



Shandong Agricultural University

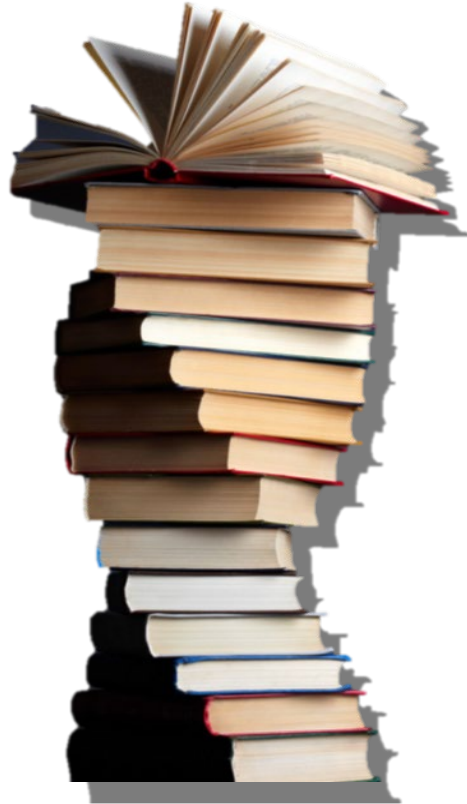
College of Animals Science and Technology

Effects of dietary supplementation with cocrystals of thymol and carvacrol on quality, nutrient composition, and oxidative stability of broiler meat

Dr. Yang Li

Florence, Italy, 01/09/2024

Contents



- 1 **Background**
- 2 **Materials and methods**
- 3 **Results**
- 4 **Conclusion**

BACKGROUND

➤ Meat production of broilers-overview

Chicken is one of the preferred meats among consumers worldwide today

- ❑ Affordable price
- ❑ High protein content
- ❑ Low-fat content

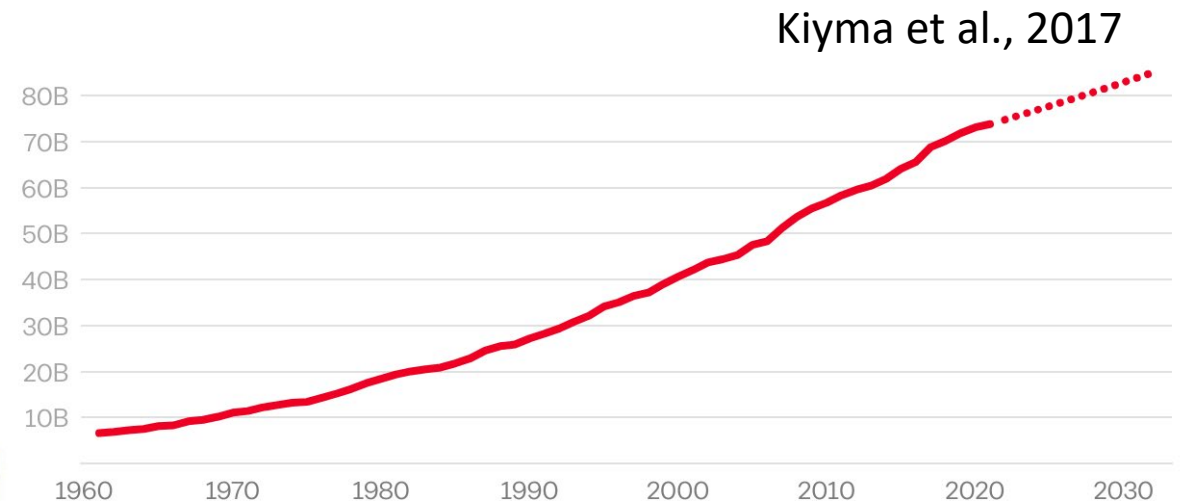


Amount Per 100 grams	
Calories 165	
% Daily Value*	
Total Fat 3.6 g	5%
Saturated fat 1 g	5%
Cholesterol 85 mg	28%
Sodium 74 mg	3%
Potassium 256 mg	7%
Total	0%
Carbohydrate 0 g	0%
Dietary fiber 0 g	0%
Sugar 0 g	
Protein 31 g	62%

Chicken Breast

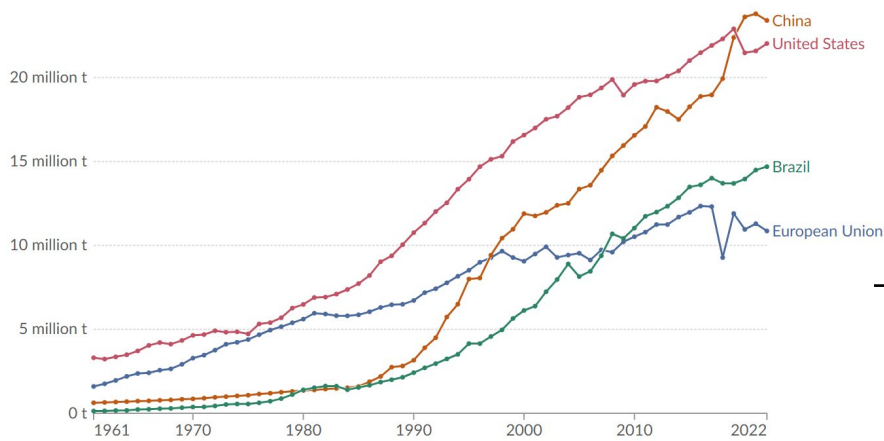


Vitamin C	0%	Calcium	1%
Iron	5%	Vitamin D	1%
Vitamin B6	30%	Cobalamin	5%
Magnesium	7%		

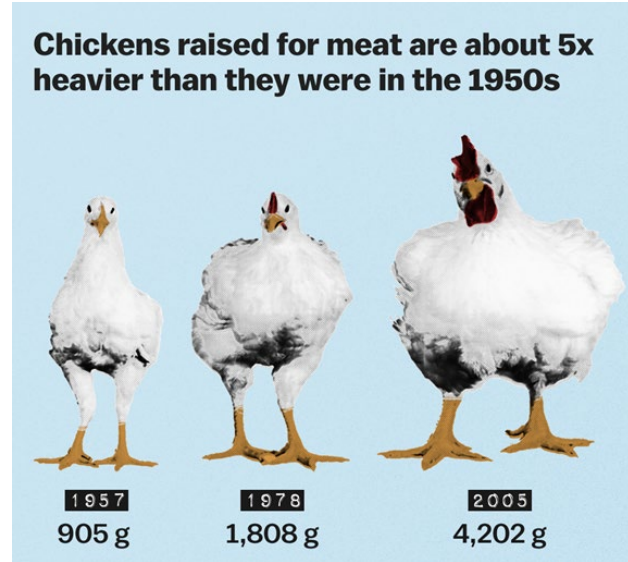


Chicken slaughtered from 1960 to 2030 (Source: OECD/FAO)

Humanity currently raises and slaughters a staggering 74 billion chickens each year, which will jump to around 85 billion annually by 2032, a 15 percent increase.



