, %	2.09	2.73	2.47	0.56	3.29^{a}	1.56^{b}	0.42	0.741	0.018	0.387

$^{a, b}$ Means within a row with no common superscripts differ significantly ($P < 0.05$)

[1]Gut health management program: CON, some medically important antibiotics (MIA) allowed; RWMIA, raised without MIA; RWA, raised without antibiotics.

[2]Feed conversion ratio uncorrected for mortality.

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Figure 1: Effect of gut health management program on relative breast weight (g/100g BW) in 28 d broiler chickens reared under commercial settings

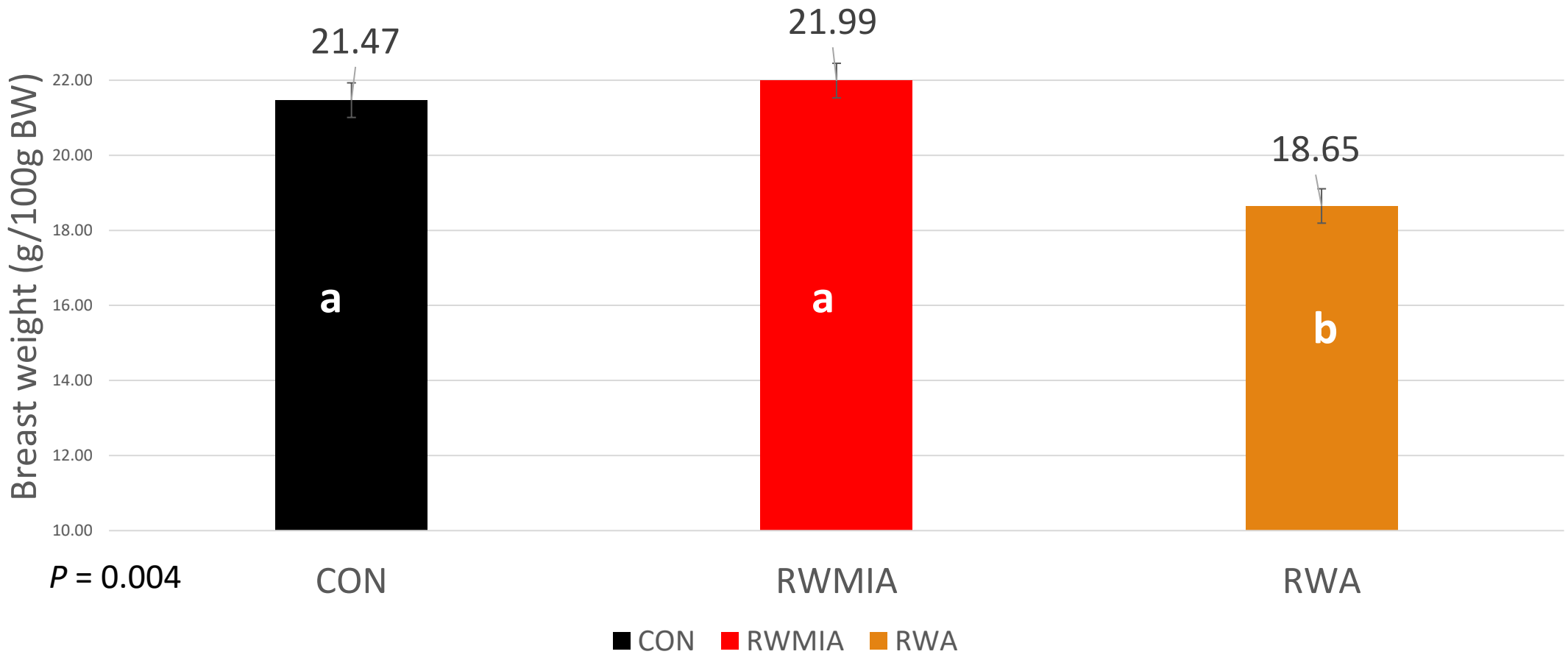

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Figure 2: Effect of gut health management program on breast weight (g/100g BW) in d 28 broiler chickens reared under research settings

