

## Responses of chemical composition, amino acid and fatty acid profiles of breast muscle to dietary crude fibre levels in China Micro-Ducks

S.P. Wang<sup>1,2,3#</sup>, D.M. Luo<sup>1,2</sup>, G.W. Liu<sup>1,2</sup>, M.J. Yin<sup>1,3</sup>, C.F. Zhou<sup>1,3</sup>,  
X.L. Zhao<sup>1,3</sup> & Y.B. Guo<sup>1,2</sup>

<sup>1</sup> College of Animal Science, Southwest University, Chongqing, P.R. China

<sup>2</sup> Xishui Fuxing Husbandry Co., Ltd., Xishui 556400, P.R. China

<sup>3</sup> Baiyu Muwang Agricultural Science and Technology Co., Ltd. / Baiyu Yumu Kangyuan Husbandry Co., Ltd., Bayu 627150, P.R. China

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### Abstract

The effects of dietary crude fibre (CF) levels on the chemical composition, amino acid (AA) and fatty acid (FA) profiles of breast muscle in male China Micro-ducks (21 - 56 d) were investigated in this study. The birds were randomly allocated to four treatments, of which dietary CF levels were 16.7, 42.6, 77.9 and 101.6 g/kg of dry matter (DM), respectively. No influences on the proportions of crude ash, crude protein, lysine, methionine, threonine, phenylalanine, histidine, arginine, aspartic acid, glutamic acid, glycine, alanine, serine, cysteine, tyrosine, proline, C12:0, C18:0, C18:1n9, C20:0 and C22:1n9 in muscle were observed across the treatments. Consequently, the concentrations of semi-essential AA, non-essential AA, total AA, aromatic AA and delicious AA in muscle, along with the  $\Delta$ -9-desaturase (18) index, were not affected by the treatments. Significant lower concentrations of valine, leucine, isoleucine, essential AA, branched-chain AA, C16:1n7 and monounsaturated FA in muscle, along with a lower ratio of branched-chain to aromatic AA, were noted in a dietary treatment with a CF level of 16.7 g/kg DM compared to other dietary treatments. The rise of the dietary CF level significantly increased the proportions of DM, ether extract, gross energy, C18:2n6, C18:3n3, C20:4n6, unsaturated FA, total FA, polyunsaturated FA, n-3 polyunsaturated FA, n-6 polyunsaturated FA, essential FA, and the  $\Delta$ -9-desaturase (16) index. Furthermore, the rise of the dietary CF level increased the ratios of unsaturated to saturated FA, polyunsaturated to saturated FA, and n-6 to n-3 polyunsaturated FA in muscle. However, it decreased the atherogenic index and the proportions of C14:0, C16:0, and saturated FA significantly. In conclusion, depending largely on dietary levels, CF profoundly and positively influenced the nutritional quality of breast muscle, especially the FA profile.

**Keywords:** China Micro-duck, dietary fibre, fatty acid, nutritional quality of meat, fatty acid

# Corresponding author: [wangshuiping1979@sina.com](mailto:wangshuiping1979@sina.com)

### Introduction

Protein from duck meat has played an indispensable role in satisfying the nutritional requirements of a growing world population of humans for high quality protein (Adeola, 2006). Duck meat is becoming increasingly popular worldwide because of its appetising flavour, nutritious value, taste and delicate texture (Liao *et al.*, 2010). In recent years, there has been increased awareness of the manipulation of duck meat quality in order to obtain specific nutritional properties. China Micro-duck (CMD) is a complete set line which was developed from selective hybridisation between several specialised native and domestic sheldrakes/shelducks (Wang *et al.*, 2013). In the actual production process, it was found that the CMD has a strong resistance to a wide range of fibrous feedstuffs (Wang *et al.*, 2017).

It is known that in poultry nutrition dietary fibre may have beneficial physiological effects, as well as negative effects (Mateos *et al.*, 2012). Mateos *et al.* (2012) concluded that the response to fibre supplementation depends on the source and level of dietary fibre and the characteristics of the diet as well as the physiological status and health of the bird. Dietary fibre has an impact on poultry owing to a multitude of aspects such as feed intake, digestive passage rate, gastrointestinal tract development, digestive enzyme

secretion, nutrient utilisation, production performance, animal physiochemical status, body health, gut microbiota, bird behaviour and animal welfare, and contributes to the characteristic flavour of meat (Mead *et al.*, 1983). Therefore, if the practical application of dietary fibre in poultry diets results in characteristic features in meat quality, a producer can supply specific poultry products to satisfy the requirements of consumers for meat with particular attributes pertaining to appearance, taste, texture and nutrients (He *et al.*, 2015).