Poultry production from 1961 to 2022



**Market
demand**



**Production
efficiency**



**Meat
quality**

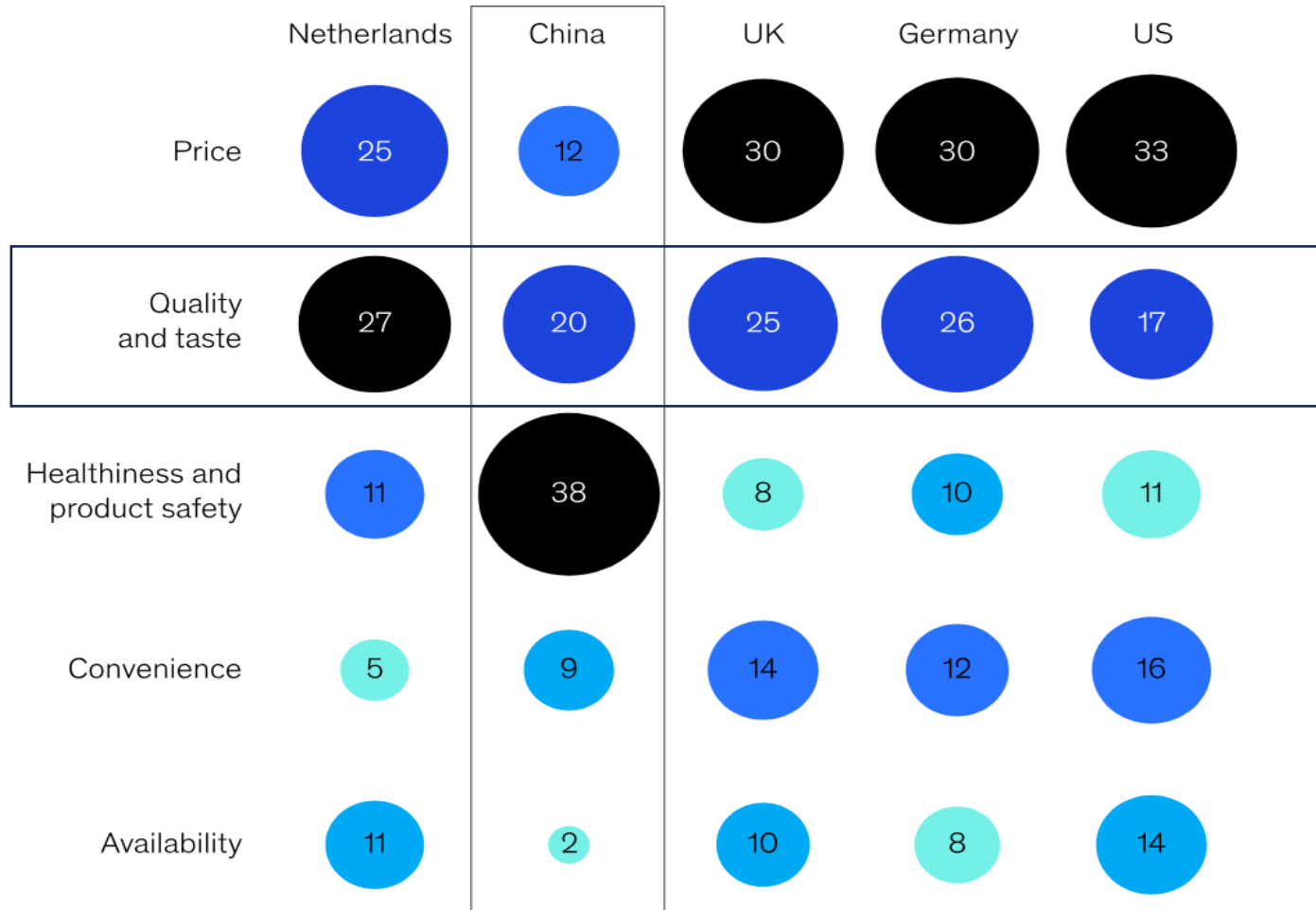


Source: FAO (2023); Zuidhof et al., 2014

Genetic selection improved production efficiency, but decreased meat quality of broilers.

Key buying factor for at-home consumption of meat,¹ % of respondents

Low  High

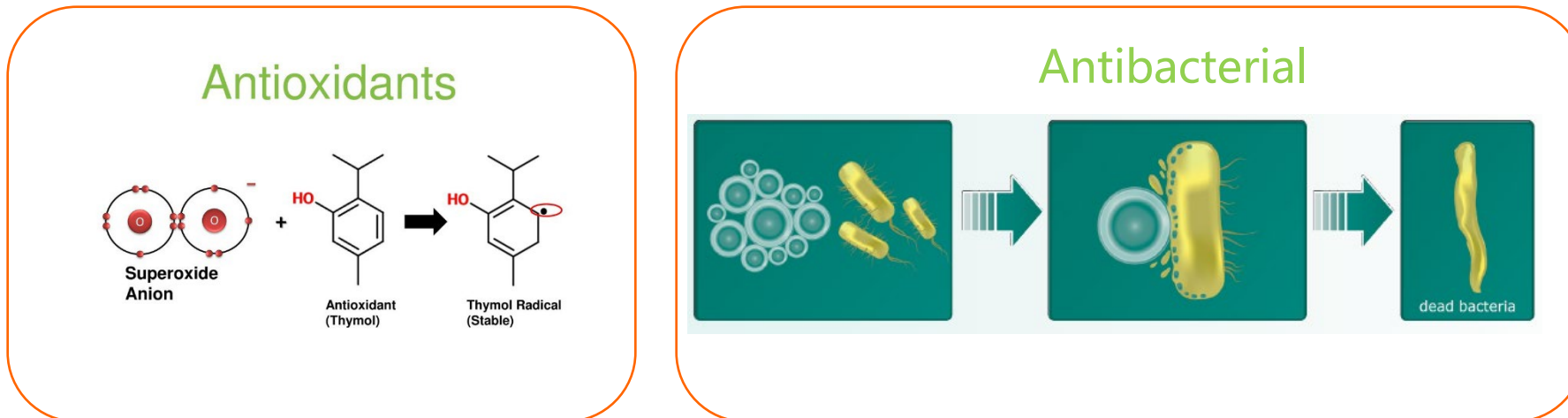


Challenge: Growing demand for safe and high-quality meat and meat products

➤ Cocrystals of thymol and carvacrol (CEO)