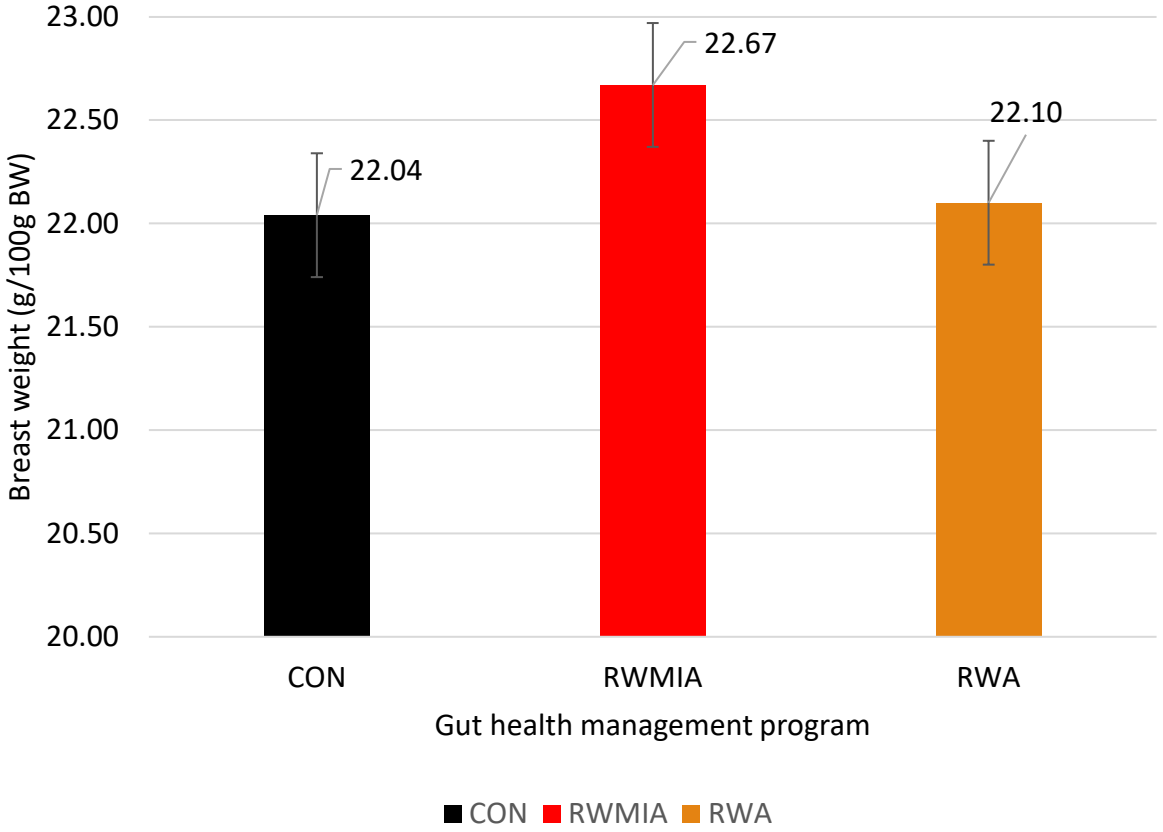
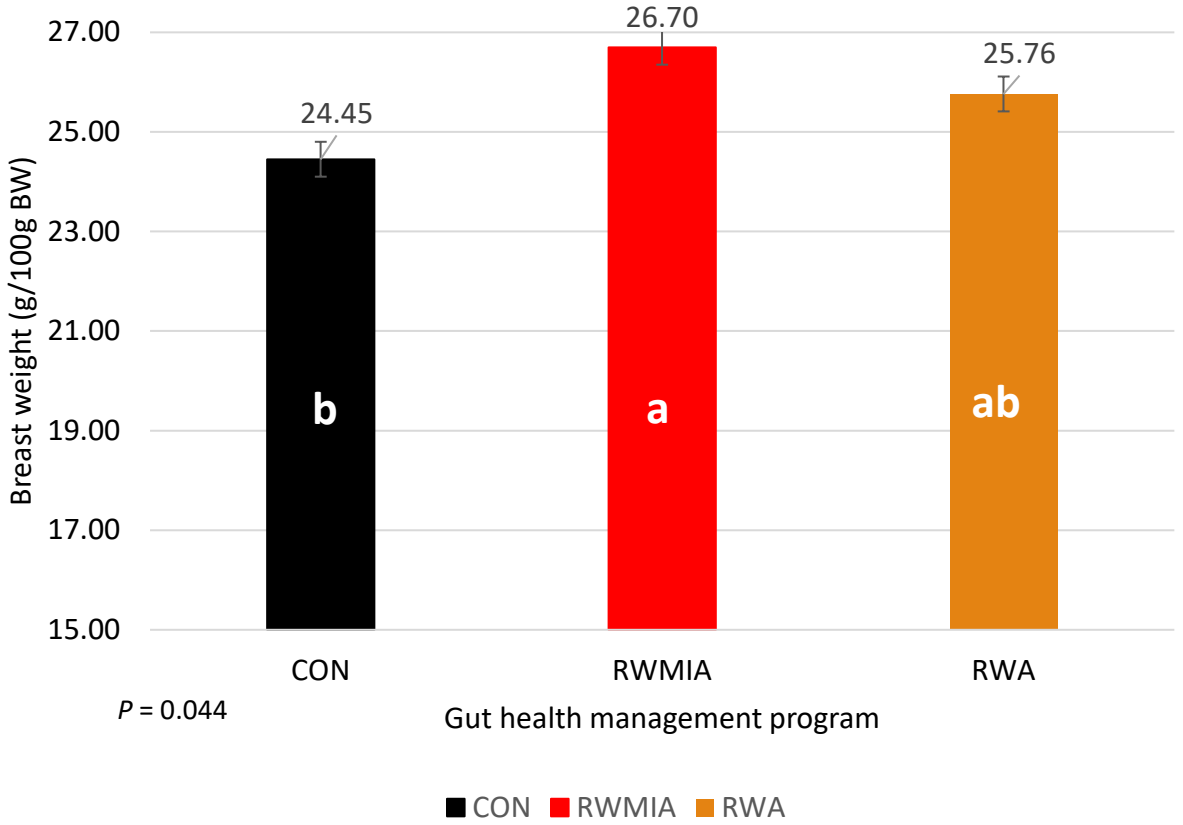