However, little information is available on the relationship between dietary fibre and meat quality in poultry. In addition, ducks have never been utilised as experimental animal species to reveal the interactions between dietary fibre and poultry. According to He *et al.* (2015), dietary fibre sources, which were mainly from corn straw silage, steam-exploded corn straw, steam-exploded wheat straw and steam-exploded rice straw, affected the protein proportion, cholesterol content and fatty acid (FA) profile of breast muscle in growing male Graylag geese. It was hypothesised that high-quality duck meat would result from the intake of diets with different crude fibre (CF) levels. The present study was designed to determine the differences in chemical composition, amino acid (AA) and FA profiles of breast muscle from male CMD in response to dietary CF levels during the growing period.

## Materials and Methods

The experimental design and procedures were approved by the Animal Care and Use Committee of Southwest University following the requirements of the Regulations for the Administration of Affairs Concerning Experimental Animals of China (The State Science and Technology Commission, 1988). The bird husbandry and the experimental design have been described in detail by Wang *et al.* (2017).

**Table 1** Ingredients and nutrient composition of the experimental diets<sup>1</sup>

Item	Dietary crude fibre levels (g/kg of dry matter)			
	16.7	42.6	77.9	101.6
<b>Ingredients composition (g/kg)</b>				
Purified corn starch	652.0	442.0	272.0	177.0
Corn	–	160.0	265.0	280.0
Fish meal	290.0	210.0	115.0	70.0
Corn gluten meal	–	45.0	120.0	150.0
Alfalfa meal	–	65.0	130.0	205.0
Soybean oil	–	20.0	40.0	60.0
Calcium hydrogen phosphate	15.0	15.0	15.0	15.0
Calcium carbonate	10.0	10.0	10.0	10.0
Sodium chloride	3.0	3.0	3.0	3.0
Premix <sup>2</sup>	30.0	30.0	30.0	30.0
<b>Analyzed chemical composition (g/kg or otherwise stated)</b>				
Dry matter	873.3	874.1	883.1	885.6
Gross energy (MJ/kg)	18.46	18.50	18.83	19.01
Crude fibre	16.7	42.6	77.9	101.6
Crude protein	216.1	220.1	218.3	219.9
Ether extract	39.5	41.3	49.9	55.0
Crude ash	81.4	80.4	76.9	72.1
Calcium	16.0	15.0	14.7	14.9
Total phosphorus	7.4	7.1	6.7	6.7

<sup>1</sup> All values were expressed on a dry matter basis except for the dry matter on an air-dried matter basis

<sup>2</sup> A sample of 1 kilogram of feed contains: vitamin A, 13 000 IU; vitamin D<sub>3</sub>, 5 300 IU; vitamin E, 50 IU; vitamin K<sub>3</sub>, 4 mg; vitamin B<sub>1</sub>, 3 mg; vitamin B<sub>2</sub>, 10 mg; vitamin B<sub>6</sub>, 7 mg; vitamin B<sub>12</sub>, 12 mg; folic acid, 2 mg; biotin, 170 mg; calcium pantothenate, 33 mg; nicotinic acid, 86 mg; Fe (FeSO<sub>4</sub>·7H<sub>2</sub>O), 100 mg; Cu (CuSO<sub>4</sub>·5H<sub>2</sub>O), 10 mg; Zn (ZnSO<sub>4</sub>·7H<sub>2</sub>O), 53 mg; Mn (MnSO<sub>4</sub>·H<sub>2</sub>O), 80 mg; Se (Na<sub>2</sub>SeO<sub>3</sub>·5H<sub>2</sub>O), 0.2 mg; and I (KI), 0.44 mg

The experimental diets (Table 1) were formulated to meet or exceed the NRC (1994) recommendations for growing ducks. The concentrations of dietary crude protein (CP) and apparent metabolisable energy were set up according to the proposal of Wang *et al.* (2013). All diets were semi-purified and had similar ingredients and nutrients; in particular, four diets were isonitrogenous and isoenergetic. Each experimental diet was in pellet form with a particle size of 2.5 mm.

The levels of CF in the experimental diets were 16.7, 42.6, 77.9 and 101.6 g/kg of dry matter (DM). The variation in dietary CF level was achieved by altering the amount of alfalfa meal in the diet. Samples ( $\pm 1$  kg/diet) from the experimental diets were randomly collected and then finely ground to pass a 1-mm sieve for further analysis. The results of the proximate, AA, and FA compositions in the experimental diets are shown in Tables 1, 2 and 3, respectively.