- ❑ Thymol and carvacrol are natural essential oils and major components of commonly used medicinal plants, such as thyme and oregano species
- ❑ Supplementation of 150 mg/kg thymol or carvacrol in broiler diets could retard lipid oxidation of meat and improve meat quality

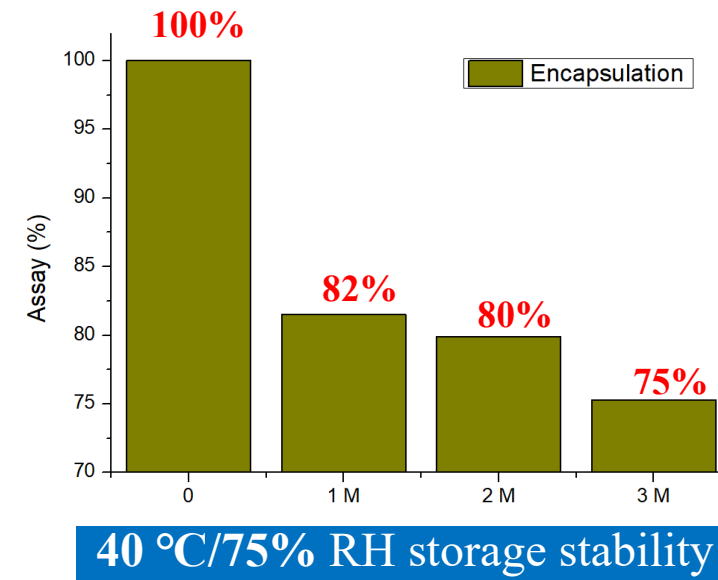
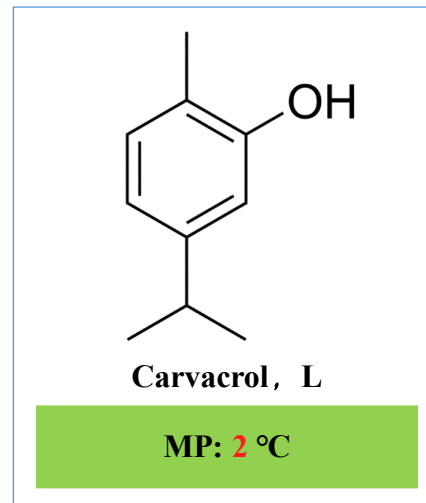
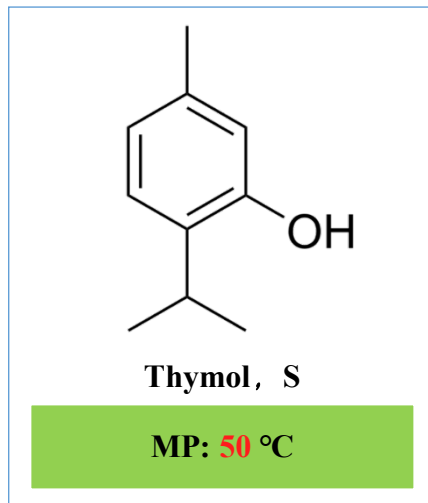
Luna et al., 2010



Disadvantage of thymol and carvacrol

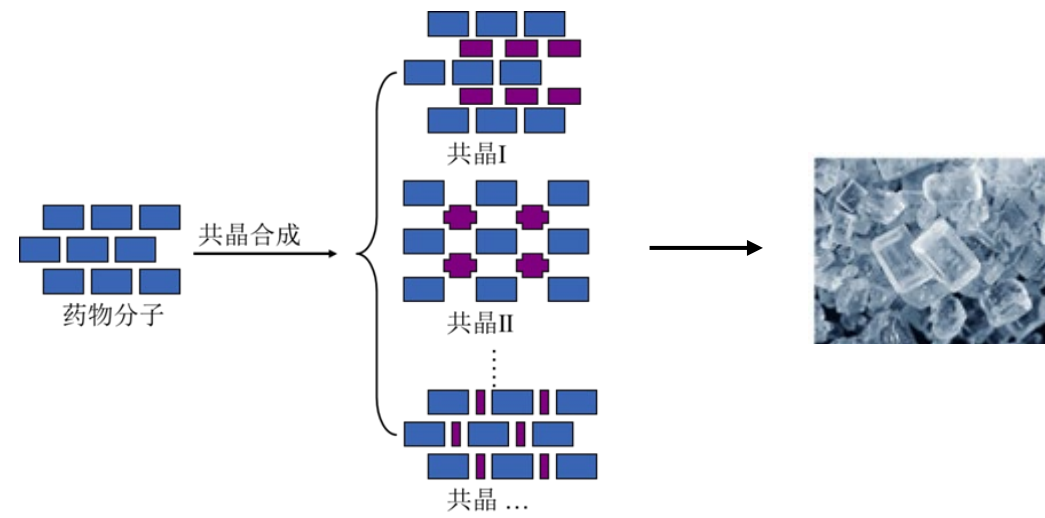
- ❑ Low solubility or even not insoluble in water
- ❑ Low melting point, high volatility
- ❑ Reaction with the air (thickening, darkening, acidic reactions)
- ❑ Unstable in the gut

