Sensory characteristics and volatile compounds of dry cured ham Speck are affected by pig dietary supplementation with antioxidant mixture.

Journal:	<i>Journal of the Science of Food and Agriculture</i>
Manuscript ID	JSFA-20-1864.R2
Wiley - Manuscript type:	Research Article
Date Submitted by the Author:	n/a
Complete List of Authors:	Rossi, Raffaella; Università degli Studi di Milano, Department of Veterinary Medicine Ratti, Sabrina; Università degli Studi di Milano, Department of Veterinary Medicine Moretti, Vittorio; Università degli Studi di Milano, Department of Veterinary Medicine Vasconi, Mauro; Università degli Studi di Milano, Department of Veterinary Medicine Corino, Carlo; Università degli Studi di Milano, Department of Veterinary Medicine
Key Words:	consumer test, speck, sensory evaluation, volatile compounds, antioxidants

SCHOLARONE™
Manuscripts

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Running head: Sensory characteristics and volatile compounds of dry cured ham Speck

Sensory characteristics and volatile compounds of dry cured ham Speck are affected by pig dietary supplementation with antioxidant mixture. ¹

Raffaella Rossi^{a*}, Sabrina Ratti^a, Vittorio Maria Moretti^a, Mauro Vasconi^a, Carlo Corino^a

^a Università degli Studi di Milano, Department of Veterinary Medicine, Via Dell'Università 6,
26900 Lodi, Italy.

* Corresponding author: Raffaella Rossi. Department of Veterinary Medicine, Via Dell' Università 6,
26900 Lodi, Italy. E-mail: raffaella.rossi@unimi.it

¹ Authors disclosure: R. Rossi, S. Ratti, V.M. Moretti, M. Vasconi, C. Corino have no conflicts of
interest.

Abstract

BACKGROUND

Dry cured ham named Speck is a typical Italian product, with consolidated processing techniques and specific quality parameters. It has gained importance in the international market after obtaining the Protected Geographical Indication. Recent studies indicate that dietary plant extracts in pig may affect quality of processed meats but there are no data on their effect on Speck. Consequently, the effects of dietary supplementation with antioxidant mixture, containing vitamin E and polyphenols (AOX) in pigs on the nutritional characteristics, volatile compounds, sensory properties and consumers' preference of Speck was evaluated.

RESULTS

The Speck weight loss during seasoning was lower in the AOX group, while products quality parameters were not affected by dietary treatments. Alcohol and terpenes concentrations were lower ($P < 0.05$) in the AOX samples than the control. Sensory profile revealed slight differences ($P < 0.05$) in Speck salty and sweet taste, whereas the consumer tests showed a higher ($P < 0.05$) preference, with mean score of 7, for Speck from pigs fed AOX.

CONCLUSION

Our results provide new insights on the quality parameters of Speck. Dietary integration with antioxidant mixture decreased Speck weight losses during seasoning. Volatile compounds concentrations and sensory profile were slight affected by dietary treatment. The consumer test revealed that dietary antioxidants, increased the overall preference for Speck, and can potentially increase its consumption.

Keywords: antioxidants, consumer test, speck, sensory evaluation, volatile compounds.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

INTRODUCTION

Italian pork products originate from ancient traditions that have led to a wide variety of products, characterized by a clear geographical identity, consolidated processing techniques and specific sensory properties.¹ Among the traditional Italian dry cured hams, Speck has gained importance in the international market, after obtaining the Protected Geographical Indication (PGI) by the European Union.^{2,3}

Traditionally the meats preservation in the mountain areas combined salting and smoking phases and the regulation of PGI for the “Speck Alto Adige” production keep this ancient tradition. Speck derived from deboned pork thighs, salting with herbs and spices mixture, and then smoked and seasoned. This quality certification requires conformity with requirements in all the production chain to ensure the final product quality.

In Italy, in 2018, Speck production increased by 4.1% compared to the previous year, reaching 35,900 tons (value a 357.6 million euros; + 4%).⁴ Although Speck is a common product in the italian consumption pattern, no data are available on its volatile compounds and sensory characteristics. Studies are required to meet the needs of consumers who are increasingly interested in food quality and safety and sustainable products.⁵

In response to recent claims regarding the potential toxicity of synthetic antioxidants, the meat industry explored plant extracts, containing polyphenols, that have shown high antioxidant and antimicrobial activities.^{6,7} Literature has reported that plant extracts dietary supplementation in pigs improves meat lipid and colour stability and vitamin E content, enhancing raw pork shelf life and quality of ripening product.⁸⁻¹⁰

To our knowledge, in literature, no studies have been published on Speck nutritional, and sensory parameters, after pigs’ dietary treatments. This study falls under a larger research on the effect of antioxidants on pork quality parameters. Considering that, data on Speck are lacking, we decided to study this product with the double aim of deepen the knowledge about Speck nutritional and

65 sensory parameters and to evaluate the impact of dietary supplementation with antioxidant mixture,
66 containing Vitamin E and verbascoside, on the Speck overall quality.