**Table 2** Determined amino acid composition of the experimental diets (g/kg as dry matter basis)

Item	Dietary crude fibre levels (g/kg of dry matter)			
	16.7	42.6	77.9	101.6
Lysine	16.6	16.1	17.1	16.9
Methionine	3.0	3.4	3.1	3.3
Threonine	8.3	7.8	7.6	7.4
Valine	10.7	10.4	9.5	9.8
Leucine	19.9	21.2	20.6	22.0
Isoleucine	7.3	6.9	6.8	6.7
Phenylalanin	9.5	10.3	9.3	9.6
Histidine	2.7	3.2	2.8	3.2
Arginine	11.5	11.2	10.3	10.9
Aspartic acid	11.8	12.4	12.5	12.2
Glutamic acid	29.5	30.1	30.6	29.8
Glycine	10.2	10.4	10.6	10.2
Alanine	11.0	11.8	11.5	11.3
Serine	8.3	8.2	8.8	8.2
Cysteine	5.4	5.0	4.7	4.7
Tyrosine	5.3	6.3	5.8	5.7
Proline	14.5	16.1	15.0	15.6
Essential amino acid	75.3	76.1	74.0	75.7
Semi-essential amino acid	14.2	14.4	13.1	14.1
Non-essential amino acid	96.0	100.3	99.5	97.6
Total amino acid	185.5	190.8	186.6	187.4

At 56 d, after a 12-h fast with free access to water, two birds close to the average weight of each pen (six pens/group) were randomly selected from each replicate. Thus, 12 birds from each group were slaughtered to harvest the breast muscle (*pectoralis major*). The birds (48 in total) were stunned via electro anaesthetic, bled immediately through cutting carotid arteries, and partial slicing of the neck by a manual neck cutter; the feathers and the horny layers of claw and beak were removed following scalding. The stripped breast muscle of each bird was manually dissected with surgical blades from the eviscerated carcass, and excluded the skins, subcutaneous fats, bones and tendons. All the muscles were freeze-dried immediately, then ground by hand with a mortar and pestle to become meat powder for analysis.

The diet and meat samples were analysed for DM, crude ash (AS), CP, ether extract (EE), gross energy (GE), and AA and FA profiles. In addition, CF, calcium and total phosphorus in the diets were assayed. All assays were conducted in triplicate. DM, CA, CF, CP, EE, calcium and total phosphorus were determined by the official methods (AOAC, 2005). GE was measured using an isoperibol bomb calorimeter XRY-1C (Henghe Instrument Company, China) with benzoic acid as a standard.

**Table 3** Determined fatty acid composition of the experimental diets (g/kg as dry matter basis)

Item	Dietary crude fibre levels (g/kg of dry matter)				
	16.7	42.6	77.9	101.6	
Lauric acid	C12:0	0.41	0.46	0.45	0.45
Myristic acid	C14:0	0.86	0.90	0.67	0.76
Palmitic acid	C16:0	5.74	6.36	7.18	8.37
Palmitoleic acid	C16:1n7	0.66	0.67	0.55	0.58
Stearic acid	C18:0	1.78	1.95	2.10	2.90
Oleic acid	C18:1n9	9.65	10.86	13.22	14.06
Linoleic acid	C18:2n6	9.84	9.69	10.04	10.57
$\alpha$ -Linolenic acid	C18:3n3	0.75	0.80	0.76	0.81
Arachidic acid	C20:0	0.42	0.39	0.44	0.52
Arachidonic acid	C20:4n6	0.21	0.20	0.17	0.19
Erucic acid	C22:1n9	0.51	0.46	0.36	0.32
Saturated fatty acid		9.20	10.06	10.84	13.00
Unsaturated fatty acid		21.63	22.68	25.09	26.51
Unsaturated fatty acid/Saturated fatty acid		2.35	2.26	2.32	2.04
Total fatty acid		30.83	32.74	35.93	39.51
Monounsaturated fatty acid		0.66	0.67	0.55	0.58
Polyunsaturated fatty acid		20.96	22.01	24.54	25.93
Polyunsaturated fatty acid/Saturated fatty acid		2.28	2.19	2.26	2.00
n-3 Polyunsaturated fatty acid		0.75	0.80	0.76	0.81
n-6 Polyunsaturated fatty acid		10.05	9.89	10.21	10.75
n-6 Polyunsaturated fatty acid/n-3 Polyunsaturated fatty acid		13.33	12.33	13.49	13.33
Essential fatty acid		10.59	10.49	10.80	11.37

The concentrations of 17 AA were quantified by high-pressure liquid chromatography (UPLC<sup>®</sup>; Waters Corp., USA) following the procedure of Llamas & Fontaine (1994). The total AA was calculated by dividing the whole into three categories (Pellett & Young, 1980; NRC, 1994). Essential AA (EAA) included lysine, methionine, threonine, valine, leucine, isoleucine and phenylalanine. Semi-essential AA (SEAA) contained histidine and arginine. Non-essential AA (NEAA) was composed of aspartic acid, glutamic acid, glycine, alanine, serine, cysteine, tyrosine and proline. Branched-chain AA (BCAA) was calculated as the sum of leucine, isoleucine and valine, while aromatic AA (AAA) was estimated as the total of tyrosine and phenylalanine and the ratio of The BCAA : AAA ratio was computed (FAO/WHO, 1973). Nourishing AA (DAA) comprised arginine, aspartic acid, glutamic acid, glycine and alanine (FAO/WHO, 1978).