Figure 3: Effect of gut health management program on breast weight (g/100g BW) in d 41 broiler chickens reared under research settings



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Breast meat attributes

Table 4: Effects of gut health management program and sex on the percentage occurrence of the broiler breast fillet myopathies wooden breast (WB), white striping (WS) and spaghetti meat (SM) based on severity (absent, moderate or severe presence) at day 41

	Program[1]				Sex			*P*-value		
Item	CON	RWMIA	RWA	SEM	Male	Female	SEM	Program	Sex	Program*Sex
Absence of WB	34.38	56.25	34.38	10.31	27.08^{b}	56.25^{a}	8.05	0.130	0.006	0.083
Moderate WB	28.13	43.75	37.50	9.98	41.67	31.25	8.10	0.567	0.393	0.679
Severe WB	37.50^{a}	0.00^{b}	28.13^{a}	7.67	31.25^{a}	12.50^{b}	6.75	0.004	0.039	0.309
Absence of SM	62.50	68.75	62.50	8.28	64.58	64.58	6.72	0.820	1.000	0.187
Moderate SM	37.50	31.25	37.50	8.28	35.42	35.42	6.72	0.820	1.000	0.187
Absence of WS	37.50^{b}	78.13^{a}	40.63^{b}	9.01	37.50^{b}	66.67^{a}	7.65	0.001	0.002	0.065
Moderate WS	50.00^{a}	21.88^{a}	50.00^{a}	9.49	56.25^{a}	25.00^{b}	7.47	0.035	0.003	0.069
Severe WS	12.50	0.00	9.38	4.35	6.25	8.33	3.67	0.178	0.709	0.868

$^{a, b}$ Means within a row with no common superscripts differ significantly ($P < 0.05$)

[1]Gut health management program: CON, some medically important antibiotics (MIA) allowed; RWMIA, raised without MIA; RWA, raised without antibiotics.

Figure 4: Percentage differential of relative organ weights in broiler chickens reared under RWMIA and RWA vs CON at 28 d under commercial settings

