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Enhancement of sperm motility and viability by turmeric by-product dietary supplementation in roosters

Wenjing Yan[a], Chihiro Kanno[b], Eiki Oshima[c], Yukiko Kuzuma[c], Sung Woo Kim[d], Hanako Bai[a], Masashi Takahashi[a], Yojiro Yanagawa[b], Masashi Nagano[b], Jun-ichi Wakamatsu[e], Manabu Kawahara[a],*

[a] Laboratory of Animal Genetics and Reproduction, Research Faculty of Agriculture, Hokkaido University, Sapporo, Hokkaido, Japan
[b] Laboratory of Theriogenology, Department of Veterinary Clinical Sciences, Graduate School of Veterinary Medicine, Hokkaido University, Sapporo, Hokkaido, Japan
[c] Field Science Center for Northern Biosphere, Hokkaido University, Sapporo, Hokkaido, Japan
[d] National Institute of Animal Science, Animal Genetic Resources Research Center, Namwon, 55717, South Korea
[e] Laboratory of Applied Food Science, Research Faculty of Agriculture, Hokkaido University, Sapporo, Hokkaido, Japan

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A B S T R A C T

Improving sperm motility and viability are major goals to improve efficiency in the poultry industry. In this study, the effects of supplemental dietary turmeric by-product (TBP) from commercial turmeric production on sperm motility, viability, and antioxidative status were examined in domestic fowl. Mature Rhode Island Red roosters were divided into two groups – controls (group C) without TBP administration and test subjects (group T) fed a basal diet supplemented with 0.8 g of TBP/day in a temperature-controlled rearing facility (Experiment 1) and 1.6 g/day under heat stress (Experiment 2) for 4 weeks. In Experiment 1, TBP dietary supplementation increased the sperm motility variables straight-line velocity, curvilinear velocity, and linearity based on a computer-assisted semen analysis, 2 weeks following TBP supplementation. In Experiment 2, using flow cytometry, sperm viability at 3 and 4 weeks following TBP supplementation was greater in Group T than C, and this increase was consistent with a reduction in reactive oxygen species (ROS) production at 2 and 4 weeks. The results of both experiments clearly demonstrate that dietary supplementation with TBP enhanced sperm motility in the controlled-temperature conditions as well as sperm viability, and reduced ROS generation when heat stress prevailed. Considering its potential application in a range of environments, TBP may serve as an economical and potent antioxidant to improve rooster fertility.

1. Introduction

For effective poultry production, sperm possessing normal motility and high viability are essential. Only motile sperm can traverse the vagina. Sperm motility is affected by physiological, nutritional, and environmental factors (Al-Qarawi, 2005). Oxidative stress also affects reproductive performance (Rui et al., 2017). High polyunsaturated fatty acids (PUFAs), sensitive to oxidative stress, in the rooster sperm plasma membrane are negatively correlated with sperm motility and viability (Surai et al., 1998). Oxidative stress may impair sperm motility (Kao et al., 2008) increase male infertility (Maya-Soriano et al., 2013; Dorostghoal et al., 2017; Li

* Corresponding author at: Laboratory of Animal Genetics and Reproduction, Research Faculty of Agriculture, Hokkaido University, Kita-9, Nishi-9, Kita-ku, Sapporo 060-8589, Japan.
E-mail address: k-hara@anim.agr.hokudai.ac.jp (M. Kawahara).

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et al., 2017). Dietary supplementation with antioxidants can protect sperm from oxidative stress. For example, vitamin E protects against oxidative stress in human sperm (Keskes-Ammar et al., 2003), and zinc sulfate improves sperm motility in the Beetal goat (Rahman et al., 2014). There is need, however, for more economical and efficient antioxidant production.

Turmeric (*Curcuma longa*), a rhizomatous herb, is widely utilized as a spice, fabric dye, and herbal medicine. Turmeric by-product (TBP), resulting from commercial turmeric production, is, however, typically discarded, even though it contains curcuminoid composed of ≥80% curcumin (Ahmed and Gilani, 2014). Curcumin possesses many beneficial biological activities, e.g., anticancer, anti-inflammatory, antimicrobial, antiviral, antifungal, and antioxidant activity (Manikandan et al., 2004; Sharma et al., 2005; Aggarwal et al., 2007). Curcumin scavenges oxygen free radicals and prevent lipid peroxidation in membranes (Kuhad et al., 2007). It is, therefore, useful for the treatment of many diseases, such as cardiovascular disorders (Ramirez-Tortosa et al., 1999; Manikandan et al., 2004) and reproductive issues (Oguzturk et al., 2012; Glombik et al., 2014). Furthermore, curcumin ameliorated the harmful effects of arsenic on both the libido and semen characteristics of rabbit bucks (Seadawy et al., 2014). Effects of curcumin on sperm motility and viability in roosters are, however, unclear.