Total fat was extracted using the direct FA methyl ester (FAME) synthesis method, described by O'Fallon *et al.* (2007). The FA composition of the FAME was determined on an Agilent Technologies 6890N gas chromatograph (Agilent Technologies, Inc., USA) equipped with an Agilent HP-88, 100 m  $\times$  0.25 mm inner diameter  $\times$  0.20  $\mu$ m film column. FA analysis was performed by manual injection of 1  $\mu$ L of each sample. Eleven kinds of FA were identified by their retention time, in line with FA standards. The data on the FA composition were processed to compute the totalities of total FA, saturated FA (SFA), unsaturated FA (UFA), monounsaturated FA (MUFA), polyunsaturated FA (PUFA), n-3 PUFA, n-6 PUFA and essential FA (EFA). The ratios of UFA to SFA, PUFA to SFA and n-6 to n-3 PUFA were counted for their potential importance in poultry and human nutrition (Ulbricht & Southgate, 1991; Wood *et al.*, 2003). The atherogenic index (AI) was calculated according to the equation described by Ulbricht & Southgate (1991):

$$AI = (C12:0 + (4 \times C14:0) + C16:0) / (MUFA + PUFA).$$

The index of the enzyme,  $\Delta$ -9-desaturase, responsible for the desaturation of two common SFAs (C16:0 and C18:0), was calculated according to the equations reported by Malau-Aduli *et al.* (1998):

$$\Delta\text{-9-desaturase (16) index} = C16:1n7 / (C16:0 + C16:1n7) \times 100$$

$$\Delta\text{-9-desaturase (18) index} = C18:1c9 / (C18:0 + C18:1c9) \times 100.$$

A randomised design was utilised to evaluate the dietary effect. All data were subjected to a one-way analysis of variance by the GLM procedure of SAS (version 9.0, SAS Institute, Cary, NC) with dietary treatments as the classification factors. All the values were processed based on the average value of each pen as an experimental unit. Results were expressed as mean  $\pm$  standard deviation (M  $\pm$  SD). Treatment means were compared using the Duncan's multiple range tests. Differences were considered significant when  $P < 0.05$ .

## Results

The basic chemical component data of breast muscle are presented in Table 4. There was no difference ( $P > 0.05$ ) in the proportions of CA and CP between the treatments. The birds fed the diet with a CF level of 16.7 g/kg DM had a lower ( $P < 0.05$ ) DM proportion in muscle than those fed diets with CF levels of 77.9 and 101.6 g/kg DM. No difference ( $P > 0.05$ ) was observed in the proportions of EE and GE between the treatment with dietary CF level of 42.6 and 77.9 g/kg of DM. However, the proportions of EE and GE in the breast muscle of birds on a diet with CF levels of 42.6 and 77.9 g/kg DM were higher ( $P < 0.05$ ) than those on a diet with a CF level of 16.7 g/kg DM, but lower ( $P < 0.05$ ) than those on a diet with a CF level of 101.6 g/kg DM.

**Table 4** Chemical composition of the male China Micro-duck breast muscle at 57 days of age<sup>1</sup>

Item	Dietary crude fibre levels (g/kg of dry matter)				SEM <sup>2</sup>	P-value
	16.7	42.6	77.9	101.6		
Dry matter (g/kg)	216.9 <sup>b</sup> $\pm$ 5.0	221.8 <sup>ab</sup> $\pm$ 4.6	222.6 <sup>a</sup> $\pm$ 2.5	225.7 <sup>a</sup> $\pm$ 6.8	1.0	0.015
Crude ash (g/kg)	56.0 $\pm$ 0.8	55.8 $\pm$ 0.7	55.8 $\pm$ 0.4	55.8 $\pm$ 0.3	0.1	0.863
Crude protein (g/kg)	882.8 $\pm$ 9.7	886.3 $\pm$ 7.3	884.3 $\pm$ 10.8	885.0 $\pm$ 8.9	1.5	0.902
Ether extract(g/kg)	70.0 <sup>c</sup> $\pm$ 3.9	79.6 <sup>b</sup> $\pm$ 3.1	80.0 <sup>b</sup> $\pm$ 3.7	84.4 <sup>a</sup> $\pm$ 1.8	1.0	0.000
Gross energy (MJ/kg)	22.26 <sup>c</sup> $\pm$ 0.35	23.30 <sup>b</sup> $\pm$ 0.33	23.37 <sup>b</sup> $\pm$ 0.59	23.83 <sup>a</sup> $\pm$ 0.31	0.12	0.000