68 MATERIALS AND METHODS

69 *Animal, diet and slaughter procedure*

70 The animals were treated according to the European Union guidelines (2010/63/EU)¹¹ and
71 approved by the Italian Ministry of Health (DL 26, 2014 March 4th).

72 The trial was performed in a commercial farm of northern Italy, producing pigs slaughtered
73 at 130 kg of live weight (LW). Seventy pigs (PIC x Max Grow), with an average LW of 95.2 ± 1.2
74 kg were randomly selected and assigned to two dietary treatments for 45 days (35 pigs per treatments;
75 5 pens per treatment). The CON group received a commercial mashed diet and the AOX group the
76 same diet with an integration of vitamin E (DL-alpha-tocopheryl acetate, DSM Nutritional Products,
77 Milan, Italy) and verbascoside from *Verbenaceae* extract to provide a daily amount of about 150 mg
78 vitamin E and 15 mg verbascoside. The diets composition was reported in Table 1.

79 The verbascoside is provided by a water-soluble extract of *Verbenaceae* (*Lippia spp.*) leaves,
80 prepared on an industrial scale using a standardized procedure including ultrasonic extraction with
81 600 g kg^{-1} aqueous ethyl alcohol followed by spray-drying with maltodextrins as an excipient. The
82 phenylpropanoid glycosides and benzoic acid content of the feed supplement was determined using
83 HPLC-UV-diode array detector methods¹². The feed supplement contained: $1.75 \pm 0.07 \text{ g kg}^{-1}$ gallic
84 acid, $0.45 \pm 0.04 \text{ g kg}^{-1}$ 3,4-dihydroxybenzoic acid, $1.91 \pm 0.09 \text{ g kg}^{-1}$ methyl gallate, $0.43 \pm 0.04 \text{ g}$
85 kg^{-1} isoverbascoside, and $4.47 \pm 0.08 \text{ g kg}^{-1}$ verbascoside. Microencapsulation technology was used
86 to protect the supplement from oxidation (Sintal Zootecnica, Isola Vicentina, Vicenza, Italy).

87 The growth performance and carcass characteristics are previously reported.¹⁰ After an on-
88 farm fasting period of 8 h, the pigs were individually weighed and transported for 2 h to the abattoir.
89 Pigs were slaughtered in a commercial slaughterhouse (Hauser Carni S.p.a., Mezzocorona, Trento,
90 Italy), according to the guidelines for the protection of animals during slaughter.¹³ The pigs were

1
2
3 91 held in lairage for 4 h with free access to water. Pigs were electrically stunned, and following
4
5 92 exsanguination, the carcasses were scalded, dehaired, and eviscerated. The slaughter weigh was 130.7
6
7
8 93 ± 1.6 kg LW. Carcasses were chilled for 24 h at +4 °. After the carcass dissection, the left thighs were
9
10 94 randomly selected from 10 pigs per treatment (2 pigs per pen). The raw hams were moved to the
11
12 95 Speck factory and processed in smoked dry cured ham, following the “Speck Alto Adige PGI” official
13
14 96 regulations.
15
16
17 97
18

19 98 ***Dry-curing processing***

20
21 99 The raw hams were deboned and trimmed to give the typical Speck shape and were weighted.
22
23
24 100 The trimmed hams were coated with sea salt and juniper, rosemary, bay leaves, garlic, coriander and
25
26 101 pepper mixtures. The salting and flavoring phase lasted 21 days at controlled temperatures and
27
28 102 relative humidity (4°C and RH 80%) and the hams were turned several times to facilitate the salt and
29
30 103 spicy mixture diffusion. After, a resting phase of 7 days (6°C and RH 70%), to diffuse and equalize
31
32 104 the salt and flavour content, the hams were cold smoked in a special room, using non-resinous wood
33
34 105 with a temperature that did not exceed 20°C. The Speck were finally seasoning in a naturally
35
36 106 ventilated room for 5 months (10-15°C and RH 70-80%).
37
38
39

40 107 ***Sampling***

41
42
43 108 The Speck were transported at the University of Milan laboratories. The Speck were weighed
44
45
46 109 and sectioned perpendicularly (containing essentially 3 muscles: *Semimembranosus*, *Biceps femoris*,
47
48 110 and *Semitendinosus*). At sampling, the colour parameters were measured. The Speck were sampling
49
50 111 into slices (1 cm thick) and vacuum-packaged and frozen at -20°C pending lab analyses. Half Speck
51
52 112 were vacuum-packaged and stored at 4°C pending sensory analyses. In order to characterize the Speck
53
54 113 overall quality, following the dietary intervention, all the analyses were performed on the whole
55
56 114 slices, including external fat.
57
58
59
60 115

