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Archiva Zootechnica 26:1, 5-14, 2023
DOI: 10.2478/azibna-2023-0001

Effect of dietary inulin on the antioxidant profile of broiler chickens' meat raised in heat stress conditions

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ABSTRACT

The study aimed to assess the effect of dietary inulin (1% dietary inclusion) supplements on broiler chickens' meat antioxidant compounds. The experiment was carried out under heat-stress conditions, on 60 Ross 308 broiler chickens. The study took place in an experimental hall with digestibility pens and controlled humidity, ventilation and light regime. Each treatment (2 groups, C and E) was replicated 6 times with 5 chicks per replicate pen with ad libitum feeding and free water access. At 42 days old, 6 birds from each group were slaughtered and breast and thigh meat samples were collected. The presence of inulin in broiler chickens' diets had a beneficial effect by increasing the iron and zinc concentrations in thigh samples. Regarding liposoluble antioxidants, the presence of inulin in diets from tissue samples had an antagonistic effect: increased concentrations of xanthophylls were registered in thigh meat and an adverse effect was noticed in breast meat while an inverse effect was noticed for vitamin E. At the thigh meat level, the antioxidant capacity was significantly improved under inulin influence. In conclusion, the nutritional quality of broilers meat (thigh meat) was improved, for the group fed with inulin-supplemented diets.

Keywords: broilers, inulin, liposoluble compounds, trace minerals, antioxidants

INTRODUCTION

Inulin is a dietary fiber called fructan with a prebiotic role in animal nutrition. As a source of inulin used in animal diet composition, mainly it was considered chicory (Attia et al., 2015a,b), but also agave (Moreno-Mendoza et

al., 2021), dahlia tuber (Abdurrahman et al., 2016) or Jerusalem artichoke (Illippangama et al., 2022).

From 2006, the ban of antibiotics forced nutritionists to find alternative sources for growth enhancers, inulin being a prebiotic considered for many studies (Guaragni et al., 2020). The positive effects of inulin on the growth performances of broiler chickens were noticed (Kareem et al., 2016). A combination of a postbiotic and inulin used in broilers' diets led to increased sensory attributes of meat (Kareem et al., 2015). The inulin can influence lipid metabolism by increasing the short-chain fatty acids (Samanta et al., 2013). Other authors demonstrated that prebiotics enhances mineral retention (Ortiz et al., 2009), including antioxidant trace elements like zinc. A significantly improved mineral profile in tibia samples was reported by Chen and Chen (2004) on birds fed with 10 g/kg inulin in feed. It was demonstrated that the effectiveness of inulin usage in poultry nutrition depends on several factors: the source of inulin, the inclusion rate, the age of birds and the environmental stress (Bucław et al., 2017).

Global poultry production is affected by environmental stressors causing economic losses due to its influence on health and productive parameters. Since antibiotics have been prohibited in animal nutrition, some additives with antioxidant potential and health enhancers were used as heat stress attenuators like chromium or vitamin C (Saracila et al., 2021, Untea et al., 2021, Shehata et al., 2022), natural products like creeping wood sorrel (Saracila et al., 2020), oregano (Vlaicu et al., 2018; Turcu et al., 2018), polyphenols from plants (Hu et al., 2019) and grapeseed or rosehip oils (Vlaicu et al., 2017).

Some authors (Shokryazdan et al., 2017) mentioned that inulin is prebiotic that can be absorbed by liver and colon cells and can act as an antioxidant. Other studies, showed that in normal raising conditions, inulin was very effective on enhancing intestinal immune function (Huang et al., 2015), and recently was reported that inulin can replace antibiotics as growth promoters without affecting the physicochemical characteristics of meat (Guaragni et al., 2020; Attia et al., 2015b).

The use of inulin in broiler chicken diets is expected to be advantageous due to their indirect positive influence on the antioxidant defence system. Scientific literature provides scarce information regarding the influence of inulin on nutritional quality of broilers raised in heat stress conditions. This observation conducted to designing an experiment on broilers in which it was tested the effect of inulin supplements on meat properties of animals raised under heat stress conditions.