Stevanović et al., 2018



Solution: Cocrystal technology

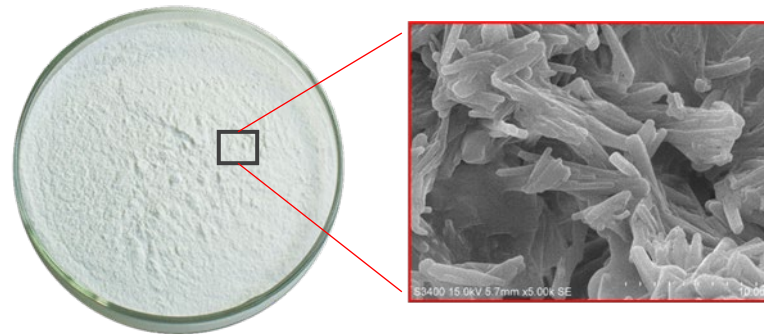
- Cocrystal technology is an emerging, effective method to improve the solubility, stability, and bioavailability of drug in the pharmaceutical industry
- Previous study proved that interactions between the essential oil molecule and suitable partners could establish a strong intermolecular network, thus stabilizing the liquid ingredient of essential oil in a solid form



Mazzeo et al., 2019

CEO preparation

- ❑ The CEO is a mixture in equal parts of the cocrystal of thymol and carvacrol with L-proline
- ❑ The thymol and carvacrol is extracted from oregano oil, and the effective content is 25% in the cocrystals of thymol and carvacrol .



Meat quality?

METHOD AND MATERIALS

➤ Animals and treatments



1-day old AA broiler

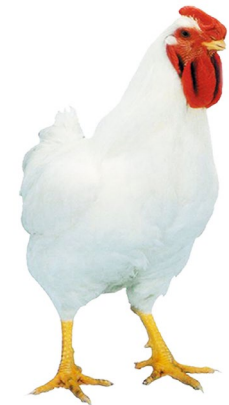
CEO0 group (basal diet)

CEO40 group (basal diet+40 mg/kg CEO)

CEO60 group (basal diet+60 mg/kg CEO)

CEO80 group (basal diet+80 mg/kg CEO)

42 day



Breast muscle sampling
(*n*=8)

➤ Measurements

- **Meat quality:** pH, color parameters, drip loss, cooking loss, thawing loss, shear force
- **Chemical composition:** moisture, crude protein, crude fat
- **Myofiber characteristics:** diameter and density
- **Glucose metabolism:** glycogen, citrate synthase, glucose-6-P, lactate, citrate synthase
- **Antioxidant capacity:** T-SOD, GSH-Px, T-AOC, MDA, ABTS, DPPH
- **Amino acid profile:** UPLC-MS/MS
- **Fatty acid profile:** GC-MS platform

RESULTS

➤ Meat quality

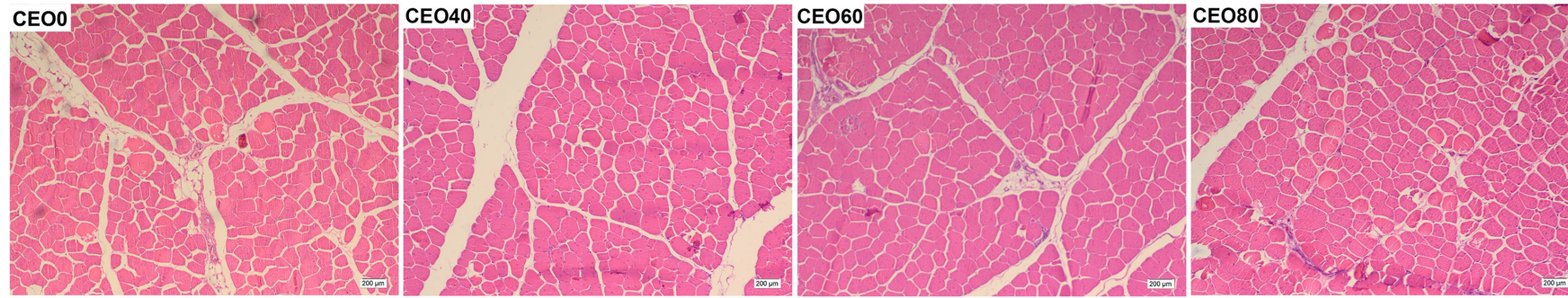
Parameter	Treatment				SEM	<i>p</i> value		
	CEO0	CEO40	CEO60	CEO80		CEO	Lin	Quad
Color parameters								
L^*_{45min}	45.60 ^b	48.72 ^a ↑	49.20 ^a ↑	48.48 ^a ↑	0.50	0.032	0.014	0.011
a^*_{45min}	2.65 ^b	3.32 ^b	4.35 ^a ↑	3.48 ^{ab}	0.19	0.006	0.017	0.020
b^*_{45min}	9.22	8.90	8.00	8.37	0.28	0.434	0.161	0.376
L^*_{24h}	55.98	57.38	58.72	58.67	0.72	0.515	0.135	0.330
a^*_{24h}	7.15	6.86	10.83	8.91	0.61	0.078	0.104	0.195
b^*_{24h}	17.18	16.33	15.15	15.08	0.59	0.555	0.155	0.372

Continued table

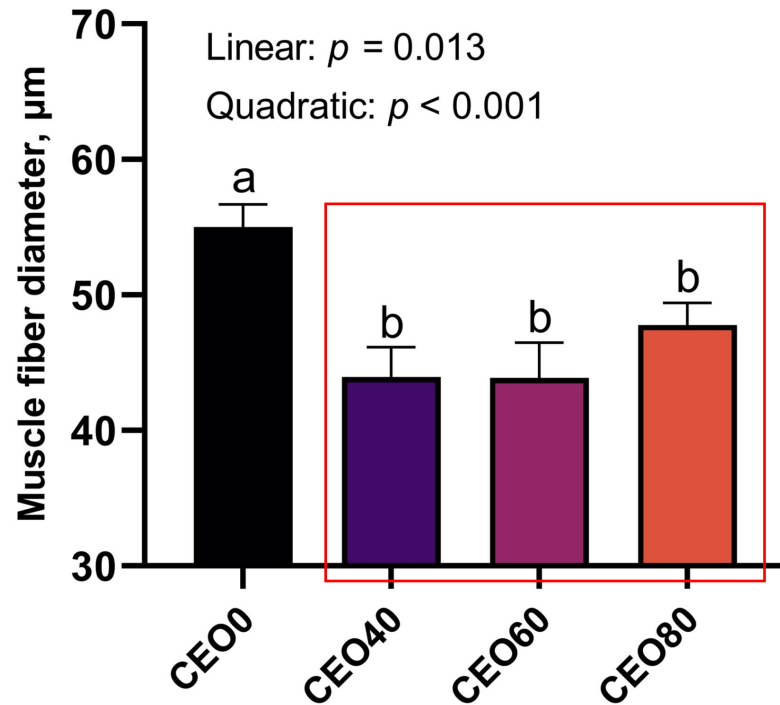
Parameter	Treatment				SEM	p value		
	CEO0	CEO40	CEO60	CEO80		CEO	Lin	Quad
pH								
pH _{45min}	6.93	6.94	6.93	6.94	0.03	0.996	1.000	0.997
pH _{24h}	5.98 ^b	6.20 ^{ab}	6.45 ^a ↑	6.15 ^{ab}	0.06	0.033	0.218	0.028
Drip loss, %	5.98	5.56	5.93	7.43	0.41	0.412	0.207	0.230
Cooking loss, %	20.23 ^a	15.99 ^c ↓	17.00 ^{bc} ↓	19.55 ^{ab}	0.58	0.025	0.625	0.008
Thawing loss, %	6.72	5.30	5.23	4.19	0.42	0.213	0.041	0.125
Shear force, N	53.00 ^a	44.29 ^b ↓	42.69 ^b ↓	49.68 ^{ab}	1.49	0.046	0.254	0.021