Physical and Chemical parameters

The hams were weighed prior and after seasoning, and the weight losses were calculated. Lightness (L^*), redness (a^*), and yellowness (b^*) values were measured on Speck muscles and subcutaneous adipose tissue using a CR-300 Chroma Meter (Minolta Camera Co., Osaka, Japan). The instrument was calibrated on the Commission Internationale d'Eclairage (CIE) LAB colour space system using a white calibration plate (Calibration Plate CR-A43; Minolta Camera Co.). The colorimeter had an 8 mm measuring area and was illuminated with a pulsed Xenon arc lamp (illuminant C) at a viewing angle of 0° . Reflectance measurements were obtained at a viewing angle of 0° and the spectral component was included. Each data was the mean of three replications measured at the slice surface on both muscles (*Semimembranosus*, *Biceps femoris*, and *Semitendinosus*) and subcutaneous adipose tissue. Total colour differences (TCD) were calculated using the following equation: $\Delta E^* = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2}$.

Dry matter (method 950.46), crude protein (method 990.03), ether extract (method 920.39), and ash content (method 920.153) of Speck samples were determined in triplicate on whole slices and on slices, after removing the external fat, after fine grinding, according to AOAC.¹⁴

Volatile compounds determination

Volatile compounds were extracted from samples by headspace-solid phase microextraction (HS-SPME) and determined by gas-chromatography-mass spectrometry (GC-MS). Briefly, 3 g of minced Speck were placed in a 20 mL vial closed by a PTFE/silicone septum. Before extraction, stabilization of the vial headspace was obtained by equilibration for 15 min at 35°C , as proposed by Garcia-Esteban *et al.*,¹⁵ using a multi-purpose sampler MPS2 XL (Gerstel GmbH, Mülheim an der Ruhr, Germany) equipped with the SPME option. The extraction was carried out at 35°C for 15 min, using a divinylbenzene/carboxen/polydimethylsiloxane fiber (DVB/CAR/PDMS), 50/30 μm (Supelco, Bellefonte, PA, USA). After exposure, the fiber was thermally desorbed in 1 min into a model 6890 GC coupled with a mass spectrometer model MS Agilent 5973 (Agilent Technologies,

CA, USA) and left in the injection port (equipped with a 0.75 mm i.d. inlet liner) for 15 min with the split valve open. The separation was performed on a Trace GOLD TG-5MS capillary column (30 m x 0.25 mm I.D., 0.25 μ m film thickness; Thermo Fisher Scientific). Carrier gas was helium with a linear flow rate of 1 mL min⁻¹. The oven temperature was: 40 °C held for 10 min, from 40 °C to 250 °C at 5 °C min⁻¹ and held for 5 min. Mass spectra were obtained under electronic ionization condition at 70 eV in the 35-300 amu range. The ion source was held at 230 °C and quadrupole at 150 °C. Blank runs were carried out as first run of the day before samples analysis. C7-C30 saturated alkanes in hexane standard solution (Sigma Aldrich) were run under the same HS-SPME GC-MS samples condition to calculate the retention index (RI) of detected compounds according to Van den Dool and Kratz¹⁶. Compounds were identified by matching mass spectral data with Wiley (2000) and NIST (1998) library database, comparison of obtained retention indices with available literature values and the retention time of standard compounds used at a preliminary stage to refine chromatographic conditions. Agilent Chemstation software was used for data analysis.

Sensory profile

A trained sensory panel was selected, consisting of eight members, familiar with descriptive analysis procedures.¹⁷ All assessments were performed in a sensory laboratory.¹⁸ Three sessions were conducted to develop a common vocabulary, to improve the judges ability to discriminate between samples and to properly use the scale. Analysis of variance was performed for each attribute to identify those that were not significant in discriminating between samples and to test the judge's discrimination skills. Attribute references were used during training sessions to calibrate the panel members. The descriptors with definitions and standard are reported in Table 2. The sensory profile was assessed according to ISO 13299¹⁷ and the panel evaluated the samples in triplicate. During training and sampling, panel members had access to unlimited water and unsalted crackers. The Speck were cut into slices of equal thickness (1.5 mm, about 10 g) and served in a randomized order. The judges were presented with two slices of Speck per treatment and the judges first scored the

appearance and aroma and then score the texture, flavour and taste. Within each session the design was balanced for order and carry-over effects.¹⁹ The intensity of each attribute was evaluated by assigning a score of between 1 (absence of sensation) and 9 (extremely intense).

Consumer test

Eighty voluntary consumers (45 females and 35 males) participated to the consumer test and all were regular Speck consumers. A maximum of 10 participants per session were included, and upon arrival they received a short introduction. The test took place in two days. The consumers evaluated two samples (2 slices per treatment) per session identified with a three-digit code, corresponding to CON and AOX samples. To avoid order and carry-over effects, samples were served in a randomized design.¹⁹ The Speck were cut into slices of equal thickness (1.5 mm) and served in a randomized order. Unsalted crackers and water were provided to all participants to rinse their mouths before tasting sample. The descriptors were: overall preference, appearance, fat colour, muscle colour, small, flavour, salty and slice texture. The preference of each attribute was evaluated by assigning a score of between 1 (undesirable) and 9 (extremely appreciated).

