EFFECT OF FERMENTED CEREALS, PROBIOTICS, AND PHYTASE ON THE SENSORY QUALITY OF POULTRY MEAT

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The sensory properties of poultry meat obtained from meat-type broiler chickens fed with fermented cereals and two different fermented supplements, and Japanese quails (*Coturnix japonica*) fed diets including fermented cereals (wheat, barley or oats), three probiotics (from *E. faecium*, *B. subtilis*, *S. cerevisiae*) and two different phytase preparations were evaluated. Fermented grains (particularly wheat and barley) decreased the sensory quality of meat. The use of three probiotic products and phytase did not negatively influence the sensory quality of the quail meats. The diets containing *S. cerevisiae* (probiotic) produced a highly appreciated meat. The less preferred meat samples were obtained from the quails fed diets containing fermented wheat, fermented barley, and *E. faecium*, due to the off-flavour and odour as well as tanginess. The supplementation of naturally or yeast-fermented liquid whey and lemon pomace was very effective to overcome the bad sensory quality (fish and metallic off-flavour and taste) of the broiler meat obtained by administering the control diet (rich in vegetable oil and fermented wheat).

Broiler meat, Japanese quails, fermented cereal grains, feeding, dietary manipulation, sensory analysis

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INTRODUCTION

Poultry meat is strongly preferred to red meat (lamb or beef) (USDA, 2017) due to its lower fat and cholesterol content (Hocquette et al., 2010; Petracci et al., 2013). Moreover, the preference towards poultry meat is largely affected by several factors including beliefs, price, and sensory properties (Font-i-furnols, Guerrero, 2014). The appearance of raw or cooked poultry meat is an important quality trait (Pearson, 2013) and is largely influenced by its colour (Sokolowicz et al., 2016). The tenderness of meat depends on the characteristics of muscle fibres and postmortem protein modifications (Lee et al., 2010). Taste, smell, and edibility are usually affected by the meat pH and nutrient composition, mostly protein and fat (Jayasena et al., 2013). The effects of different levels of fishmeal fed to poultry on the sensory properties of the resulting meat has been extensively studied (Guerrero-Legarreta, 2010); no differences were found in the flavour of meat samples cooked immediately. However, the sensory attributes of the cooked chicken meat decreased, and the fish-off flavour increased in the samples refrigerated overnight.

Commercial meat-types of poultry species have been subjected to genetic and breeding improvements to maximize the lean tissue (breast and legs). The nutrient composition and the sensory quality of poultry meat are generally influenced by genotype (breed/strain), age, sex of birds (Lopez et al., 2011), breeding (Dal Bosco et al., 2012; Zhao et al., 2012; Riedel et al., 2013; Umaya, 2014), rearing systems (Aguiar et al., 2008), meat processing and packaging conditions (Boselli et al., 2012), and cooking methods (Jayasena et al., 2013; Pereira et al., 2013).

Table 1. Composition of the experimental diets. Control diet (CON1) used for quails, CON1 supplemented with fermented and re-dried wheat (FW), barley (FB) or oat grains (FO), and control (CON2) diet used for broilers (g kg^{-1}, as fed).

Formulation (%, w/w)	CON1	FW	FB	FO	CON2
Corn	60.0	--	--	--	30-40
Fermented wheat	--	60.0	--	--	25-28
Fermented barley	--	--	57.0	--	
Fermented oat	--	--	--	57.0	
Soya bean meal	30.3	32.3	24.0	23.2	22-25
Fish meal	7.0	3.0	10	10	5.0-9.0
Vegetable oil	--	2.0	6.3	7.0	4.5-6.0
Enzyme*	*	--	--	--	--
Probiotic**	**	--	--	--	--
Fermented additives***					***
Others (vitamins, minerals, amino acids)	2.7	2.7	2.7	2.7	3.25
Total	100	100	100	100	100
Dry matter (DM) (g kg^{-1})	89.8	89.9	90.5	90.0	89-90
Crude Protein (CP) (g kg^{-1})	24	24.1	24.0	23.9	23-20
Metabolisable energy (ME) (kJ kg^{-1})	12.1	12.1	12.1	12.1	13.0-13.6

*Three commercial enzymes, PHY500, PHY1000 and PHY5000 were added to CON1 diet for quails. **Three commercial probiotics, D-bacteria, D-spores and D-yeast were added to CON1 diet for quails. ***Natural (NFA) or yeast (YFA) fermented additives were added to CON2 diet for broiler chickens.

Dietary manipulations such as changing the profile of fatty acids and amino acids, cholesterol lowering, and increase of antioxidants affect both the nutritional composition and sensory characteristics of poultry meat (Guerrero-Legarreta, 2010).