➤ Myofiber characteristics

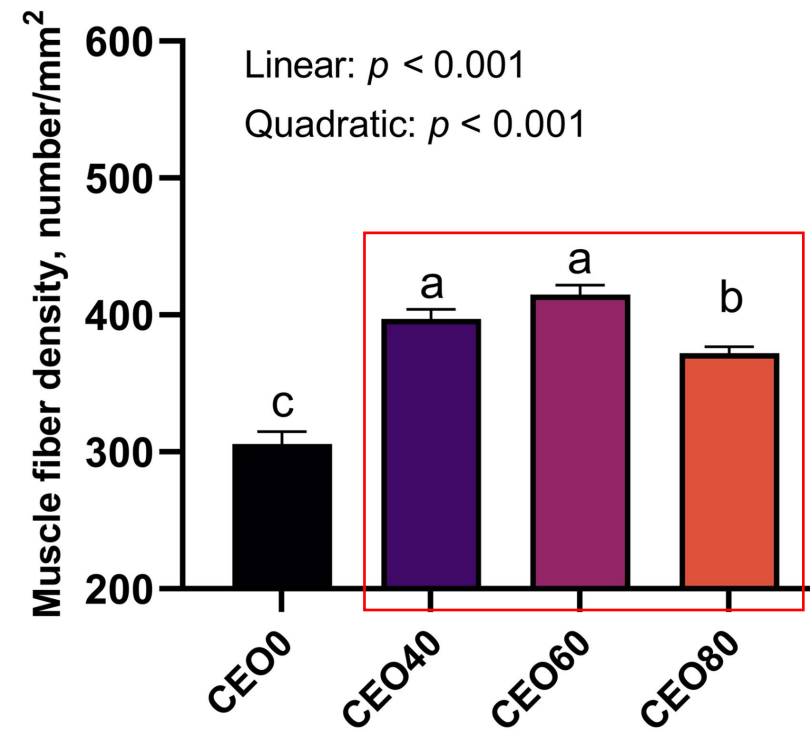
A



B

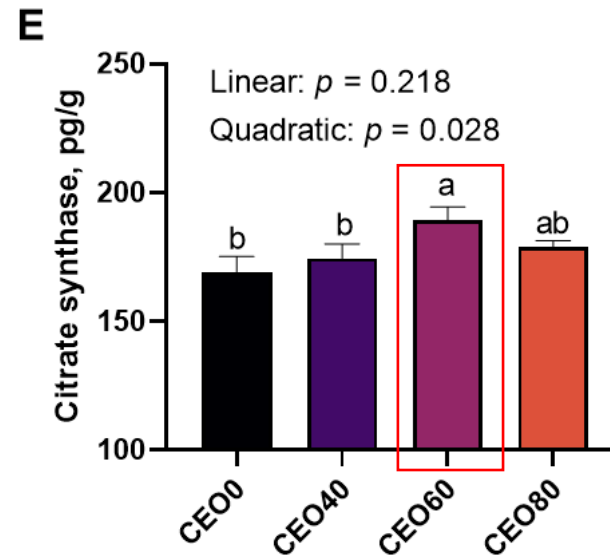
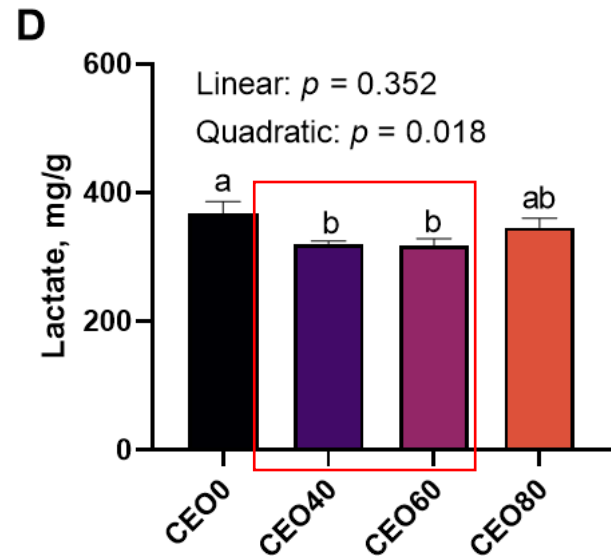
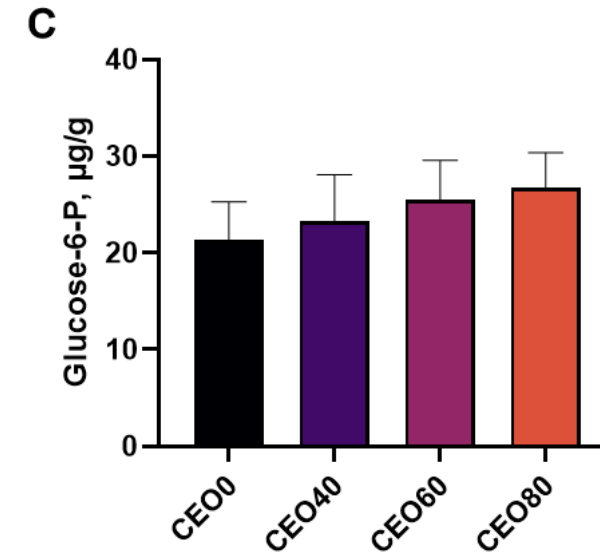
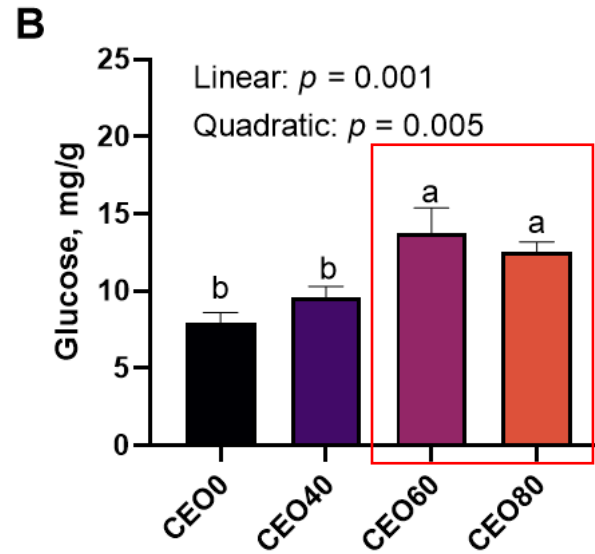
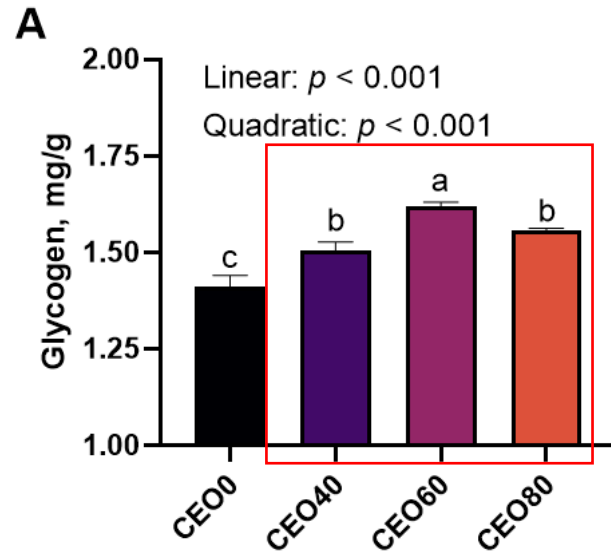