Statistical analyses

Data statistical analyses were performed using SPSS (SPSS/PC Statistics 24.0, IBM, USA). Physical and chemical parameters, and volatile compounds were analyzed by one-way analysis of variance (ANOVA) with the dietary treatments as fixed effect. Data from sensory profile were submitted to three-way ANOVA with samples, judges, replicates, and their interactions as effects.¹⁶ The significance of these effects was tested with F tests. Consumer test were analyzed by one-way ANOVA with the dietary treatments as fixed effect and considering panelist, session, tasting and presentation order as random effect. The pig was considered as the experimental unit for all the quality parameters. All data are reported as mean $\pm$ SEM. Differences among treatments were considered significant at $P < 0.05$.

1
2
3 194
4
5
6 195
7
8 196
9
10 197
11
12 198
13
14
15 199
16
17 200
18
19 201
20
21
22 202
23
24 203
25
26 204
27
28 205
29
30
31 206
32
33 207
34
35 208
36
37
38 209
39
40 210
41
42 211
43
44
45 212
46
47 213
48
49 214
50
51 215
52
53
54 216
55
56 217
57
58 218
59
60 219

RESULTS AND DISCUSSION

Physical and chemical parameters

The ham weight before and after seasoning was not affected by dietary treatment (Table 3). However, the Speck weight losses during seasoning was lower ($P = 0.037$) in the AOX than CON group. In the literature, there are no data on Speck weight losses during seasoning. Previous studies have reported that diet and genetic types are important factors affecting the quality of dry-cured hams.^{20,21} Seasoning was more successful increasing pig age and slaughter weight, as these parameters are correlated with high adiposity.²² Moreover, in dry-cured hams higher fat coverage and lower lean cuts are negatively and positively correlated with weight loss, respectively.²³

The redness (a^*) and yellowness (b^*) indexes, were not affected by dietary treatments, but a lower ($P < 0.01$) muscle lightness (L^*) was observed in the AOX group than in the CON group. The TCD values of Speck were 3.2 and 2.13 for muscle and fat respectively, indicating a distinct difference in perceivable colour ($1.5 < \text{TCD} < 3$).²⁴ The Speck colour parameters are comparable with the values of PGI Dalmatian smoked dry-cured ham.²⁵ In Dalmatian ham, the redness (a^*) and yellowness (b^*) values were lower than our data ²⁶, probably due to the different pig breeding, smoking phase and ripening period.

The colour in smoked products was related to chemical and physical events during the smoking process such as the smoke coloring compounds adhesion, polymerization and oxidation of the smoke component phenols and aldehydes and the reaction of between smoke carbonyl groups and protein amino groups on the product surface. ²⁷

The physical parameters such as pH, colour and water-holding capacity (WHC) were evaluated in the same animals on the target muscle *Longissimus dorsi*¹⁰. The pH values and WHC were not affected by dietary treatments and the colour parameters showed a color-stabilizing effect of the AOX mixture during refrigerate storage of samples packed in a modified atmosphere. Moreover, our previous study in pigs fed the same dosage of plant extract titrated in verbascoside

showed no effect on raw *Biceps femoris* colour parameters and drip losses and a positive effect on oxidative stability of raw muscle, but not of the final product Salami Cremona.⁹

Dietary antioxidant mixture did not affect the chemical composition of Speck whole slice and the slice without external fat (Table 4). The mean value of the whole slice (crude protein 270 g kg⁻¹, water to protein ratio of 1.51, fat to protein ratio of 0.92) were in line with data of the official regulations for production (crude protein > 200 g kg⁻¹; water to protein ratio max 2 and fat to protein ratio max 1.5). The Speck nutritional characteristics were in accord with data reported by Lucarini *et al.*,¹ although the fat content was higher in our study (251 vs 191 g kg⁻¹, respectively), probably due to breeding techniques, pig genetic type, feeding and slaughter weight. In our study, pigs were slaughtered at a medium-heavy weight of 130 kg. Several data have shown that increasing slaughter weight resulted in higher thigh adiposity^{22,28}, that is associated with more intramuscular fat and saturated fatty acids, with positive effects on the dry-cured ham sensory quality.^{29,30} As expected, the Speck chemical composition was unaffected by dietary antioxidant, as observed in raw meat and seasoned products.^{9, 31}

Volatile compounds

Table 5 reports the Speck volatile compounds. A total of 57 volatile compounds were identified: 2 acids, 4 alcohols, 6 aldehydes, 4 ketones, 14 hydrocarbons, 1 sulfur compound, 3 nitrogen compounds, 1 furan, 2 phenols, and 19 terpenes. No differences between experimental groups were observed for acids, aldehydes, ketones, hydrocarbons, sulfur and nitrogen compounds, furan and phenols. The total terpenes content was lower ($P = 0.05$) in Speck from AOX pigs than controls, with a lower content of β -pinene, β -myrcene, α -terpinene and limonene. A similar trend was found for 1-octen-3-ol, the only alcohol which showed differences ($P < 0.05$) between experimental groups.