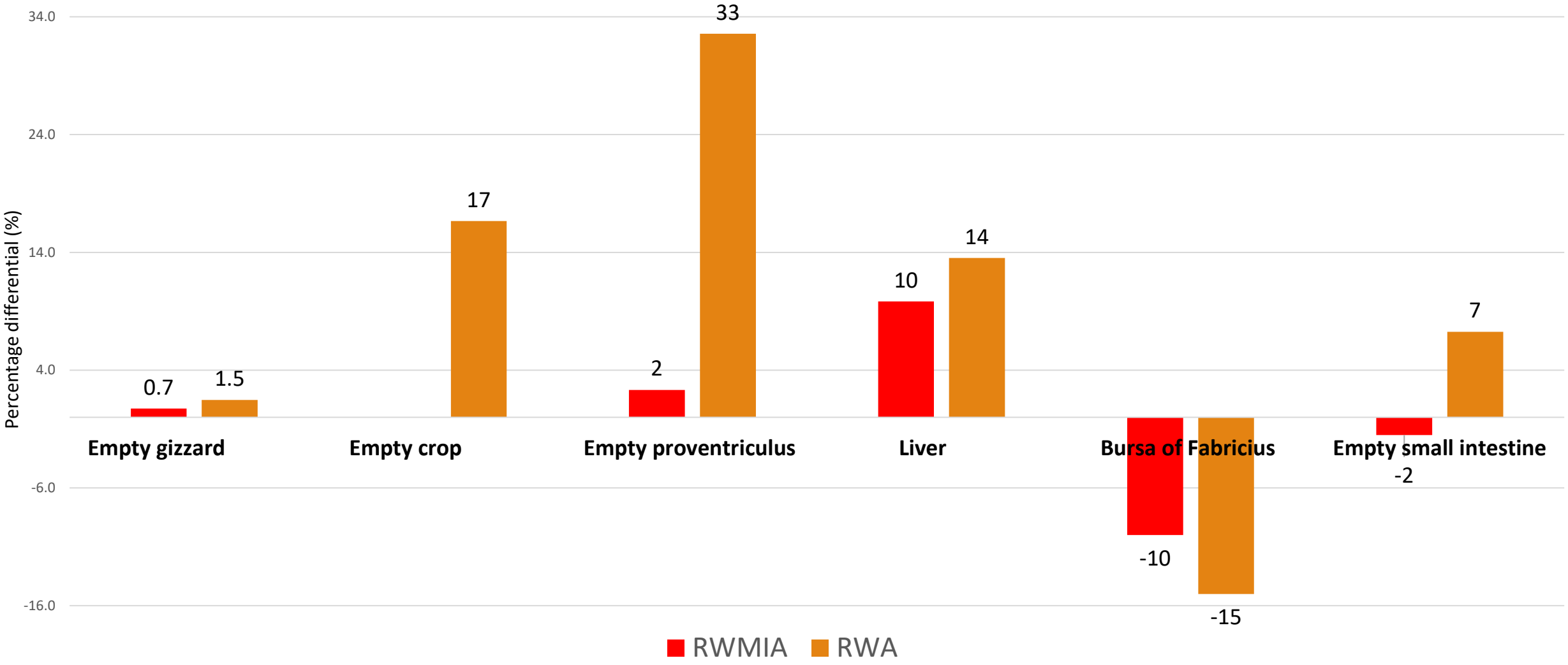

Figure 5: Percentage differential relative organ weights of broiler chickens reared under RWMIA and RWA vs CON at 28 d under research settings