C



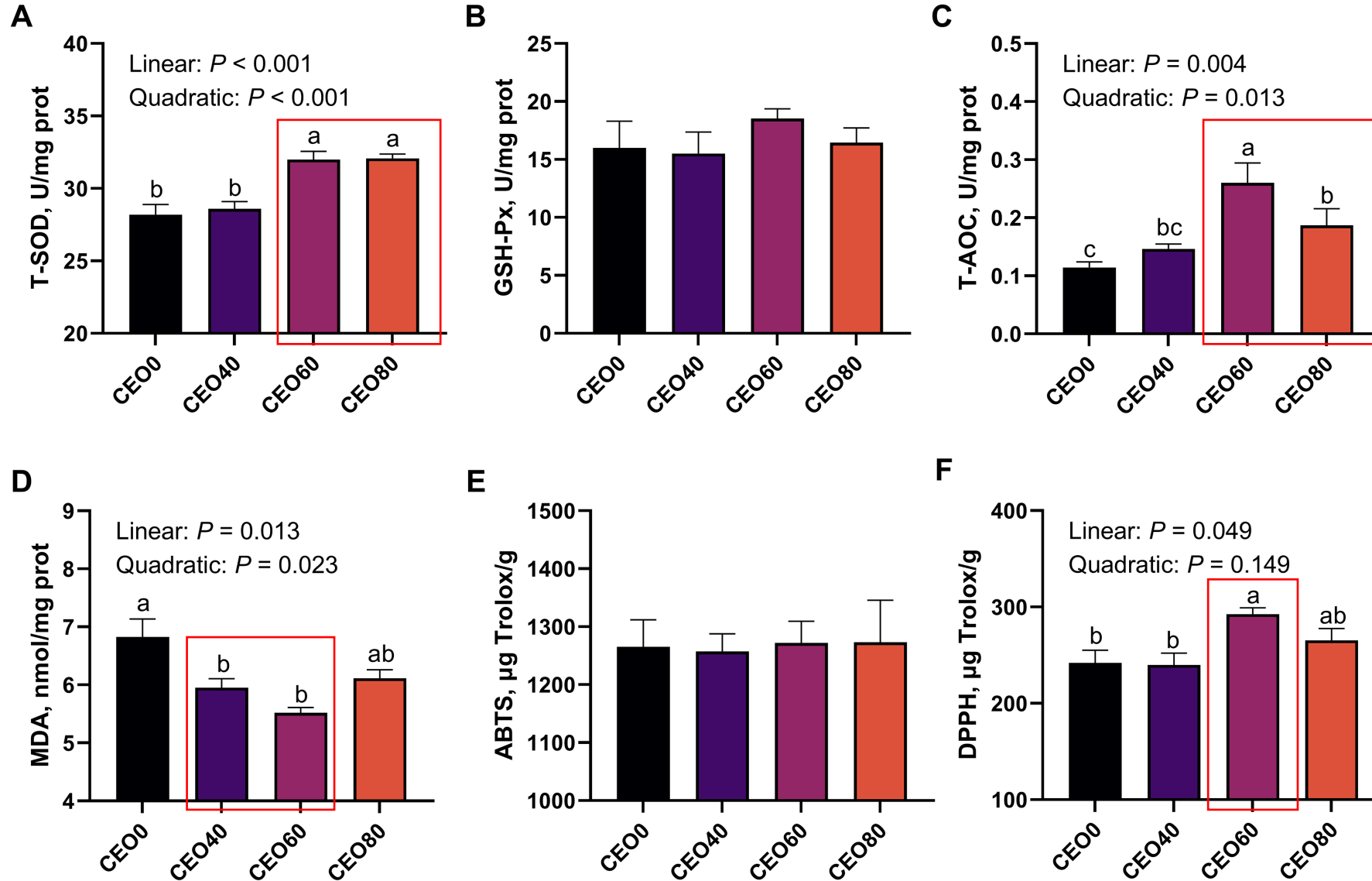
CEO supplementation decreased myofiber diameter and increased myofiber density.

➤ Glucose metabolism



60 mg/kg CEO supplementation increased muscle glycogen, glucose and citrate synthase levels, and decreased muscle lactate content.