MATERIALS AND METHODS

The experiment presented in the current study was performed to comply with Directive 2010/63/EU on the protection of animals used for scientific purposes and all procedures described, were approved by the Ethical Commission of National Research and Development Institute for Biology and Animal Nutrition.

Experimental design

This study used 60, Ross 308 unsexed broiler chickens for the trial. After the starter phase, when the birds were at the age of 14 days, the actual trial started and an inulin nutritional supplement was tested. A diet based on corn-soybean meal and corn gluten was used as the main ingredients for control diet (C) and the same basal diet with additional 1% inulin (Frutafit® IQ) extract from chicory root was used as experimental diet (E), in both raising phases (grower and finisher) as presented in Table 1.

Table 1. Ingredients and chemical composition of broilers diets

Item	Grower		Finisher	
	C	E	C	E
Ingredients				
Corn, %	44.5	43.5	47.23	46.23
Wheat, %	10.00	10.00	10.00	10.00
Soybean meal, %	35.45	35.45	32.16	32.16
L-lysine, %	0.32	0.32	0.12	0.12
Dl- methionine, %	0.28	0.28	0.27	0.27
L-threonine, %	0.04	0.04	0.03	0.03
Calcium carbonate	1.26	1.26	1.17	1.17
Monocalcium phosphate, %	1.59	1.59	1.48	1.48
Salt, %	0.37	0.37	0.37	0.37
Vegetable oil, %	5.12	5.12	6.10	6.10
Choline, %	0.07	0.07	0.07	0.07
Premix*, %	1.00	1.00	1.00	1.00
Inulin, %	-	1.00	-	1.00
Total	**100**	**100**	**100**	**100**
Chemical analysis				
ME (kcal/kg)	3129		3218	
CP (%)	21.50		20.00	
EE (%)	6.01		6.49	
CF (%)	3.57		3.36	
Ca (%)	0.87		0.81	
P (%)	0.70		0.65	

*1 kg premix contains: 1,100,000 IU/kg vit A; 200,000 IU/kg vit D3; 2700 IU/kg vit E; 300 mg/kg vit K; 200 mg/kg Vit. B1; 400 mg/kg vit B2; 1485 mg/kg pantothenic acid; 2700 mg/kg nicotinic acid; 300 mg/kg vit B6; 4 mg/kg Vit. B7; 100 mg/kg vit B9; 1.8 mg/kg vit B12; 2000 mg/kg vit C; 8000 mg/kg Mn; 8000 mg/kg Fe; 500 mg/kg Cu; 6000 mg/kg Zn; 37 mg/kg Co; 18 mg/kg Se

ME – metabolizable energy; CP – crude protein; EE – ether extract; CF – crude fiber

The study took place in an experimental hall with digestibility pens and controlled microclimate conditions (humidity, ventilation and light regime), following the recommendations of the broiler breeding management guide. The temperature was set at 32 °C during the entire feeding period (1 to 42 days). Each treatment was replicated 6 times with 5 chicks per replicate pen with *ad libitum* feeding (ground feed) and free water access. One day old unsexed broilers were purchased from a commercial hatchery. At 42 days old, 6 birds from each group (1 chicken randomly selected from each replication) were slaughtered according to the veterinary procedures and breast and thigh meat samples were collected.

Chemical analysis

Dry matter (DM), crude protein (CP), ether extract (EE) and crude ash (Ash) determined in breast and thigh meat samples were determined as described previously by Untea et al., (2020). The same authors described the analytical methods used in this study for determining the total phenol content (TPC) and antioxidant capacity (Folin–Ciocalteu method and DPPH method respectively).

Liposoluble compounds (vitamin E and lutein and zeaxanthin) were determined by RP-HPLC as it was described by Varzaru et al., (2015).

Flame atomic absorption spectrometry was used for mineral determinations according to methods described by Untea et al., (2012).