The aromatic profile was dominated by terpenes, mainly derived from the spices.^{27,32} The main terpenes were α and β pinene, linalool, limonene β -phellandrene and 3 carene, which probably

1
2
3 246 derived from pepper, coriander, rosemary and laurel.²⁵ The α -pinene, limonene, and linalool showed
4
5 247 a specific aroma, such as pine and peppery notes, fresh and citric notes, and flowery, citrus notes.³³ It
6
7
8 248 is possible that some active principles of *Lippia* spp. extract decreased the Speck terpenes content,
9
10 249 although the mechanism was not elucidated and further studies are required to validate this
11
12 250 hypothesis.

14
15 251 The volatile compounds derived from wood smoke were alcohols, aldehydes, aromatic
16
17 252 hydrocarbons, phenols and pyridines.³⁴ Hydrocarbons were the second group of Speck volatile
18
19 253 compounds and although they represented a large group, they only slightly affected the aroma.³⁵

21
22 254 Aldehydes are the main volatile compounds in smoked dry-cured ham, contributing to the
23
24 255 products flavour.²⁷ The 3-methylbutanal was found in the largest quantities and derived from the
25
26 256 amino acids degradation.³⁶ Linear aldehydes, such as hexanal and nonanal, derive from the β -
27
28 257 oxidation of unsaturated fatty acids, above all from linoleic acid.³⁷ The dietary antioxidant did not
29
30
31 258 affect the Speck aldehydes content, according with a study that reported no effect of vitamin E
32
33 259 supplementation on ham aldehyde profile.³⁸ In contrast, a lower aldehydes content was observed in
34
35 260 dry-cured ham due to the antioxidant effect of dietary vitamin E on lipid oxidation, possibly for
36
37
38 261 different length of seasoning.³⁹

39
40 262 Alcohols were affected by AOX supplementation and a lower amount of 1-octen-3-ol was
41
42 263 observed. This compound, derived from lipid oxidation, is responsible for a moldy aroma in Iberian
43
44 264 ham, which was the most discriminating variable affecting sensory evaluation.⁴⁰ The lower presence
45
46
47 265 of this compound in the AOX group could indicate a decrease in lipid oxidation with a positive effect
48
49 266 on sensory characteristics.

51
52 267 The ketones, phenols, nitrogen and sulfur compounds were not affected by dietary treatments.
53
54 268 Phenols are formed primarily by the pyrolysis and lignin oxidation and represented the second volatile
55
56 269 compounds group in Dalmatian smoked dry-cured ham.²⁷ Ketones were detected in small amounts
57
58 270 and they could be linked to lipid oxidation or to microorganisms metabolism.⁴¹
59
60

271

3.4 Sensory attributes and consumer's preference

Table 6 reports the F values for the parameters of the Speck sensory profile. A difference ($P < 0.05$) was observed between CON and AOX groups in salty and sweet taste. The appearance, aroma, flavour and texture were comparable in both groups. The judges recorded differences ($P < 0.001$) for all the descriptors and this is common due to the different use of the scale.⁴² There was no difference ($P > 0.05$) between the sample, repetition and interactions, demonstrating that the mean scores for each descriptor can be assumed satisfactory for the Speck sensory profile. The spider plot is reported in Figure 1.

The consumer's test data is reported in Figure 2 and revealed that Speck from AOX were preferred ($P < 0.05$) over CON. Consumers perceived differences ($P < 0.05$) on the fat colour, aroma, flavour and slice texture. The antioxidant mixture positively affected the consumers' preference for Speck, without affecting other quality parameters. No previous studies reported a consumer preference for Speck obtained from pigs fed with antioxidant mixture. The trained panel detected only slight differences between the speck from CON group and a product obtained from animals fed with antioxidant mixture. These data agree with previous studies reported that dietary antioxidants in pig did not modify *Longissimus dorsi* muscle, cooked ham, bacon, sausages and ribs sensory characteristics.^{43,44} On the other hand, Pastorelli *et al.*,⁹ showed that antioxidant mixture dietary integration improved the red color of Salami Cremona that was more intense, probably due to the higher content of antioxidants, with protective effects on lipid oxidation.⁴⁵

CONCLUSION

Our study shows that pig's short-term dietary supplementation with antioxidant mixtures improved the Speck seasoning losses, without affecting other physical and chemical parameters. Dietary treatment affected the volatile compounds with a reduction in 1-octen-3-ol and total terpenes. The sensory profile was slightly affected by dietary antioxidant however the consumer tests showed an overall preference for Speck from the AOX group. Considering the limited data on the Speck

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

298 quality, the results of the present study are interesting for extend the knowledge about the nutritional
299 and sensory characteristics of this typical Italian product.