Means with different superscripts (<sup>a, b, c</sup>) within the same row differ at  $P < 0.05$

<sup>1</sup> All values were expressed on a dry matter basis except for the dry matter on a fresh matter basis

<sup>2</sup> SEM: standard error of mean

Information on AA composition and percentage of breast muscle is reflected in Table 5. No effect of dietary CF levels on the contents of lysine, methionine, threonine, phenylalanine, histidine, arginine, aspartic acid, glutamic acid, glycine, alanine, serine, cysteine, tyrosine and proline was found ( $P > 0.05$ ), and the concentrations of SEAA, NEAA, total AA, AAA and DAA were not affected ( $P > 0.05$ ) by dietary treatments. Lower ( $P < 0.05$ ) contents of valine, leucine, isoleucine, EAA and BCAA, and a lower ( $P < 0.05$ ) BCAA to AAA ratio were observed in a dietary treatment with a CF level of 16.7 g/kg DM compared to other dietary treatments.

Data on breast muscle FA composition and percentage are summarised in Table 6. The change in dietary CF levels did not influence ( $P > 0.05$ ) the proportions of C12:0, C18:0, C18:1n9, C20:0 and C22:1n9 or that of the  $\Delta$ -9-desaturase (18) index in muscle. The birds fed a diet with a CF level of 16.7 g/kg DM had lower ( $P < 0.05$ ) C16:1n7 and MUFA proportions in muscle than the others. With increasing levels of dietary CF, the proportions of C18:2n6, C18:3n3, C20:4n6, UFA, total FA, PUFA, n-3 PUFA, n-6 PUFA, EFA, or the  $\Delta$ -9-desaturase (16) index and the ratios of UFA to SFA, PUFA to SFA, and n-6 to n-3 PUFA increased ( $P < 0.05$ ), but the AI and the proportions of C14:0, C16:0, and SFA decreased ( $P < 0.05$ ).

## Discussion

Very few studies have been conducted to appraise the effects of dietary fibre on the nutritional quality of poultry meat. There were almost no reports to investigate the relationship between dietary CF levels and the nutrient components of duck muscle. He *et al.* (2015) suggested that the types of dietary fibre sources resulted in significant differences in the proportion of protein, cholesterol content, and FA profile of breast muscle in growing male Graylag geese. In the present research, the vast majority of dietary CF was botanical and originated from alfalfa meal. Alfalfa, which is high-quality forage for ruminants, contains a considerable amount of insoluble fibre (McDonald *et al.*, 2011). Yang (2002) asserted that alfalfa can be fed

to waterfowl because the CF derived from alfalfa is largely digestible. According to production practice, it has been observed that CMD adapts well to various fibrous feedstuffs (Wang *et al.*, 2013; Wang *et al.*, 2017). The present results revealed that dietary fibre levels also altered the ratios of some constituents existing in the breast muscle of growing CMD.