Probiotic and enzyme preparations are additives used to enhance the digestibility of animal diets and to improve the nutritive quality of animal feedings (Yasar, 2011). Chickens and other monogastric animals lack the alloenzymes from rumen microbiota. So, for these species it is advisable to provide added enzyme supplementation not available from resident intestinal microbiota to derive optimal nutrient benefit from complex feed matrices (Pariza, Cook, 2010). However, real improvements of the quality of the resulting meat are sometimes questioned (Zakaria et al., 2010). For this reason, the effect of enzymes on meat quality needs further study.

Fermented and re-dried cereal grains (wheat, barley, and oats) under a solid-state fermentation process led to favourable changes in growth rate, efficiency of feed utilization and carcass yield in Japanese quails fed diets containing 40–60% of fermented grains (Yasar, Gok, 2014).

The tenderness and juiciness of cooked poultry meat can be improved by adding probiotics to the diets fed to broilers (Liu et al., 2012; Alloui et al., 2013). Park (2014) reported a statistically significant increase in the water-holding capacity and a decrease of the drip loss in breast meat of birds fed with *Bacillus subtilis*. The use of oligosaccharides (prebiotics) obtained from pea seeds (3 g kg^{-1} feed) induced favourable changes in the sensory characteristics and water-holding capacity, whereas an increased dose caused colour brightening in raw breast meat (Gardzielewska et al., 2004). From these studies, it is difficult to conclude whether supplementing the poultry diets with probiotics would or would not lead to any improvement of the sensory characteristics of poultry meat.

However, the addition of probiotics and enzymes in poultry diets induced an improved growth rate, feed efficiency ratio, and carcass yield in recent studies (Yasar, Akinci, 2014; Yasar, Desen, 2014). Ogungbesan et al. (2014) reported improved sensory quality of broiler meat produced by feeding a diet containing pentosanases and phytases. Furthermore, Yasar, Yegen (2017) described a feed additive similar to commercial yeast showing beneficial effects on the broiler performance.

In the current work, the effects of experimental diets supplemented with dry fermented wheat (FW), barley (FB) or oat grains (FO) as well as with phytase and three different probiotics (*Enterococcus faecium, B. subtilis,* and *Saccharomyces cerevisiae*) on the sensory quality and acceptability of cooked poultry meat (Japanese quails and broilers) were evaluated.

MATERIAL AND METHODS

Experiments with Japanese quails

Three fattening experiments were conducted with Japanese quails (*Coturnix japonica*). A control basal diet based on a corn-soya meal (CON1) was formulated to meet the nutrient requirements of growing Japanese quails (Table 1).

In experiment 1, the CON1 diet was added with three commercial probiotic products: 0.28 g kg^{-1} of a preparation Cylactin (DSM, Switzerland) containing *E. faecium* NCIMB 10415 (D-bacteria); 0.50 g kg^{-1} of a preparation Clostat (Kemin, Belgium) with live spores of *B. subtilis* ATCC PTA-6737 (D-spores); and 0.45 g kg^{-1} of a preparation Fubon (Angel Yeast, China) with a viable probiotic yeast (*S. cerevisiae)* (D-yeast).

In experiment 2, the CON1 diet was added with three commercial phytase enzyme products, Phy-500 (Rovaphos 500, Trouw Nutrition, LLC, USA), Phy-1000 (Ronozyme HiPhos, DSM Heerlen, the Netherlands), and Phy-5000 (Natuphos 5000, BSAF Ludwigshafen, Germany), at 500, 1000, and 5000 FTU phytase per kg of the diet, respectively.

In experiment 3, the amount of corn in the CON1 diet containing no additives was completely replaced by around 60% of fermented and re-dried wheat (FW), barley (FB), and oat (FO), respectively. Wheat, barley, and oat grains were fermented and then re-dried using a solid-state fermentation method (30–40°C for 8 h, $4 < pH < 5$; 60% moisture) and 1.1 or 1.2 kg fresh whey per kg of grain added with 1–2.5% fresh citrus pomace.

In each of these experiments, each diet was offered to 48 chicks in 4 replicated cages (each with 12 chicks) from 1-day-old until the age of 34 days. An exception was made in experiment 2 where the chicks were fed from 14 days until 35 days of age with the aim of testing the effects of early or late administration of the dietary treatment. All chicks were reared in electrically heated battery brooders and subjected to similar management practices (brooding, lighting, feeding, and wire-mesh floor watering) throughout the experiments. Ten dietary treatments (including the control) were carried out in the three experiments using quails. These experiments were coded from 1 to 10 for the statistical analysis (CON1, FW, FB, FO, Phy500, Phy1000, Phy5000, D-bacteria, D-spores, and D-yeast, respectively).