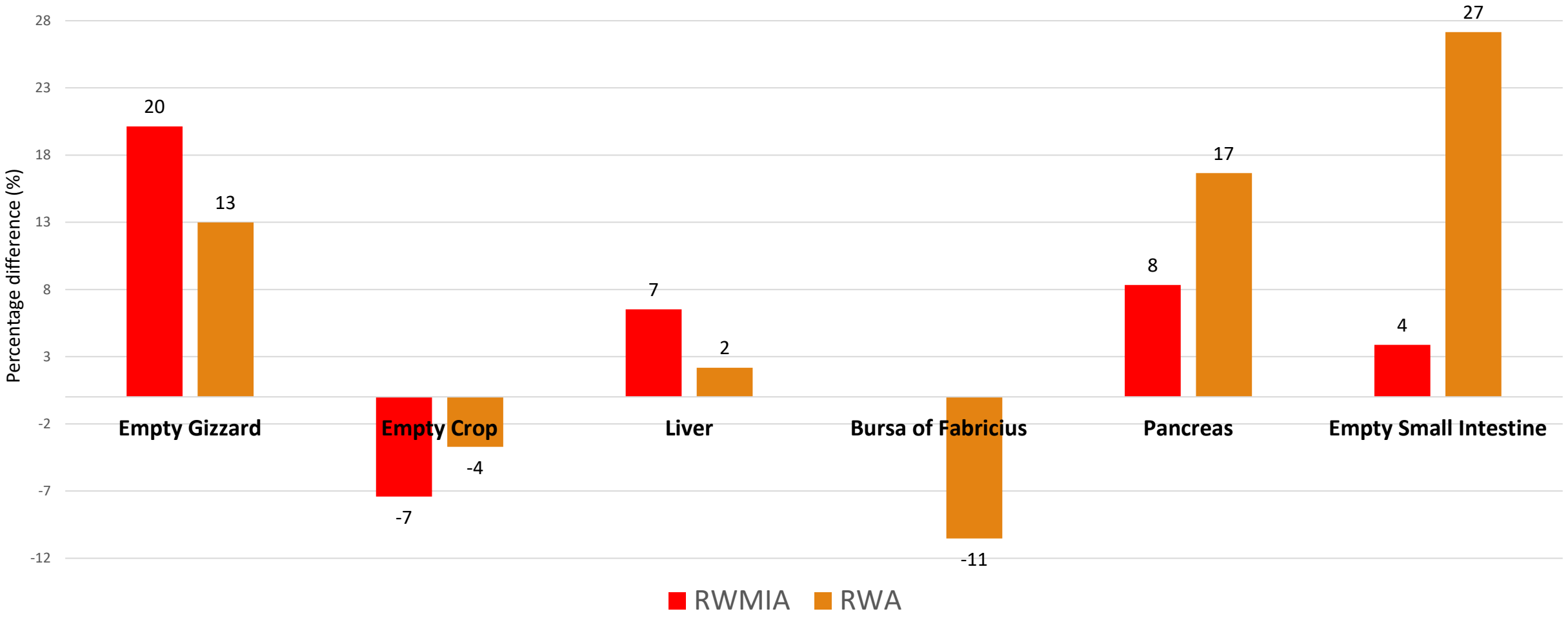

Figure 6: Effect of gut health management program on relative small intestine weight (g/100g BW) in broiler chickens at d 28 reared under commercial settings

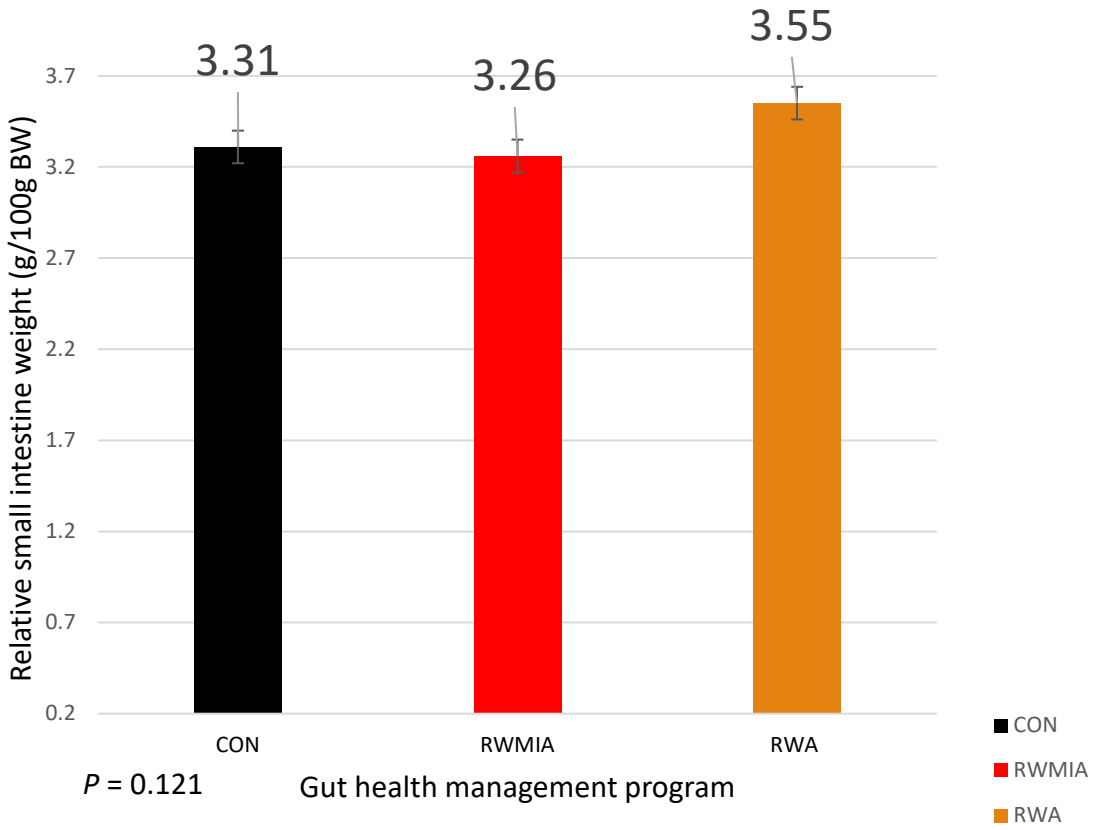

Figure 7: Effect of gut health management program & sex on relative small intestine weight (g/100g BW) in broiler chickens at d 28 reared under research settings