Several antioxidant substances, such as dried ginger rhizomes (Akhlaghi et al., 2014), guanidinoacetic acid (Tapeh et al., 2017), and dietary vitamin C and vitamin E (Min et al., 2016), exhibit beneficial effects on sperm motility in domestic fowl, but these results are based on visual observations and, therefore, are not objective. In other species, including pigs (Didion, 2008), cattle (Kang et al., 2015), rats (Slott et al., 1991), and humans (Liu et al., 1991), computer-assisted sperm analysis (CASA), has been applied; this method is more objective than the conventional method and provides a more comprehensive assessment of motility variables [e.g., straight-line velocity (VSL), curvilinear velocity (VCL), average path velocity (VAP), linearity (LIN, ratio of VSL/VCL), straightness (STR, VSL/VAP), amplitude of lateral head displacement (ALH) and beat-cross frequency (BCF)], which are associated with sperm fertilizability and fertility (Holt et al., 1997; Larsen et al., 2000). In addition, fluorescence-activated cell sorting analysis (FACS) is used for mammalian semen assessment, e.g., in bulls (Anzar et al., 2009) and boars (Awda et al., 2009). Assessments of rooster sperm, however, using CASA and FACS are limited (Partyka et al., 2010; Partyka et al., 2013).

In the present study, to enhance the understanding of the andrological characteristics of domestic fowl, the effectiveness of dietary TBP on rooster sperm motility and viability through the suppression of ROS generation were evaluated using the CASA system in a temperature-controlled rearing facility and using FACS when heat stress prevailed.

2. Material and methods

2.1. Turmeric by-product

Wheat meal containing 20% TBP (FL-D3575) was kindly provided by a company that processes commercial turmeric, Inabata Co.,Ltd. (Osaka, Japan). TBP, of which 4.86% (w/w) is curcuminoid according to the manufacturer, is generated during the refinery process.

2.2. Animals and sperm preparation

All experimental procedures for the care and use of animals were conducted in accordance with approved guidelines of the Animal Care Committees of Hokkaido University. The 9–15-month-old Rhode Island Red roosters were maintained individually

Table 1
Composition of the diets with or without turmeric by-product (TBP) for roosters.

	Experiment 1		Experiment 2	
Item (%)	group C	group T	group C	group T
Wheat meal	25.5	22.4	25.5	19.3
Wheat meal with turmeric by-product	0	3.1	0	6.2
Wheat bran	31.4	31.4	31.4	31.4
Corn	27.2	27.2	27.2	27.2
Oat	2.7	2.7	2.7	2.7
Soybean meal	2.7	2.7	2.7	2.7
Rice bran	0.9	0.9	0.9	0.9
Salt	0.3	0.3	0.3	0.3
Commercial formula feed	9.0	9.0	9.0	9.0
Vitamin-mineral premix	0.1	0.1	0.1	0.1

All roosters were individually maintained with the photoperiod being 12 L: 12D (lights on at 06:00) with *ad libitum* access to water and food (with or without TBP); Diets contained 0.8 and 1.6 g of TBP mixed with wheat meal in Experiments 1 and 2, respectively; Commercial formula feed (Kanematsu Agritec Co., Ltd.) was composed of corn, polished rice, milo, wheat, 56.7 g/kg; soybean cake, rapeseed meal, corn gluten meal, 12.6 g/kg; corn distillers grain soluble, 7.2 g/kg; pork meal, fish meal, 3.6 g/kg; calcium carbonate, animal fat and oil, salt, calcium phosphate, paprika extract, silicic anhydride, 9.9 g/kg; Vitamin-mineral premix was composed of vitamin A, 3500 IU/kg; vitamin D_3, 700 IU/kg; acetic acid DL-α- tocopherol, 0.5 mg/kg; menadione sodium bisulfite, 0.4 mg/kg; thiamine nitrate, 0.5 mg/kg; riboflavin, 1 mg/kg; pyridoxine hydrochloride, 0.25 mg/kg; nicotinic acid, 2 mg/kg; d-calcium pantothenate, 1 mg/kg; choline chloride, 50 mg/kg; folic acid, 0.05 mg/kg; cyanocobalamin, 0.001 mg/kg; $MnSO_4$, 32.3 mg/kg; $FeSO_4$, 16.8 mg/kg; $CoSO_4$, 0.03 mg/kg; $ZnSO_4$, 27.5 mg/kg; Gross percentage is not 100% because of truncation by setting the number of decimal places.