Experiment with broiler chickens

One experiment was conducted using Ross 308 PM chicks from day 1 till 42 days of age. The birds were fed a control diet (CON2) containing no feed additives (Table 1); the CON2 diet supplemented with 0.5% (0.5NFA) or 1.0% (1.0NFA) of naturally fermented additive (NFA) and the CON2 diet supplemented with 0.5% (0.5YFA) or 1.0% (1.0YFA) yeast fermented additive (YFA). NFA was produced from a microbial fermentation with no microbial inoculant on grain flour using liquid whey and lemon pomace; YFA was produced from a microbial fermentation of inoculated *S. cerevisiae* on grain flour using liquid whey and lemon pomace. Each diet was offered to 63 broiler chicks, kept in 3 floor pens, each with 21 chicks until the age of slaughtering. Birds received similar management practices during the experiment. Five dietary treatments were coded from 1 to 5 in statistical analysis, representing 1.0YFA, 0.5YFA, CON2, 1.0NFA, and 0.5NFA, respectively. The effects of these dietary treatments on the birds' performance were discussed in previous papers and summarized in Table 2.

Sensory analysis

After the completion of the experiments, the birds (quails and broilers) fasted for 12 h were slaughtered. Three carcasses were randomly chosen from each of 3 replicate pens (providing 9 broiler carcasses for each diet) or 4 replicate cages (providing 12 quail carcasses for each diet) for sensory analysis. The carcasses were stored at 6°C for 24 h. The entire muscles from both legs of all birds (12 quails or 9 broilers) from a single dietary treatment group were removed and were pooled for each of the diet groups. After the codification and size standardization of each sample, all the muscles were thoroughly mixed and then cooked in a pre-heated oven (180°C) until the core temperature reached 80°C. The cooked samples were then divided into 10 equal portions (one portion per each assessor) randomly and then administered to the trained judges for the sensory analysis. The serving temperature of the samples was 60°C (AMSA, 2015).

The sensory panel was trained according to ISO standards (ISO 13300-2:2006). The testing room was equipped with lights, temperature and seating arrangements with individual testing compartments so as not to distract the members of the panel (ISO 8589:2007). Twelve (six women and six men) trained panelists aged between 28 to 48 years took part in the sensory panel. They were firstly asked to evaluate the sensory quality of quail meats in one session by using the round table method under the supervision of a moderator (panel leader) (Moskowitz et al., 2012). After the completion of this test, two panelists (1 female and 1 male) were identified as outliers and they were excluded from the statistical analysis and subsequent sensory session. Therefore, the next session was carried out with only 10 panelists. The evaluation of the sensory quality was based on a total of 14 descriptors (Q).

Table 2. Effects of different dietary treatments on the performance of birds (summarized results of three studies on Japanese quails and one study with broilers).

Study 1[1]			
Treatments	Feed intake, g bird^{-1}	Final Weight, g bird^{-1}	Feed Conversion Ratio
CON1	460.6±18.0	170.0±5.7	2.91±0.03
FW	469.2±20.0	182.6±4.8	2.69±0.04
FB	461.6±19.5	175.5±6.1	2.75±0.01
FO	389.6±13.7	154.1±3.7	2.67±0.04
Study 2[2]			
CON1	305.2±3.2	143.9±2.9	3.15±0.02
Phy-500	310.6±4.1	147.7±3.6	3.10±0.01
Phy-1000	280.3±2.9	144.6±3.0	2.89±0.01
Phy-5000	310.9±1.8	148.6±4.0	3.07±0.03
Study 3[3]			
CON1	399.7±5.1	139.1±2.5	3.16±0.01
D-bacteria	398.3±3.6	142.8±2.8	3.04±0.02
D-spore	394.6±3.5	141.6±3.3	3.03±0.03
D-yeast	412.3±5.0	143.7±3.7	3.13±0.05
Study 4[4]			
CON2	4890±68	2276±55	2.20±0.01
1.0 YFA	4906±75	2374±42	2.11±0.01
0.5 YFA	4843±63	2286±38	2.17±0.03
1.0 NFA	5088±96	2502±66	2.08±0.03
0.5 NFA	4934±101	2406±68	2.10±0.01

[1]Yasar, Gok 2014; [2]Yasar, Desen 2014; [3]Yasar, Akinci 2014; [4]Yasar, Yegen 2017. CON1 and CON2, control diets; FW, FB and FO, diets containing fermented wheat, barley and oats grains, respectively; Phy-500, -1000 and -5000, diets supplemented with phytase. D-bacteria, D-spore and D-yeast, diets supplemented with commercial probiotics; NFA, diet supplemented with naturally fermented additive; YFA, diets supplemented with a yeast fermented additive.