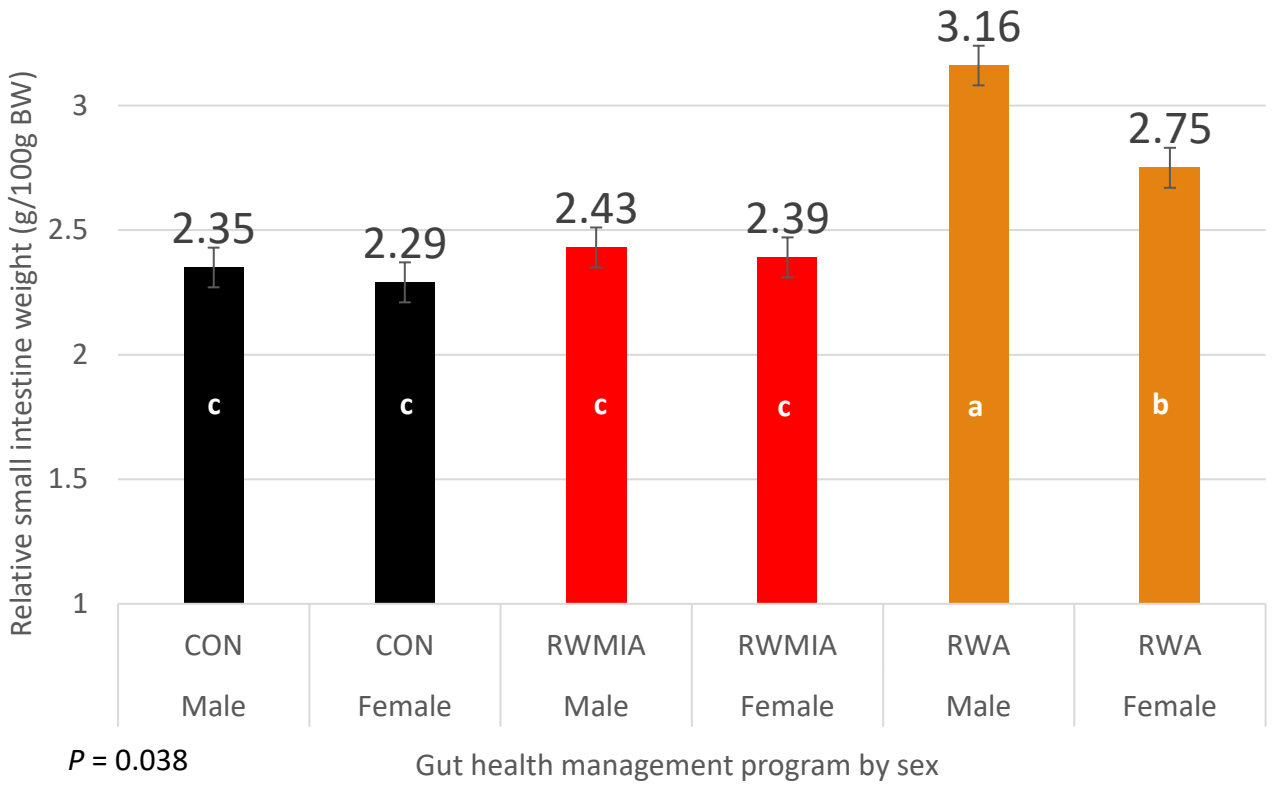

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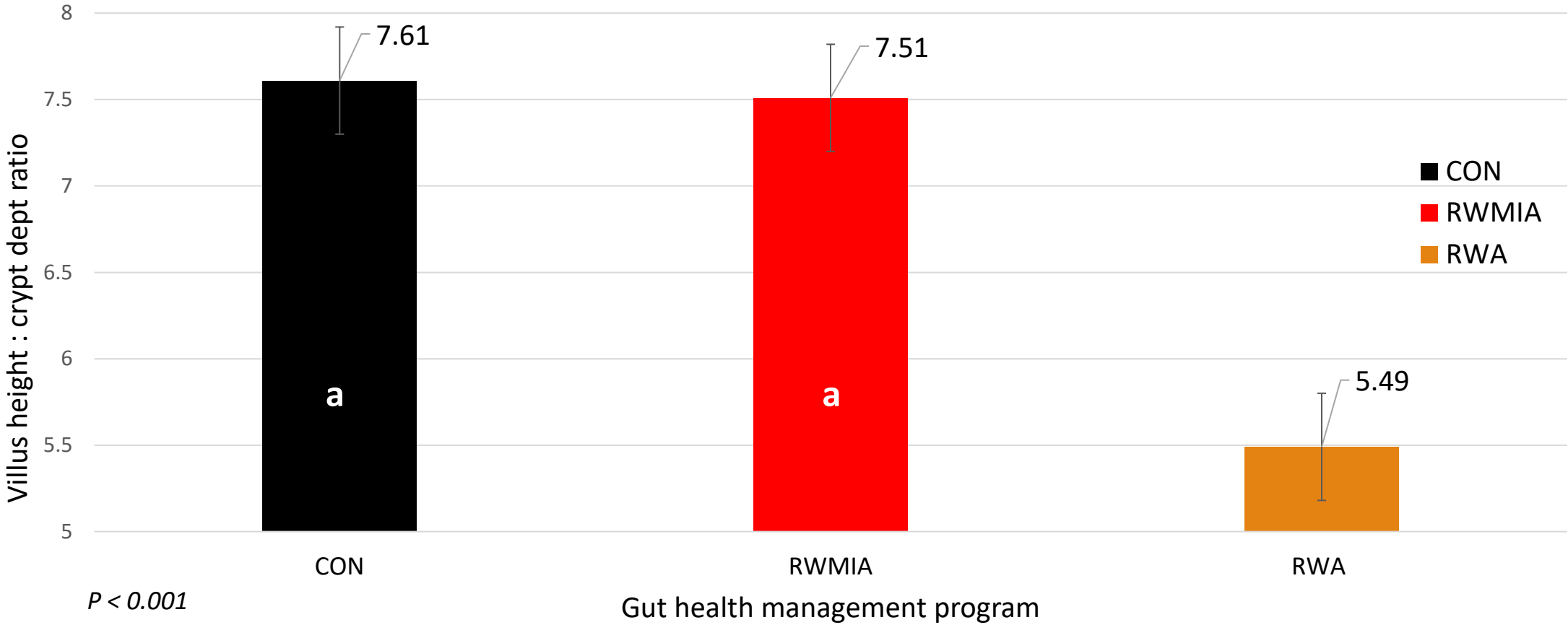
Figure 8: Effect of gut health management program on VH:CD Ratio in broiler chickens at d 28 reared in research settings



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Ceca digesta short chain fatty acids

Figure 9: Effect of gut health management program on ceca digesta concentration (µmol/g) of short chain fatty acids in 28 d broilers reared under research settings