**Table 5** Amino acid profile of the male China Micro-duck breast muscle at 57 days of age (g/kg as dry matter basis)

Item	Dietary crude fibre levels (g/kg of dry matter)				SEM <sup>1</sup>	P-value
	16.7	42.6	77.9	101.6		
Lysine	71.1 ± 0.1	71.1 ± 0.1	71.1 ± 0.1	71.1 ± 0.2	0.0	0.879
Methionine	21.3 ± 0.2	21.4 ± 0.2	21.4 ± 0.3	21.4 ± 0.4	0.0	0.956
Threonine	34.4 ± 0.6	34.3 ± 0.7	34.4 ± 0.6	34.5 ± 0.6	0.1	0.986
Valine	35.1 <sup>b</sup> ± 0.2	36.3 <sup>a</sup> ± 0.2	36.4 <sup>a</sup> ± 0.3	36.4 <sup>a</sup> ± 0.3	0.1	0.000
Leucine	66.7 <sup>b</sup> ± 1.7	69.6 <sup>a</sup> ± 1.7	69.4 <sup>a</sup> ± 1.7	69.5 <sup>a</sup> ± 1.7	0.3	0.006
Isoleucine	34.1 <sup>b</sup> ± 0.2	35.2 <sup>a</sup> ± 0.3	35.2 <sup>a</sup> ± 0.4	35.2 <sup>a</sup> ± 0.3	0.0	0.000
Phenylalanin	30.7 ± 0.0	30.6 ± 0.0	30.7 ± 0.1	30.6 ± 0.2	0.0	0.724
Histidine	21.9 ± 0.2	21.7 ± 0.2	21.6 ± 0.2	21.7 ± 0.3	0.0	0.311
Arginine	53.7 ± 0.0	53.6 ± 0.2	53.7 ± 0.1	53.6 ± 0.2	0.0	0.616
Aspartic acid	72.2 ± 0.6	71.8 ± 0.7	71.5 ± 0.7	71.7 ± 1.1	0.1	0.355
Glutamic acid	122.1 ± 4.9	120.9 ± 6.2	121.0 ± 4.3	121.0 ± 2.3	0.7	0.952
Glycine	46.7 ± 2.3	46.4 ± 1.9	46.5 ± 2.2	46.5 ± 2.1	0.3	0.991
Alanine	49.1 ± 2.2	48.7 ± 2.1	48.8 ± 2.1	49.2 ± 2.0	0.3	0.951
Serine	31.0 ± 0.4	30.9 ± 0.6	30.7 ± 0.4	30.7 ± 0.4	0.0	0.642
Cysteine	9.9 ± 0.6	9.9 ± 0.6	9.4 ± 0.8	9.3 ± 0.7	0.1	0.288
Tyrosine	23.8 ± 2.1	22.6 ± 2.0	22.6 ± 2.1	22.4 ± 2.2	0.3	0.590
Proline	37.0 ± 2.1	36.4 ± 2.2	36.4 ± 2.1	36.5 ± 1.9	0.3	0.943
Essential amino acid	293.7 <sup>b</sup> ± 1.7	298.8 <sup>a</sup> ± 1.7	298.8 <sup>a</sup> ± 1.5	299.0 <sup>a</sup> ± 1.5	0.4	0.000
Semi-essential amino acid	75.6 ± 0.2	75.3 ± 0.3	75.4 ± 0.2	75.4 ± 0.4	0.0	0.405
Non-essential amino acid	392.1 ± 14.6	387.9 ± 16.0	387.2 ± 13.9	387.7 ± 10.9	2.3	0.892
Total amino acid	761.5 ± 16.0	762.1 ± 17.5	761.5 ± 15.2	762.2 ± 12.0	2.5	0.937
Branched-chain amino acid	136.0 <sup>b</sup> ± 1.3	141.2 <sup>a</sup> ± 1.3	141.1 ± 1.2 <sup>a</sup>	141.2 <sup>a</sup> ± 1.3	0.4	0.000
Aromatic amino acid	54.5 ± 2.1	53.3 ± 2.0	53.3 ± 2.1	53.1 ± 2.2	0.3	0.563
Branched-chain/Aromatic amino acid	2.49 <sup>b</sup> ± 0.07	2.65 <sup>a</sup> ± 0.08	2.64 <sup>a</sup> ± 0.08	2.65 <sup>a</sup> ± 0.09	0.01	0.001
Delicious amino acid	344.0 ± 9.4	341.6 ± 10.7	341.7 ± 8.9	342.2 ± 6.0	1.5	0.946

Means with different superscripts (<sup>a,b</sup>) within the same row differ at  $P < 0.05$

<sup>1</sup> SEM: standard error of mean

Dietary fibre improved poultry carcass quality by reducing the amount of fat deposits in the carcass (Yang, 2002; McDonald *et al.*, 2011). Siregar *et al.* (1982) found that feeding White Pekin ducklings increased amounts of dietary fibre led to a reduction in carcass fat. However, the correlation between dietary fibre content and muscle fat is not clear. The current study found that a rise of CF levels in the diet enhanced the proportion of muscular fat. The amount of fat in the muscle positively influences meat tenderness and juiciness (Wood *et al.*, 2003). Hence, higher levels of CF in the diet of growing CMD were beneficial to the quality of breast muscle. Meanwhile, with the increment in dietary CF levels, both the proportion of DM and the concentration of GE in muscle were heightened to some extent, implying that the unequal levels of dietary CF brought about some variations in the breast muscle components of duck.

Producing high quality protein is the main purpose of breeding duck for human consumption. Although no difference was found in the breast muscle CP proportion between several treatments, dietary

CF levels somehow impacted the AA profile. The data showed that dietary fibre elevated the muscle EAA content due to the enhanced BCAA. The ratio of BCAA to AAA in muscle was also improved for the same reason, which illustrated that dietary fibre increased the quality of breast muscle because meat with a higher BCAA : AAA ratio is more beneficial to the protection of liver function (FAO/WHO, 1973). However, the beneficial results of the muscle AA profile stimulated by dietary fibre were limited. Only the contents of valine, leucine and isoleucine in the breast muscle were varied, but neither CP percentage nor total AA proportion were changed. The variations of three kinds of BCAA were not closely related to dietary CF levels because no difference was noticed between dietary treatments with CF level of 42.6, 77.6, and 101.6 g/kg DM.