The panelists rated the cooked meat using a 5-point intensity (or hedonic) scale for each descriptor. Only the lower and the highest extremes for each descriptor (Q) are reported below for brevity. The external view (appearance) of the meat was evaluated as follows: Q1 – colour (1, not good; 5, very good); Q2 – colour intensity (1, light; 5, dark), and Q3 – integrity test (1, very parted; 5, not parted). The texture was evaluated as follows: Q4 – hardness (1, very soft; 5, very hard); Q5 – degree of degradability or chewiness (1, easy; 5, hard); Q6 – wet or dry (1, too dry; 5, too wet), and Q7 – fatness (1, without fat; 5, too fatty). The flavour was evaluated as follows: Q8 – taste, smell or odour (1, not good; 5, very good); Q9 – undesirable taste (1, weak; 5, strong); Q9A – fish-off taste and off-odour (1, weak; 5, strong); Q9B – metallic-off taste and smell (1, weak; 5, strong); Q9C – sour-off taste and smell (1, weak; 5, strong), and Q10 – tanginess (1, weak; 5, strong). Finally, the overall acceptability was evaluated as follows: Q11 – acceptability (1, certainly unacceptable; 5, highly acceptable). The sample order of presentation to each assessor was randomized. The panelists were not given any information regarding the dietary treatments. They were asked to rinse their mouth with water between two samples.

Statistical analysis

The sensory data were used to calculate the descriptive statistics for each of the dietary treatments by using the statistical function of the MS Excel. Significant differences among the different diets were determined with one-way ANOVA followed by the Tukey's test ($P < 0.05$) (GraphPad Prism 5 for Windows; La Jolla, USA). Principal Components Analysis (PCA) was carried out on the averaged data from 10 panelists to establish sample groupings and to determine the significant variables explaining the variance of the experimental model. The data used for PCA were not transformed in any way. The PCA was performed using The Unscrambler ver 9.8 software (Camo Software AS, Oslo, Norway).

RESULTS

The data regarding the sensory evaluation of poultry meat are presented in Table 3. The use of a 5-points intensity scale is a common procedure to differentiate among products as well as within product variations (King, Meiselman, 2010; Gondekova et al., 2014).

In Figs. 1–3, the bi-plots of the PCA models containing both the loadings of the variable vectors and scores (of the samples) are presented. In addition, the performance data of the animals were discussed in previous works by the same authors, as reported in the legend of Table 2. The birds performed significantly differently depending on the diets containing fermented cereal grains or feed additives of different types.

Sensory analysis of Japanese quail meats

As reported in Table 3, the meat samples from the quails fed diets containing FB (sample No. 3) and Phy1000 (sample No. 6) received a high score for colour, colour intensity, and integrity of the meat, whereas the meat samples of quails fed diets containing FW and FO grains (No. 2 and 4, respectively) received significantly lower scores. The only significant difference between female and male assessors was found in the evaluation of the meat colour of quails fed the diets containing FW, FO, and D-bacteria; the men preferred the colour of the D-bacteria meat samples (4.3 ± 1),

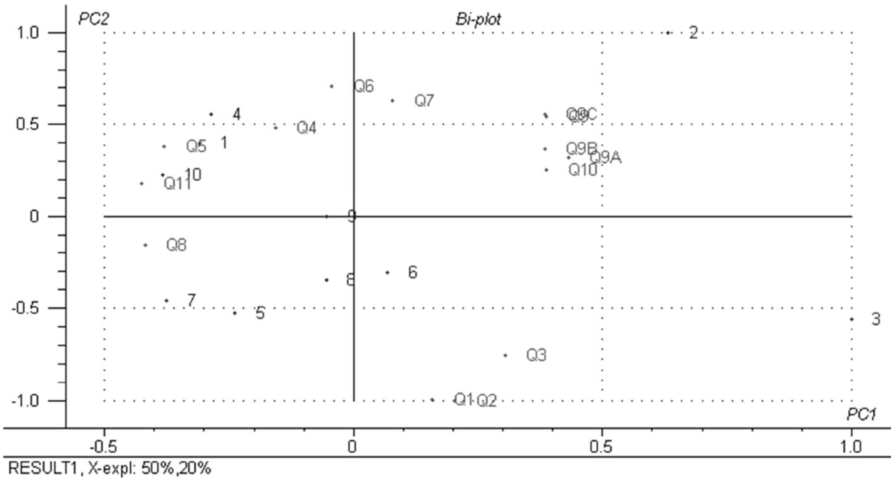

Fig. 1. Bi-plot of the Principal Component Analysis of Japanese quails (sample numbers from 1 to 10) across the variables (from Q1 to Q11); PC1 vs PC2, accounting for 70% of the total variance (PC1, 50%; PC2, 20%)