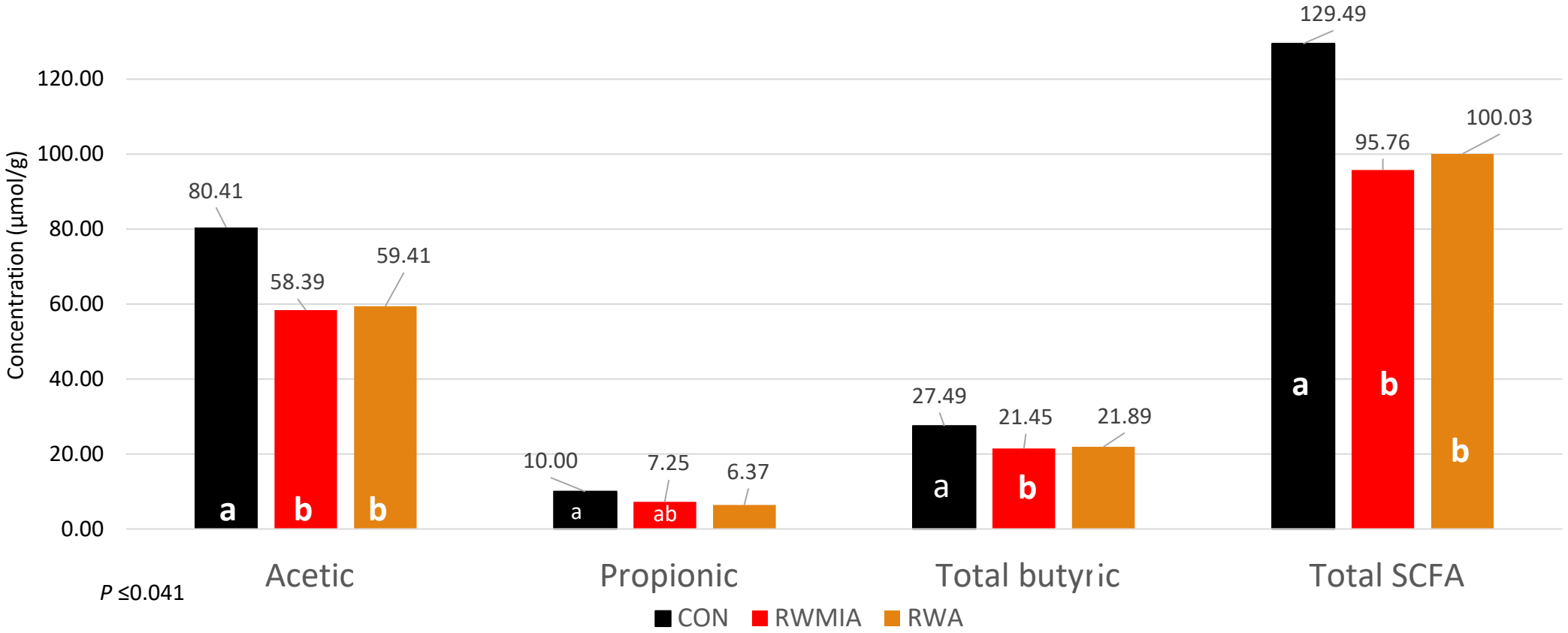

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Table 5: Effect of gut health management programs on plasma enzyme profile in 28 d broiler chickens reared under commercial settings and in 28 d and 41 d broiler chickens reared under research settings

Enzymes, U/L	Program[1]			SEM	*P*-value
	CON	RWMIA	RWA		
Commercial settings d 28					
Alkaline phosphatase	6147.90^{ab}	5889.57^{b}	8635.02^{a}	752.61	0.040
Amylase	486.71^{ab}	571.10^{a}	423.76^{b}	24.35	0.007
Aspartate transaminase	242.75^{a}	240.67^{a}	195.54^{b}	7.80	0.005
Creatine kinase	10925.14^{a}	9789.39^{a}	4222.89^{b}	1376.49	0.003
Gamma-glutamyl transferase	13.33^{b}	13.41^{b}	15.33^{a}	0.46	0.030
Glutamate dehydrogenase	2.38	2.58	2.12	0.20	0.296
Lactate dehydrogenase	848.57^{ab}	942.28^{a}	575.50^{b}	99.50	0.036
Research settings d 28					
Alkaline phosphatase	5808.50^{b}	5858.06^{b}	10928.00^{a}	1138.44	0.007
Amylase	763.94	490.94	468.5	93.90	0.103
Aspartate transaminase	177.18^{b}	216.06^{a}	202.56^{ab}	7.50	0.003
Creatine kinase	5837.25^{b}	11328.00^{a}	7047.69^{ab}	1458.41	0.029
Gamma-glutamyl transferase	13.50^{ab}	15.56^{a}	13.13^{b}	0.77	0.049
Glutamate dehydrogenase	3.63^{b}	5.56^{a}	3.69^{ab}	0.58	0.028
Lactate dehydrogenase	692.56	870.69	760.18	55.92	0.070
Research settings d 41					
Alkaline phosphatase	1783.44^{b}	1497.69^{b}	3107.19^{a}	274.49	<0.001

[1]Gut health management program: CON, some medically important antibiotics (MIA) allowed; RWMIA, raised without MIA; RWA, raised without antibiotics

[a, b] Means within a row with no common superscripts differ significantly ($P < 0.05$)

Tibia attributes

Table 6 : Effect of gut health management programs on tibia attributes of broiler chickens at d 28 reared under commercial settings

Item	Program[1]			SEM	*P*-value