**Table 6** Fatty acid profile of the male China Micro-duck breast muscle at 57 days of age (g/kg as dry matter basis)

Item	Dietary crude fibre levels (g/kg of dry matter)				SEM <sup>1</sup>	P-value	
	16.7	42.6	77.9	101.6			
Lauric acid	C12:0	0.95 ± 0.04	0.92 ± 0.06	0.91 ± 0.03	0.90 ± 0.06	0.00	0.361
Myristic acid	C14:0	1.25 <sup>a</sup> ± 0.02	1.09 <sup>b</sup> ± 0.04	0.98 <sup>c</sup> ± 0.07	0.88 <sup>d</sup> ± 0.03	0.02	0.000
Palmitic acid	C16:0	15.26 <sup>a</sup> ± 1.28	12.91 <sup>b</sup> ± 0.46	12.91 <sup>b</sup> ± 0.81	10.16 <sup>c</sup> ± 1.35	0.36	0.000
Palmitoleic acid	C16:1n7	1.53 <sup>b</sup> ± 0.10	1.65 <sup>a</sup> ± 0.10	1.66 <sup>a</sup> ± 0.09	1.66 <sup>a</sup> ± 0.09	0.01	0.030
Stearic acid	C18:0	10.43 ± 0.80	10.29 ± 0.64	10.24 ± 0.96	10.24 ± 1.07	0.14	0.969
Oleic acid	C18:1n9	15.95 ± 0.83	16.45 ± 1.84	16.51 ± 1.52	16.68 ± 0.84	0.22	0.728
Linoleic acid	C18:2n6	4.30 <sup>c</sup> ± 0.76	7.81 <sup>b</sup> ± 0.73	10.14 <sup>a</sup> ± 0.59	10.15 <sup>a</sup> ± 1.03	0.45	0.000
α-Linolenic acid	C18:3n3	0.49 <sup>d</sup> ± 0.03	0.67 <sup>c</sup> ± 0.03	0.82 <sup>b</sup> ± 0.03	0.90 <sup>a</sup> ± 0.07	0.02	0.000
Arachidic acid	C20:0	0.64 ± 0.04	0.64 ± 0.02	0.64 ± 0.02	0.63 ± 0.02	0.00	0.826
Arachidonic acid	C20:4n6	3.85 <sup>c</sup> ± 0.18	5.09 <sup>b</sup> ± 0.44	6.91 <sup>a</sup> ± 0.42	7.13 <sup>a</sup> ± 0.63	0.25	0.000
Erucic acid	C22:1n9	0.62 ± 0.05	0.63 ± 0.02	0.62 ± 0.05	0.64 ± 0.03	0.00	0.807
Saturated fatty acid		28.5 <sup>a</sup> ± 1.96	25.7 <sup>b</sup> ± 0.91	25.7 <sup>b</sup> ± 0.91	22.8 <sup>c</sup> ± 2.12	0.45	0.000
Unsaturated fatty acid		26.8 <sup>c</sup> ± 1.59	32.3 <sup>b</sup> ± 1.87	36.7 <sup>a</sup> ± 1.17	37.2 <sup>a</sup> ± 1.80	0.80	0.000
Unsaturated/Saturated fatty acid		0.93 <sup>d</sup> ± 0.04	1.24 <sup>c</sup> ± 0.06	1.42 <sup>b</sup> ± 0.06	1.63 <sup>a</sup> ± 0.11	0.04	0.000
Total fatty acid		55.3 <sup>c</sup> ± 3.29	58.2 <sup>bc</sup> ± 2.40	62.4 <sup>a</sup> ± 1.62	60.0 <sup>ab</sup> ± 3.59	0.66	0.000
Monounsaturated fatty acid		1.53 <sup>b</sup> ± 0.10	1.65 <sup>a</sup> ± 0.10	1.66 <sup>a</sup> ± 0.09	1.66 <sup>a</sup> ± 0.09	0.01	0.030
Polyunsaturated fatty acid		25.2 <sup>c</sup> ± 1.52	30.7 <sup>b</sup> ± 1.84	35.0 <sup>a</sup> ± 1.20	35.5 <sup>a</sup> ± 1.85	0.79	0.000
Polyunsaturated/Saturated fatty acid		0.88 <sup>d</sup> ± 0.04	1.18 <sup>c</sup> ± 0.06	1.36 <sup>b</sup> ± 0.06	1.56 <sup>a</sup> ± 0.11	0.04	0.000
n-3 Polyunsaturated fatty acid		0.49 <sup>d</sup> ± 0.03	0.67 <sup>c</sup> ± 0.03	0.82 <sup>b</sup> ± 0.03	0.90 <sup>a</sup> ± 0.07	0.02	0.000
n-6 Polyunsaturated fatty acid		8.15 <sup>c</sup> ± 0.78	12.90 <sup>b</sup> ± 0.88	17.05 <sup>a</sup> ± 0.51	17.29 <sup>a</sup> ± 1.17	0.68	0.000
n-6/n-3 Polyunsaturated fatty acid		16.61 <sup>c</sup> ± 1.45	19.04 <sup>b</sup> ± 1.01	20.65 <sup>a</sup> ± 1.10	19.24 <sup>ab</sup> ± 1.83	0.35	0.000
Essential fatty acid		4.79 <sup>c</sup> ± 0.78	8.48 <sup>b</sup> ± 0.75	10.96 <sup>a</sup> ± 0.60	11.06 <sup>a</sup> ± 1.05	0.47	0.000
Atherogenic index		0.79 <sup>a</sup> ± 0.04	0.56 <sup>b</sup> ± 0.03	0.48 <sup>c</sup> ± 0.02	0.39 <sup>d</sup> ± 0.02	0.02	0.000
Δ-9-desaturase (16) index		9.15 <sup>c</sup> ± 0.74	11.37 <sup>b</sup> ± 0.51	11.43 <sup>b</sup> ± 0.55	14.21 <sup>a</sup> ± 1.83	0.36	0.000
Δ-9-desaturase (18) index		60.5 ± 1.41	61.4 ± 2.42	61.7 ± 3.15	62.0 ± 2.88	0.44	0.667