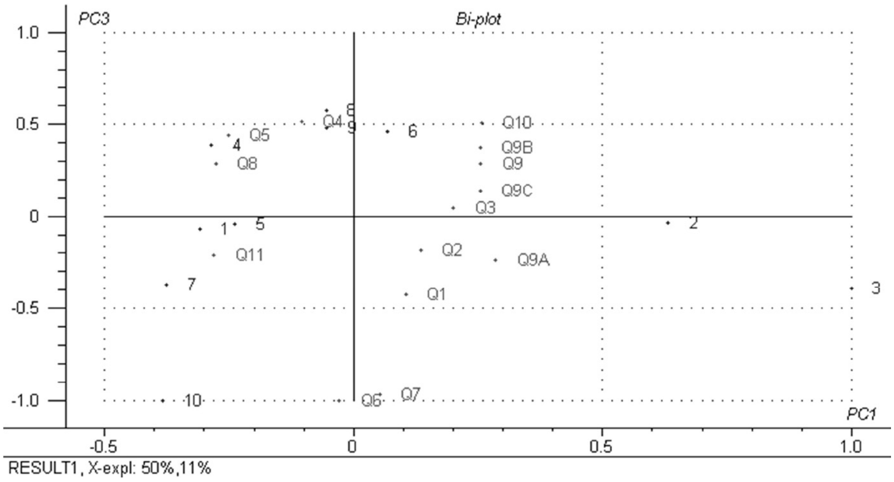

Fig. 2. Bi-plot of the Principal Component Analysis of Japanese quails (sample numbers from 1 to 10) across the variables (from Q1 to Q11); PC1 vs PC3, accounting for 61% of the total variance (PC3, 11%)

Table 3. Average values of the sensory analysis (n=10 assessors) for quail meat (upper part) and broiler meat (bottom part) in a 5-point intensity scale. For each descriptor (Q), different superscript letters indicate statistically different samples within a group of poultry fed with different diets.

Sample	Description	Descriptors													
	Quails	Q1 color	Q2 color intensity	Q3 integrity	Q4 hardness	Q5 chewiness	Q6 dryness	Q7 fatness	Q8 off-flavour	Q9 off-taste	Q9A off-fish	Q9B metallic	Q9C sour	Q10 tanginess	Q11 overall acceptance
1	CON1	3.33^{bcd}	3.00	4.00	3.00	2.83	3.25	2.42	3.58	1.42^{b}	1.58^{a}	1.50	1.58	2.58	4.00
2	FW	$2.75^{b,c,d}$	2.92^{a}	4.33	2.67	2.50	3.08	2.83	2.58	2.50^{a}	3.00^{b}	2.25^{a}	1.92	3.08	3.42
3	FB	4.75^{a}	4.08^{b}	4.75	2.50	2.17	2.92	2.50	2.50	2.17	3.33^{b}	2.17	1.83	3.00	2.75^{a}
4	FO	$3.17^{b,c,d}$	2.92^{a}	3.83	3.25	2.92	3.08	2.25	3.50	1.83	1.75^{a}	1.50	1.50	2.58	3.75
5	Phy500	4.08^{a}	3.25	4.50	2.67	2.75	2.83	2.25	3.25	1.33^{b}	1.25^{a}	1.17^{b}	1.25	2.67	4.00
6	Phy1000	$3.50^{b,c,d}$	3.33	4.67	2.67	2.67	2.67	2.17	3.33	1.67	1.58^{a}	1.75	1.58	2.75	3.75
7	Phy5000	$3.42^{b,c,d}$	3.42	4.25	2.25	2.67	2.83	2.42	3.75	1.33^{b}	1.33^{a}	1.25	1.25	2.17	3.92
8	D-bacteria	3.67	3.75	4.17	3.33	2.58	2.50	2.25	3.42	1.83	1.50^{a}	1.50	1.33	2.75	3.67
9	D-spores	$3.17^{b,c,d}$	3.33	4.25	3.00	2.58	2.42	2.58	3.67	1.67	1.58^{a}	2.08	1.42	2.67	3.83
10	D-yeast	$3.58^{b,c,d}$	3.33	4.00	3.08	2.58	3.33	3.00	3.42	1.42^{b}	1.50^{a}	1.25	1.25	2.33	4.33^{b}
	pooled m	3.54	3.33	4.28	2.84	2.63	2.89	2.47	3.30	1.72	1.84	1.64	1.49	2.66	3.74
	pooled sd	0.55	0.37	0.30	0.35	0.21	0.30	0.27	0.43	0.38	0.72	0.40	0.24	0.27	0.42
	Broilers														
1	YFA 1.0	2.90^{a}	3.10	3.70	3.30	2.80	2.70	2.50	2.70	2.10	1.80	1.60^{a}	nd	2.80	3.10
2	YFA 0.5	3.70	3.00	4.20	2.90	2.20	2.80	2.50	$3.60^{a,c}$	1.70^{a}	1.30^{a}	1.10^{a}	nd	2.60	4.00^{b}
3	CON2	$3.20^{a,c}$	3.50	3.80	2.90	2.80	2.80	2.70	2.00^{b}	3.00^{b}	2.50^{b}	2.90^{b}	nd	3.00	2.10^{a}
4	NFA 1.0	3.40	3.80	3.90	2.90	2.40	2.80	2.90	3.40^{c}	$1.30^{a,c}$	1.20^{a}	1.50^{a}	nd	3.10	3.90^{b}
5	NFA 0.5	4.10^{b}	3.80	4.10	3.40	3.10	2.20	2.30	3.20	1.60^{a}	1.80	1.70	nd	2.50	3.60^{b}
	pooled m	3.46	3.44	3.94	3.08	2.66	2.66	2.58	2.98	1.94	1.72	1.76	nd	2.80	3.34
	pooled sd	0.46	0.38	0.21	0.25	0.36	0.26	0.23	0.64	0.66	0.52	0.68	nd	0.25	0.78