	CON	RWMIA	RWA		
Tibia ash, g/kg BW	1.16	1.16	1.18	0.02	0.903

Table 7: Effect of gut health management programs & sex on tibia attributes of broiler chickens at d 28 and d 41 reared under research settings

Item	Program[1]			SEM	Sex		SEM	*P*-value		
d 28	CON	RWMIA	RWA		Male	Female		Program	Sex	Program*Sex
Tibia ash, g/kg BW	1.16	1.17	1.15	0.02	1.19[a]	1.13[b]	0.01	0.809	0.001	0.852
d 41										
Tibia ash, g/kg BW	1.23	1.23	1.21	0.02	1.28[a]	1.17[b]	0.01	0.646	<0.0001	0.126

[1]Gut health management program: CON, some medically important antibiotics (MIA) allowed; RWMIA, raised without MIA; RWA, raised without antibiotics

[a, b] Means within a row with no common superscripts differ significantly ($P < 0.05$)

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Conclusions

- Gut health management programs showed similar effects on performance
- Gut health management programs impacted breast attributes
- Condemnations were higher in birds reared on alternative gut health management programs
- Differences in gastrointestinal responses did not appear to impact gut efficiency
- Differences in plasma metabolites did not appear to impact performance

Future considerations and challenges

- **Antibiotic mandates are applied nationally**
  - Commercial gut health management programs are formulated based on geography and ingredient availability therefore, all possible commercial diets must be considered
- **Economics and sustainability need to be considered**
  - Increased feed costs stemming from ingredient restriction and inclusion of gut ecology modulators
  - Inclusion of lesser quality by-product ingredients
  - Inclusion of animal proteins
- **Evaluate and categorize condemnations at the commercial level**

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