Means with different superscripts (<sup>a, b, c, d</sup>) within the same row differ at  $P < 0.05$

<sup>1</sup> SEM: standard error of mean

The FA composition of meat always receives a great deal of attention in research because of its implications for human health (Raes *et al.*, 2004). Besides a lower total fat intake, human nutritionists are recommending a higher consumption of PUFA and especially of n-3 PUFA at the expense of n-6 PUFA in order to reduce the risk of developing cardiovascular diseases (Hu *et al.*, 2001; Wood *et al.*, 2008). Consequently, maximising the muscle PUFA proportion, particularly that of n-3 PUFA, would enhance the nutritional value of meat (WHO, 2003). The FA profile of poultry meat is generally manipulated by using a selected feeding with particular nutritional characteristics. The on-going research provides an alternative

strategy aimed at heightening the ratio of PUFA to SFA as well as ameliorating the FA profile in the breast muscle of ducks. The fact that the birds fed a diet with a higher CF level in the present study had a more optimal FA framework in muscle than those fed a diet with a lower CF level verified the above-mentioned deduction. The variations in the FA profile of breast muscle between dietary treatments could be attributed to different CF levels in the diet of ducks since the analysed compositions of proximate nutrients AA and FA for four experimental diets were very close to each other, except for the dietary CF levels. In addition, the responses of the descending AI as well as the ascending  $\Delta$ -9 desaturase activity index for C16 FA in muscle to the elevating levels of dietary CF illustrated that dietary fibre could encourage the antioxidant capacity and depress lipid oxidation so as to directly affect the sensory characteristics of meat and indirectly provide multiple health benefits to consumers (Wood *et al.*, 2003).

## Conclusions

The present study revealed the major differences resulting from dietary CF levels with regard to the nutritional quality of CMD breast muscle. Feeding the ducks a diet with a CF level of 101.6 g/kg DM resulted in the highest concentrations of DM, EE and GE in muscle, as well optimal FA composition, indicating the superior potential of a high dietary fibre level to improve the lipid profile of meat to provide health benefits to consumers. The diet with a CF level of 16.7 g/kg DM might be consumers' last choice because it brings about the lowest contents of DM, EE and GE as well as the worst profiles of AA and FA in muscle. Little variation existed in the composition of chemical components, AA, and most FA profiles in muscle between the treatment with dietary CF levels of 42.6 and 77.9 g/kg DM, except for significant differences in the proportions of C14:0, C18:2n6, C18:3n3 and C20:4n6. Depending on dietary levels, CF has a positive effect on the nutritional quality of CMD breast muscle, especially the FA profile. However, in order to thoroughly evaluate the impact of dietary CF levels on meat quality of CMD, further trials are required to explore the relationship between consumer consumption, and the safety and technological aspects pertaining to the production of meat.

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## Authors' Contributions

SPW, DML and GWL contributed equally to this work as the first co-authors.

## Conflict of Interest Declaration

There is no conflict of interest.

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