m, mean; sd, standard deviation. CON1 and CON2, control diets. FW, FB and FO, diets containing fermented wheat, barley and oats grains, respectively. Phy-500, -1000 and -5000 were the diets supplemented with phytase. D-bacteria, D-spore and D-yeast, diets supplemented with the commercial probiotics. NFA, diet supplemented with naturally fermented additive; YFA, diets supplemented with a yeast fermented additive.

whereas the women preferred the colour of FW (3.7 ± 1) and FO (3.5 ± 1) meat samples. A similar case was also reported for the integrity of the meat samples from quails fed with the CON1; the female assessors (4.7 ± 0.5) liked it, whereas the male assessors did not (3.3 ± 1.4). Meat samples of quails administered diets of CON1, FW, FO, D-bacteria, D-spores, and D-yeast had a good texture assessed by high scores for either meat hardness, chewiness, juiciness or fatness (Q4–Q7), whereas the remaining dietary treatments (FB and enzymes) led to a worse texture in quail meats. The CON1 and FO treatment resulted in soft meat texture easy to chew, but FW and FB led to a hard texture (for chewing). The CON1 and D-yeast treatment yielded juicy meat texture whereas D-spores and D-yeast yielded dry meat texture. The diets of FW and of D-yeast additive yielded a fat meat texture whereas FO, Phy500, Phy1000, and D-bacteria caused a lean meat texture. The CON1 and FW, FB, Phy-1000, and D-yeast treatments were scored differently for texture parameters (hardness, chewiness, juiciness, and fatness) by the females and males, respectively, suggesting that there was a gender difference in the assessment of the texture parameters (for instance, CON1 was usually scored high by the female assessors). Q8 is the main attribute of the meat flavour and was evaluated separately from Q9 and Q9A, B, and C. In general, the diets containing FW and FB caused low scored meat samples for flavour parameter, whereas the meat samples from quails fed the remaining dietary treatments including CON1 received high scores for meat taste. In other words, FW, FB, and partially meats obtained with diets supplemented with D-spores were scored high for bad taste, fish-off-taste, metallic-off-taste, sour-off-taste, and tanginess. One of the important results is that the dietary treatments of FW and FB were scored high by females and low by males about the taste (flavour). On the other hand, the treatments of FB, one probiotic and two enzyme additives were scored high by males and low by females for the same parameters. The overall acceptability (Q11) of the meat was high for the quails fed with the diets of D-yeast, CON1, Phy500, and Phy5000, whereas FW and FB again were scored low. The gender difference in the overall acceptance (Q11) of quail meat was only evident for FW and Phy5000, indicating no important effect of gender on the general acceptability.

Principal Component Analysis of Japanese quail meats

For a better readability of the results, the average sensory data obtained from the judges were elaborated with PCA. Three PCA components (PC1, PC2, and PC3) accounted for 50, 20, and 11% of the total variance of the model, respectively. In Fig. 1 and Fig. 2, the load of the variables (the descriptors from Q1 to Q11) and the distribution of the samples (from 1 to 10) are depicted in two bi-plots. The first bi-plot represents PC1 vs PC2, whereas the second bi-plot depicts PC1 vs PC3. In this way, a better overview of the multidimensional space corresponding to the statistical model could be displayed. The data used for the elaboration were normalized by their standard deviation.