301 **ACKNOWLEDGEMENTS**

302 This work was supported by the University of Milan (grant No. 17801). The authors are grateful to
303 Tomasoni farm and Hauser Carni S.p.a., for their support during the experimental trial.

305 **CONFLICT OF INTEREST**

306 The authors have no conflicts of interest to declare.

REFERENCES.

1. Lucarini M, Saccani G, D'Evoli L, Tufi S, Aguzzi A, Gabrielli P, Marletta L. Lombardi-Boccia G, Micronutrients in Italian ham: A survey of traditional products. *Food Chem* **140**:837–842 (2013).
2. European Community (1996). *Commission Regulation 1107/96 of 12 June 1996 on the registration of geographical indications and designations of origin under the procedure laid down in Article 17 of Council Regulation (EEC) No 2081/92* [Online] Available at: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31996R1107&from=EN> [20 April 2020].
3. European Community (2017). *Commission Implementing Regulation (EU) 2017/119 of 13 January 2017 approving non-minor amendments to the specification for a name entered in the register of protected designations of origin and protected geographical indications [Speck Alto Adige/ Südtiroler Markenspeck/Südtiroler Speck (PGI)]* [Online] Available at: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017R0119&from=GA> [20 April 2020].
4. ASSICA, *Industrial Association of Meat and Meat Product. Report 2018* [Online]. <https://www.assica.it/it/pubblicazioni/rapporto-annuale/archivio.php> [20 April 2020].
5. Roman S, Sanchez-Siles LM, Siegris M, The importance of food naturalness for consumers: Results of a systematic review. *Trends Food Sci Tech* **67**:44e57 (2017).
6. Karre L, Lopez K, Getty KJ, Natural antioxidants in meat and poultry products. *Meat sci* **94**:220–227 (2013).
7. Papuc C, Goran GV, Predescu CN, Nicorescu V, Stefan G, Plant polyphenols as antioxidant and antibacterial agents for shelf-life extension of meat and meat products: classification, structures, sources, and action mechanisms. *Compr Rev Food Sci* **16**:1243–1268 (2017).
8. Kumar J, Narayan D, Tanbir Y, Narsaiah, AK, Recent trends in the use of natural antioxidants for meat and meat products. *Compr Rev Food Sci Food Saf* **4**:796–812 (2015).

9. Pastorelli G, Rossi R, Ratti S, Corino C, Plant extracts in heavy pig feeding: effects on quality of meat and Cremona salami. *Anim Prod Sci* **56**:1199–1207 (2015).
10. Rossi R, Stella S, Ratti S, Maghin F, Tirloni E, Corino C, Effects of antioxidant mixtures in the diet of finishing pigs on the oxidative status and shelf life of longissimus dorsi muscle packaged under modified atmosphere. *J Anim Sci* **95**:4986–4997 (2017).
11. European Community (2010). *Council Directive 2010/63/EU of 22 September 2010 on the protection of animals used for scientific purposes*. [Online] Available at: <https://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:276:0033:0079:EN:PDF> [20 April 2020].
12. Piccinelli, AL, De Simone F, Passi S, Rastrelli L, Phenolic constituents and antioxidant activity of *Wendita calysina* leaves (Burrito), a folk Paraguayan tea. *J Agric Food Chem* **52**:5863–5868 (2004).
13. European Community (2009). *Council directive 1099/2009/EC of 24 September 2009 on the protection of animals at the time of killing*. [Online] Available at: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02009R1099-20191214&from=IT> [20 April 2020].
14. Association of Official Analytical Chemists (AOAC) *Official methods of analysis* (17th eds.). Journal Arlington, VA, USA (2002).
15. Garcia-Esteban M, Ansorena D, Astiasarán I, Ruiz J, Study of the effect of different fiber coatings and extraction conditions on dry cured ham volatile compounds extracted by solid-phase microextraction (SPME). *Talanta*, **64**:458–466 (2004).
16. van Den Dool H and Kratz PD, A generalization of the retention index system including linear temperature programmed gas—liquid partition chromatography. *J Chromatogr A*, **e11**:463–471 (1963).
17. ISO 13299 (2016). *International organization for standardization. Sensory analysis - Methodology - General guidance for establishing a sensory profile*. (Geneva, Switzerland).