Statistics

The analytical results were statistically interpreted using two-way ANOVA followed by Tukey's HSD test provided by XLSTAT software (Adinsoft, 2022) and $P<0.05$ was considered significant for the differences between the average values. Each broiler selected for meat samples collection was considered an experimental unit.

RESULTS AND DISCUSSION

The productive performances were not affected by dietary treatment in terms of final body weight, average daily gain or feed consumption (unpublished data).

The effect of dietary inulin on major nutrition components of meat was investigated and the results obtained are presented in Table 2. The dry matter content in thigh meat was significantly lower than in breast, observation was available also for crude protein content and crude ash. A different situation was observed for crude fat; the concentrations registered for thigh meat samples were more than two times higher than breast tissue. The effect of inulin was remarkable in protein content, the experimental group presented

significantly higher concentrations than the control. The crude fat content was lower (P<0.05) for animals fed with inulin supplements but only in thigh meat samples.

The beneficial effect of inulin (improving nutrient absorption, protein, minerals etc) can be explained by prevention of the pathogenic bacteria colonization (Xu et al., 2003). Other researchers found that fat-producing enzymes from the liver are influenced by inulin and the synthesis of fatty acids and triglycerides is reduced. This can explain the lowering effect of inulin on crude fat content in thigh meat.

Table 2. Effect of inulin supplements on proximate composition of meat

Tissue	Diet	DM (%)	CP (%)	CF (%)	CA (%)
Breast	**C**	24.93^{ab}	22.13^{a}	1.736^{c}	1.214^{a}
	E	26.89^{a}	23.24^{a}	2.965^{bc}	1.219^{a}
Thigh	**C**	25.12^{ab}	18.25^{b}	5.881^{a}	1.117^{ab}
	E	24.37^{b}	18.94^{b}	4.370^{b}	0.986^{b}
Main effects					
Diet					
	C	25.02	20.19^{b}	3.809	1.165
	E	**25.63**	**21.09^{a}**	**3.667**	**1.102**
	SEM	**0.333**	**0.281**	**0.244**	**0.025**
Tissue					
	Breast	25.91^{a}	22.68^{a}	2.350^{b}	1.216^{a}
	Thigh	24.74^{b}	18.60^{b}	5.126^{a}	1.052^{b}
	SEM	0.333	0.281	0.244	0.025
P value					
	Diet	0.222	0.043	0.689	0.103
	Tissue	0.030	0.001	0.0001	0.001
	Diet x tissue	0.014	0.603	0.002	0.083

Note: SEM – standard error of the mean; P – level of significance. DM – dry matter; CP – crude protein; CF – crude fat; CA – crude ash. ^{abc} Means within a row with no common superscript differ (P <0 .05). C – control diet; E – control diet with the addition of 1% inulin.

Regarding the trace mineral composition, the concentrations determined in breast and thigh meat samples (Table 3) showed that thigh meat can be considered a deposit for zinc compared with breast tissue.

The presence of inulin in broilers' diets had a beneficial effect by increasing the iron and zinc concentrations in thigh samples. The positive effect of inulin on mineral absorption and deposition was demonstrated earlier by Scholz-Ahrens and Schrezenmeir, (2007). They showed that inulin-type fructans increase the solubility of minerals in the intestine by increasing the concentrations of short-chain fatty acids in the intestinal lumen.

Untea et al., (2016) found that the use of a dietary symbiotic product (with inulin as prebiotic) in broilers' diets, led to increased trace mineral

concentrations in thigh meat. Also, Vanhoof and DeSchrijver (1996) and Yalçınkaya et al. (2012) proved the positive effect of inulin on Fe and Zn absorption.