➤ Antioxidant Capacity



CEO supplementation improved muscle antioxidant capacity.

➤ Chemical composition

Item, %	Treatment				SEM	<i>p</i> value		
	CEO0	CEO40	CEO60	CEO80		CEO	Lin	Quad
Moisture	73.67	73.67	73.50	73.63	0.22	0.993	0.927	0.989
Crude protein	22.65 ^b	23.80 ^{ab}	23.92 ^{ab}	24.65 ^a ↑	0.24	0.021	0.002	0.009
Crude fat	0.88	0.97	0.94	0.84	0.04	0.782	0.832	0.576

80 mg/kg CEO supplementation increased crude protein content in breast muscle.

➤ Amino acid profiles

Item, mg/g	Treatment				SEM	<i>p</i> value		
	CEO0	CEO40	CEO60	CEO80		CEO	Lin	Quad
Histidine	7.78	7.42	7.45	8.04	0.14	0.327	0.843	0.087
Arginine	16.53	16.48	16.95	16.69	0.29	0.951	0.554	0.832
Serine	4.72	4.83	5.11	5.06	0.07	0.213	0.060	0.171
Glycine	10.18	10.26	10.67	10.49	0.15	0.652	0.277	0.560
Aspartic acid	17.74	17.98	18.26	18.12	0.23	0.883	0.569	0.841
Glutamic acid	35.76	36.85	38.54	37.73	0.58	0.384	0.272	0.553
Threonine	11.35	11.42	11.82	11.78	0.16	0.641	0.293	0.566
Alanine	14.31	14.38	14.69	14.79	0.17	0.718	0.241	0.491

Continued table

Item, mg/g	Treatment				SEM	<i>p</i> value		
	CEO0	CEO40	CEO60	CEO80		CEO	Lin	Quad
Proline	8.76	8.77	9.22	8.99	0.13	0.595	0.448	0.742
Lysine	22.95	23.57	23.76	23.82	0.33	0.788	0.355	0.640
Cystine	4.34 ^b	4.70 ^{ab}	4.97 ^a ↑	4.47 ^b	0.07	< 0.01	0.318	0.018
Tyrosine	8.48	8.56	9.08	8.83	0.15	0.476	0.329	0.613
Methionine	6.38	6.30	6.57	6.24	0.13	0.842	0.914	0.956
Valerine	12.66	12.33	12.33	12.61	0.15	0.809	0.806	0.755
Isoleucine	12.50	12.33	12.43	12.58	0.14	0.942	0.584	0.800
Leucine	20.44	20.27	20.81	20.86	0.25	0.810	0.268	0.533
Phenylalanine	10.12	10.21	10.35	10.47	0.13	0.800	0.381	0.645

60 mg/kg CEO supplementation increased cystine content in breast muscle.

➤ Fatty acid profiles

Item	Treatment				SEM	p value		
	CEO0	CEO40	CEO60	CEO80		CEO	Lin	Quad
Fatty acid composition (% total fatty acid)								
C8:0	0.03	0.02	0.02	0.03	0.002	0.271	0.937	0.134
C12:0 (lauric acid)	0.012 ^c	0.017 ^a ↑	0.016 ^{ab} ↑	0.014 ^{bc}	0.001	0.009	0.227	0.003
C14:0	0.31	0.38	0.38	0.36	0.013	0.173	0.152	0.078
C15:0	0.036	0.052	0.049	0.045	0.002	0.080	0.154	0.035
C16:0	24.04	25.11	24.53	23.70	0.293	0.374	0.779	0.209
C17:0	0.07	0.07	0.07	0.08	0.002	0.665	0.204	0.454
C18:0	14.89	11.31	11.97	13.12	0.604	0.165	0.226	0.077
C20:0	0.10	0.08	0.08	0.10	0.004	0.168	0.753	0.078
C21:0	0.04	0.02	0.03	0.03	0.003	0.442	0.496	0.258
C22:0	0.05	0.04	0.04	0.05	0.003	0.245	0.876	0.139
40 and 60 mg/kg CEO supplementation increased lauric acid content in breast muscle.								
C24:0	0.02	0.02	0.02	0.02	0.002	0.441	0.536	0.394
Total SFA	39.64	37.15	37.24	37.58	0.396	0.074	0.038	0.030

Continued table

Item	Treatment				SEM	<i>p</i> value		
	CEO0	CEO40	CEO60	CEO80		CEO	Lin	Quad
C16:1	2.19	3.66	3.04	2.65	0.262	0.243	0.493	0.145
C18:1n9c	30.76	37.34	35.70	34.33	1.252	0.302	0.271	0.169
C20:1	0.54	0.52	0.56	0.59	0.026	0.831	0.491	0.660
Total MUFA	33.48	41.52	39.30	37.57	1.472	0.271	0.284	0.150

CEO supplementation has no significant effects on MUFA concentration in the breast muscle.

Continued table

Item	Treatment				SEM	p value		
	CEO0	CEO40	CEO60	CEO80		CEO	Lin	Quad
C18:2n6c	16.75	14.85	16.23	16.29	0.411	0.412	0.776	0.385
C18:3n6 (GLA)	0.09	0.09	0.10	0.09	0.004	0.687	0.559	0.753
C18:3n3 (ALA)	0.32 ^b	0.38 ^a ↑	0.38 ^a ↑	0.38 ^a ↑	0.009	0.030	0.010	0.011
C20:2	1.22	0.87	0.95	1.14	0.088	0.488	0.645	0.289
C20:3n6	1.75	1.32	1.39	1.61	0.119	0.593	0.572	0.378
C20:4n6	6.09	3.42	3.94	4.79	0.514	0.288	0.299	0.151
C20:5n3 (EPA)	0.22	0.15	0.16	0.21	0.018	0.426	0.683	0.245
C22:6 (DHA)	0.45	0.26	0.32	0.34	0.038	0.392	0.315	0.251