As expected, the global acceptance of the cooked meat (Q11) was positively related to Q8 (very good taste, smell, and odour) and to Q5 (hard to cut) and partially related to Q4 (very hard texture). On the opposite side of both the bi-plots there were Q3 (integrity), tanginess (Q10), and defects and off-flavours (Q9, Q9A, Q9B, and Q9C, respectively). Surprisingly, the colour of the cooked meat (Q1 and Q2) did not affect the global acceptability with respect to other more effective variables. In fact, there is a 90° angle between the Q11 vector and Q1 and Q2 (indicating no correlation at all in both bi-plots). The natural fatty taste of the meat (Q7) did not affect the acceptability of the meat (no dressing was added). Also, dryness/wetness (Q6) of the meat was not really a crucial variable influencing the acceptance of the meat. However, very wet samples (Q6), such as sample No. 1 (the control diet) and No. 10 (D-yeast additive) were the

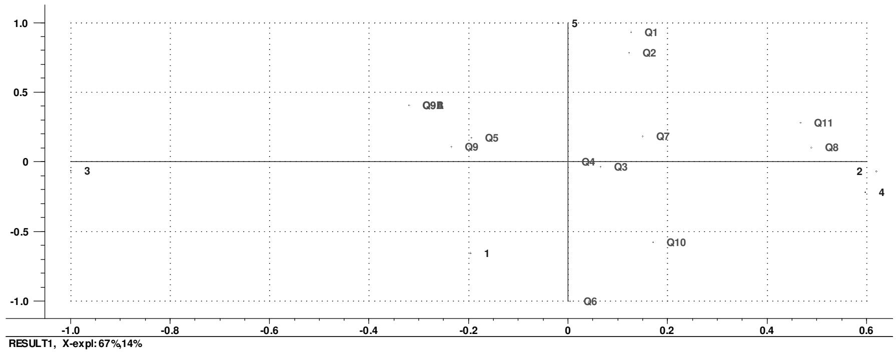

Fig. 3. Bi-plot of the Principal Component Analysis of broiler meats (samples from 1 to 5) across the variables (from Q1 to Q11); PC1 vs PC2, accounting for 81% of the total variance (PC1, 67%; PC2, 14%)

most preferred meats, probably due to the high juiciness associated with these samples.

The meat samples of the quails fed the diets of CON1, D-yeast, Phy500, and Phy5000 were highly appreciated by the panel, and the meat of quails fed the diet containing FO was also well appreciated. The less preferred meat samples were obtained from the quails fed the diets containing FW, FB, and D-bacteria, due to the bad taste and odour as well as tanginess.

Sensory analysis of broiler meats

The sensory data and descriptive statistics for broiler meats are also presented in Table 3 (bottom part). There were no notable differences in the evaluation between men and women in the panel test. Meats obtained from broiler chickens fed diets of CON, NFA 1.0%, and YFA products at 0.5 or 1.0% dosage did not substantially differ with regard to the external view (Q1 to Q3), whereas the preferred external view was obtained from the meat samples of birds fed with 0.5% of NFA. In addition, the overall texture parameters (hardness, chewiness, juiciness and fatness) of meat samples did not differ among the dietary treatments, or the difference among the treatments was too small. Among the texture parameters, the fatness was scored low for meats of the birds fed the diets with 0.5NFA, and the lowest score for chewiness was registered for the treatments with 0.5YFA and 1.0NFA. On the contrary, the meat samples of broilers fed with the CON2 diet received a low score for good flavour. The same meat samples received high scores for bad taste, fish-off-taste, metallic-off-taste, and tanginess, as compared to any other treatment. The overall acceptability of CON2 diet for broilers was the lowest among all. Finally, the diets supplemented with YFA at 0.5% and with NFA at 1.0% were also considered highly acceptable by the panelists.

Principal Component Analysis of broiler meats

The results of PCA performed on these samples indicated that a total variance of 81% was explained by the first two components, PC1 and PC2 (Fig. 3).

The biplot (Fig. 3) showed that the dietary treatments were very effective to overcome the bad sensory quality (fish and metallic bad taste) of the broiler meat obtained by feeding the CON2 diet. The meat samples of the treatment with 0.5NFA were clearly differentiated through the sensory descriptors. The CON2 (sample No. 3) was completely different with respect to the other samples, and particularly from the samples no. 2 and No. 4 (with YFA at 0.5% and NFA at 1.0%), due to its low quality. The supplementation of CON2 with YFA at 0.5% and with NFA at 1.0% reduced these off-flavours. The meat samples for these treatments were highly preferred by the judges because of their good taste and flavour, high fatty taste, high integrity, and low sensory defects.