Table 3. Effect of inulin supplements on the mineral composition of meat

Tissue	Diet	Fe (mg/kg)	Zn (mg/kg)
Breast	**C**	27.40^{ab}	25.53^{c}
	E	27.61^{ab}	21.09^{c}
Thigh	**C**	23.34^{b}	52.71^{b}
	E	30.44^{a}	59.46^{a}
Main effects			
Diet			
	C	25.37^{b}	39.12
	E	29.02^{a}	40.28
	SEM	0.890	1.791
Tissue			
	Breast	27.50	23.31^{b}
	Thigh	26.89	56.09^{a}
	SEM	0.890	1.791
P value			
	Diet	0.013	0.046
	Tissue	0.637	0.0001
	Diet x tissue	0.018	0.047

Note: SEM – standard error of the mean; P – level of significance. Fe – iron; Zn – zinc. ^{abc} Means within a row with no common superscript differ (P <0 .05). C – control diet; E – control diet with the addition of 1% inulin.

The presence of inulin in diets on liposoluble compounds from tissue samples had an antagonistic effect: increased concentrations of xanthophylls were registered in thigh meat and an adverse effect was noticed in breast meat while an inverse effect was noticed for vitamin E (Table 4). Also, the results proved the antagonism between these two classes of compounds (xanthophylls and tocopherols): in breast tissue, better absorption of vitamin E led to a decreased deposition of lutein and zeaxanthin.

In thigh meat samples, increased concentrations of lutein were accompanied by decreased values of vitamin E. Saracila et al. (2022) observed the same antagonism between liposoluble compounds deposition in meat and considered that the biological mechanism requires further studies.

Table 4. Effect of inulin supplements on liposoluble antioxidants of meat

Tissue	Diet	Lutein & zeaxanthin (mg/kg)	Vitamin E (mg/kg)
Breast	**C**	1.851[a]	54.31[b]
	E	1.048[b]	119.41[a]
Thigh	**C**	1.006[b]	114.83[a]
	E	1.745[a]	74.68[b]
Main effects			
Diet			
	C	1.428	84.57
	E	1.397	97.05
	SEM	0.130	6.285
Tissue			
	Breast	1.449	86.86
	Thigh	1.376	94.76
	SEM	0.130	6.285
P value			
	Diet	0.867	0.186
	Tissue	0.695	0.392
	Diet x tissue	0.0001	0.0001

Note: SEM – standard error of the mean; P – level of significance. [abc] Means within a row with no common superscript differ (P <0 .05). C – control diet; E – control diet with the addition of 1% inulin.

The antioxidant capacity and the polyphenols content registered higher values in breast tissue compared to the thigh (Table 5).

Table 5. Effect of inulin supplements on hydrosoluble antioxidants of meat

Tissue	Diet	Total polyphenols (mg/g)	Antioxidant capacity mM Trolox
Breast	**C**	1.373[a]	2.216[a]
	E	1.223[a]	2.717[a]
Thigh	**C**	0.737[b]	1.368[b]
	E	0.844[b]	2.262[a]
Main effects			
Diet			
	C	1.055	1.792[b]
	E	1.034	2.490[a]
	SEM	0.056	0.112
Tissue			
	Breast	1.298[a]	2.466[a]
	Thigh	0.790[b]	1.815[b]
	SEM	0.056	0.112
P value			
	Diet	0.792	0.001
	Tissue	0.0001	0.001
	Diet x tissue	0.131	0.237

Note: SEM – standard error of the mean; P – level of significance. [abc] Means within a row with no common superscript differ (P <0 .05). C – control diet; E – control diet with the addition of 1% inulin.

The effect of inulin was statistically significant ($P<0.05$). At the thigh meat level, the antioxidant capacity was significantly improved under inulin influence. Guaragni et al. (2020) studied the effect of inulin on the meat quality of broiler chickens and found an improvement in the antioxidant profile due to increased activity of antioxidant enzymes superoxide dismutase and catalase (Table 5).

CONCLUSION

The antioxidant parameters of broiler chickens' meat samples fed with inulin-supplemented diets were improved in terms of zinc content, lutein and zeaxanthin and antioxidant capacity of thigh meat. Also, the nutritional quality of thigh meat was improved by a decreased concentration of crude fat compared to control samples.

ACKNOWLEDGEMENTS

This research was funded by the Ministry of Research, Innovation and Digitalisation, Project PN 19 09 0102, and the National Research Development Project to Finance Excellence (PFE)-8/2021.

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