18. ISO 8589 (2014). *International organization for standardization*. Sensory analysis - General guidance for the design of test rooms. (Geneva, Switzerland).
19. MacFie HJ, Bratchell N, Greenhoff K, Vallis, LV, Designs to balance the effect of order of presentation and first-order carry-over effects in hall tests. *J Sens Stud* **4**:129–148 (1989).
20. Bermúdez R, Franco D, Carballo J, Lorenzo JM, Physicochemical changes during manufacture and final sensory characteristics of dry-cured Celta ham. Effect of muscle type. *Food Control* **43**:263–269 (2014).
21. Čandek–Potokar M and Škrlep M, Factors in pig production that impact the quality of dry-cured ham: a review. *Anim.* **6**:327–338 (2012).
22. Čandek–Potokar M, Zlender B, Bonneau M, Effects of breed and slaughter weight on longissimus muscle biochemical traits and sensory quality in pigs. *Ann Zootech* **47**:3-16. (1998).
23. Dall' Olio S, Aboagye G, Nanni Costa L, Gallo M, Fontanesi A, Effects of 17 performance, carcass and raw ham quality parameters on ham weight loss at first salting in heavy pigs, a meat quality indicator for the production of high quality dry-cured hams. *Meat Sci* **162**:108012. (2020)
24. Adekunle AO, Tiwari BK, Cullen PJ, Scannell AGM, O'donnell, CP, Effect of sonication on colour, ascorbic acid and yeast inactivation in tomato juice. *Food Chem* **122**:500–507 (2010).
25. Marušić N, Petrović M, Vidaček S, Petrak T, Medić H, Characterization of traditional Istrian dry-cured ham by means of physical and chemical analyses and volatile compounds. *Meat Sci* **88**:786–790 (2011).
26. Petričević S, Radovčić NM, Lukić K, Listeša E, Medić H, Differentiation of dry-cured hams from different processing methods by means of volatile compounds, physico-chemical and sensory analysis. *Meat Sci* **137**:217–227 (2018).
27. Radovčić NM, Vidacek S, Janci T, Medic H, Characterization of volatile compounds, physico-chemical and sensory characteristics of smoked dry-cured ham. *J Food Sci Technol* **53**:4093–4105 (2016).

- 1
2
3 385 28. Lebrete B, Lefaucheur L, Mourot J, Bonneau M. Influence des facteurs d'elevege sur la qualite'
4 386 de la viande de porc. *J. Rech Porc Fr* **28**:137–156 (1996).
5
6
7
8 387 29. Bosi P, Russo V, The production of the heavy pig for high quality processed products. *It J Anim*
9 *Sci* **4**:309–321. (2004).
10 388
11
12 389 30. Lo Fiego DP, Macchiolini P, Minelli G, Santoro P, Lipid composition of covering and
13 intramuscular fat in pigs at different slaughter age. *It J Anim Sci* **9**:200–205 (2010).
14 390
15
16
17 391 31. Rossi R, Ratti S, Pastorelli G, Crotti A, Corino C, The effect of dietary vitamin E and verbascoside
18 on meat quality and oxidative stability of *Longissimus dorsi* muscle in medium–heavy pigs. *Food*
19 392 *Res Int* **65**:88–94 (2014).
20 393
21
22
23
24 394 32. Górska E. Nowicka K. Jaworska D, Przybylski W, Tambor K, Relationship between sensory
25 attributes and volatile compounds of polish dry-cured loin. *Asian-Australas J Anim Sci* **30**:720–
26 395 727 (2017).
27 396
28
29
30
31 397 33. Luna G, Aparicio R, García-González DL, A tentative characterization of white dry-cured hams
32 from Teruel (Spain) by SPME-GC. *Food Chemi* **97**:621–630 (2006).
33 398
34
35 399 34. Hierro E, De la Hoz L, Ordóñez JA, Headspace volatile compounds from salted and occasionally
36 smoked dried meats (cecinas) as affected by animal species. *Food Chem* **85**:649 –657 (2004).
37 400
38
39
40 401 35. Carrapiso AI. and García C, Iberian ham headspace: odorants of intermuscular fat and differences
41 with lean. *J Sci Food Agr* **84**:2047–2051 (2004).
42 402
43
44
45 403 36. Sabio E, Vidal-Aragon MC, Bernalte MJ, Gata, JL, Volatile compounds present in six types of
46 dry-cured ham from south European countries. *Food Chem* **61**:493–503(1998).
47 404
48
49 405 37. Shahidi F (eds). *Flavor of meat, meat products and seafoods*. Blackie Academic and Professional,
50 London (1998).
51 406
52
53
54 407 38. Ruiz J, de la Hoz L, Isabel B, Rey AI, Argimiro Daza C, López-Bote J, Improvement of Dry-
55 cured Iberian Ham Quality Characteristics Through Modifications of Dietary Fat Composition
56 408 and Supplementation with Vitamin E. *Food Sci Technol Int* **11**:327–335. (2005).
57 409
58
59
60