DISCUSSION

The results of the sensory analysis of quail meat samples evaluated by a trained panel indicated that the dietary composition enormously affected most of the sensory parameters. The opinion or liking of a trained panel might not be the same as that of the general population, which is formed by untrained consumers. However, the use of a trained panel for the sensory analysis of specific food products has become not only a scientific standard, but also a legally recognized procedure (E U , 2013).

The diets including a high amount (60%) of fermented wheat and barley (FW and FB) and the diets supplemented with phytase at 1000 FTU were not accepted by the panel due to bad taste, flavour and odour as well as tanginess when compared to the untreated control diet (CON1). Moreover, the present study indicated that the bad sensory quality of poultry meat obtained by feeding with fermented cereals was due to undesirable tastes (fish-off, sour-off, and metallic-off) and increased fatness. The fermented grains were included in the poultry diet by more than 40%; it is well known that fermented grains contain appreciable amount of organic acids produced during the fermentation (which by the way decreases the pH) (S r i p r i y a et al., 1997). This might be the main reason of the low acceptability of the meat obtained with the reported diets.

An increased feed intake was more evident (Fig. 2) with the birds fed with FW and FB-based diets than FO based diets (Y a s a r , G o k , 2014). The higher feed intake could be the reason for the highly scored sour-taste of the cooked meat of birds fed fermented FB and FW-based diets compared to fermented oats-based diets. The latest ones did not cause any negative effect on the sensory quality of quail meat (these birds consumed significantly less feed). Although fermented feeds are beneficial for the growth performance and health of birds, the panelists disliked the meat produced with such diets due to their high level of organic acids mentioned above.

In the current study, the use of three probiotic products and two enzyme products did not negatively influence the sensory quality of the quail meats, whereas the diets containing D-yeast (probiotic) produced a highly appreciated meat. Our findings generally complied with previously observed similar findings on the use of probiotics in poultry diets (K a b i r , 2009; A l f a i g et al., 2013; K i m et al., 2016).

Among three enzyme preparations, Phy500 and Phy5000 improved the sensory quality of quail meat; those meats were highly appreciated by the panel. These products degrade the phytate present in the feed and improve the bioavailability of phosphorus for the birds (Y a s a r , D e s e n , 2014). Although the degradation of phytic acid may increase the amount of soluble iron, zinc, and calcium several folds (H a a r d et al., 1989) there was no direct evidence showing that this degradation process might have caused any formation of sensory active molecules.

In this study, the samples of broiler meat differed in their sensory quality between the dietary treatments. The meat produced by feeding the CON2 diet was scored low when compared with the meat produced by feeding NYA and YFA products. The diets supplemented with YFA at a concentration of 0.5% and NFA at a rate of 1.0% were very appreciated by the panelists. The reason for low-scored broiler meat obtained with the CON2 diet (control) could be due to a relatively high level of fishmeal content (5–9%), causing undesirable taste and odour sensed by the panelists. The use of yeast or naturally fermented additive (NYA and YFA) overcame the undesirable taste in the broiler meat, when added to the CON2 diet (control). The meat obtained with quails fed diet containing D-yeast probiotic was also highly accepted by the panelists. This indicated that the probiotics obtained from yeast or feed additives fermented by yeast enhanced the sensory quality of the poultry meat. These results agree with those of Kabir (2009), indicating that the addition of probiotics to broiler diets improved tenderness and juiciness. The mechanism by which the tenderness and juiciness are improved by the dietary effect of probiotics has not been reported yet. However, the increase of water holding capacity and decrease of drip-loss (not measured in our study) in the poultry meat obtained from the broiler chicken fed on the diet supplemented with probiotics was reported to play a crucial role in affecting tenderness and juiciness of poultry meat (Chen et al., 2012).

There were differences between female and male panelists in the sensory perception of quail meat, not of broiler meat, in our study. The difference was most pronounced for the parameters of texture and flavour, but less for external view and general acceptance. Similar results were reported previously by Gondekova et al. (2014), indicating gender differences in detecting odour, juiciness, and taste in the sensory evaluation of beef meat. However, it is beyond the aims of this work to address this issue, because more experimental data on the physiological differences between sensory perceptions related to the gender would be needed.

CONCLUSION

Feeding poultry species with the diets high in fermented grain contents, particularly wheat and barley, negatively affected the sensory properties of meat evaluated by a trained panel. One plausible reason for this result is that the significant changes in nutrient composition of poultry diets have negatively affected the meat quality; the level of fishmeal in the commercially available poultry diet was too high.

In this study, natural and yeast-fermented additives or yeast probiotics, as well as some commercial enzyme products based on phytase affected the sensory attributes of poultry meat. The trained judges effectively perceived differences in the sensory parameters of the meats. When used at appropriate levels, the above-mentioned additives improved the sensory quality of broiler and quail meats.

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