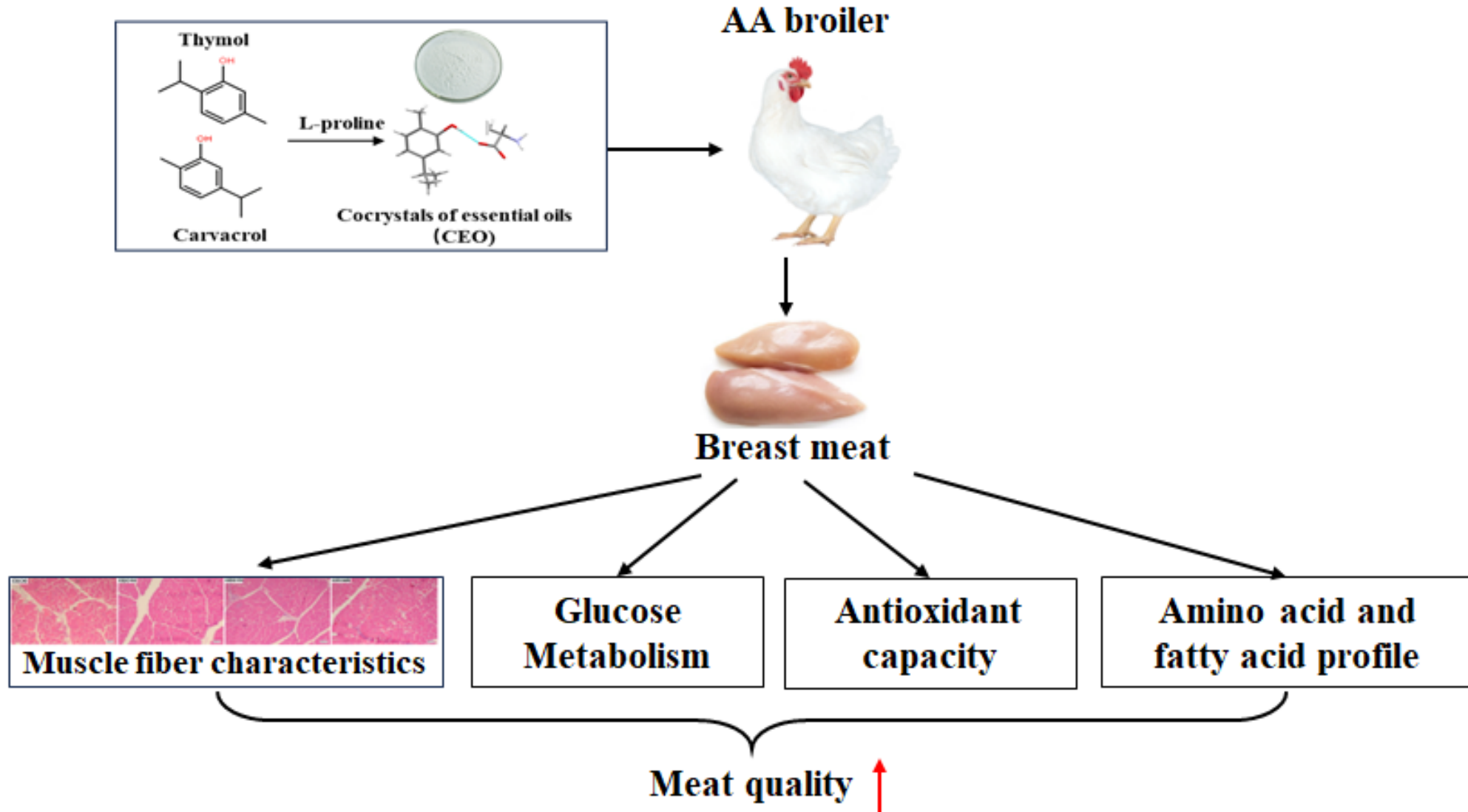
CEO supplementation increased ALA concentration in the breast muscle.

Continued table

Item	Treatment				SEM	<i>p</i> value		
	CEO0	CEO40	CEO60	CEO80		CEO	Lin	Quad
n-3 PUFA	0.99	0.79	0.86	0.93	0.048	0.539	0.625	0.343
n-6 PUFA	24.26	20.08	22.25	23.67	0.828	0.295	0.766	0.186
Total PUFA	26.88	21.34	23.47	24.85	1.131	0.383	0.492	0.239
Total USFA	59.65 ^b	61.92 ^a ↑	62.86 ^a ↑	61.56 ^b	0.384	0.001	0.352	< 0.001
USFA:SFA	1.53	1.70	1.69	1.66	0.027	0.084	0.045	0.034

40 and 60 mg/kg CEO supplementation increased total USFA content in breast muscle.

CONCLUSION

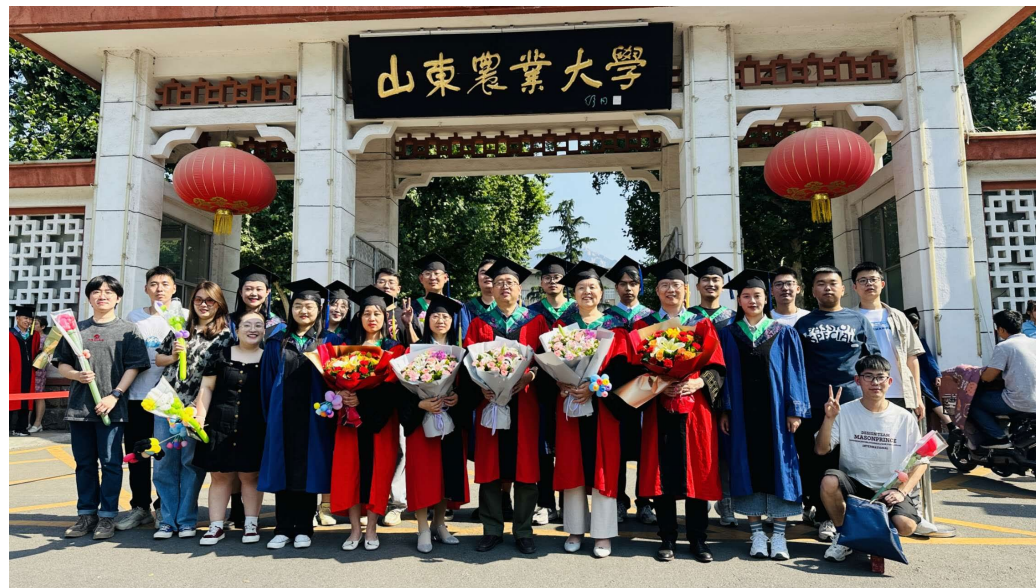


60 mg/kg CEO has the greatest beneficial effect on breast muscle meat quality.



山東農業大學
SHANDONG AGRICULTURAL UNIVERSITY

Thank you for your attention



Feed Research and Swine Nutrition Team