39. Timón ML, Martín L, Petrón MJ, Jurado A, García C, Composition of subcutaneous fat from dry cured Iberian hams as influenced by pig feeding. *J Sci Food Agr* **82**:186-191. (2002).
40. Carrapiso AI., Jurado A., Timón ML, García C, Odor-Active compounds of iberian hams with different aroma characteristics. *J Agric Food Chem* **50**:6453-6458 (2002).
41. Pastorelli G, Magni S, Rossi R, Pagliarini E, Baldini P, Dirinck P, Van Opstaele F, Corino C, Influence of dietary fat, on fatty acid composition and sensory properties of dry-cured Parma ham. *Meat Sci* **65**:571–580 (2003).
42. Lea P, Naes T, Rodbotten M, *Analysis of variance for sensory data*. New York: Chirchester John Wiley & Sons Ltd (1997).
43. Valencia I, O'Grady MN, Ansorena D, Astiasarán I, Kerry JP, Enhancement of the nutritional status and quality of fresh pork sausages following the addition of linseed oil, fish oil and natural antioxidants. *Meat Sci* **80**:1046–1054 (2008).
44. Sheard PR., Enser M, Wood JD, Nute GR, Gill BP, Richardson RI, Shelf life and quality of pork and pork products with raised n-3 PUFA. *Meat Sci* **55**:213-221 (2000).
45. Ventanas S, Estevez M, Tejeda JF, Ruiz J, Protein and lipid oxidation in Longissimus dorsi and dry cured loin from Iberian pigs as affected by crossbreeding and diet. *Meat Sci* **72**:647–655 (2006).

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Table 1. Ingredients of experimental diet (as fed basis).

Item	CTR	AOX
Ingredient, g kg ⁻¹		
Corn	440.2	440.2
Soybean meal, 440 g kg ⁻¹ CP	168.8	168.8
Barley	140.3	140.3
Wheat middlings	99.7	98.7
Wheat bran	80.5	80.5
Beet pulp	29.5	29.5
Calcium carbonate	14.0	14.0
Trace element and vitamin premix ¹	7.8	7.8
Dicalcium phosphate	8.2	8.2
Animal fat	4.9	4.9
NaCl	2.1	2.1
L-lysine HCL	1.0	1.0
AOX supplement ²	-	1.0
DL-Methionine	0.8	0.8
L-Threonine	0.2	0.2
<i>Calculated composition, g kg⁻¹</i>		
ME, kcal/kg	3,155	3,155
Crude protein	156.1	156.1
Ether extract	34.0	34.0
Lysine	11.2	11.2
Methionine + Cystine	5.1	5.1
Threonine	6.9	6.9
Tryptophan	2.8	2.8
Ca	8.1	8.1
P	6.2	6.2

¹ Vitamin–trace mineral premix provided the following nutrients per kilogram of diet: 3 mg all-trans retinol, 0.049 mg cholecalciferol, 15 mg vitamin E, 3.0 mg riboflavin, 0.015 mg cyanocobalamin, 10

mg pantothenic acid, 150 mg Fe as Fe-sulfate, 0.5 mg I as $\text{Ca}(\text{IO})_3$, 0.3 mg Se as Na_2Se , 12 mg Cu as CuSO_4 , 100 mg Zn as ZnO_2 , 50 mg Mn as MnO_2 .

² The AOX supplement contain per kilogram: 50 mg of vitamin E (DL-alpha-tocopheryl acetate) and a water-soluble extract of *Verbenaceae* (*Lippia spp.*) leaves, titrated in verbascoside, to obtain 5 mg verbascoside.

For Peer Review

Table 2. Descriptors, definitions and standard for sensory analysis of dry cured ham Speck.

Descriptor		Definition	Standard
<i>Appearance</i>			
Red colour	Color of thin part		Breasola della Valtellina
White colour	Color of fat part (white)		Lard slice
Marbling	Amounts of intramuscular fat		Ham with a high presence of intramuscular fat
<i>Aroma</i>			
Seasoned	Characteristic odors of seasoned ham perceived through smell		Parma ham (24 months)
Smoky	Aroma associated with smoke perceived through smell		Bacon
Pepper	Aroma associated with pepper perceived through smell		Pepper powder
<i>Taste</i>			
Sweet	Level of salt taste		Parma ham (24 months)
Salty	Level of sweet taste		Toscana ham
<i>Flavour</i>			
Seasoned	Flavour associated with seasoned ham		Parma ham (24 months)
Smoky	Flavour associated with smoke		Bacon
Pepper	Flavour associated with pepper		Pepper powder
Juniper	Flavour associated with juniper		Juniper powder
<i>Texture</i>			
Tender	Force needed to masticate the meat ready for swallowing		Undercooked roast beef
Juicy	Degree of juice released while chewing the meat		Undercooked roast beef
Fibrous	Amount of fibers/strands perceived during chewing		Boiled beef meat

Table 3. Characteristics and colour indices of Speck from pig fed control (CON) or antioxidant mixture (AOX) supplemented diet.

Speck characteristics [‡]	Dietary treatment			
	CON	AOX	SEM	<i>P</i> -value
Weight of raw ham, kg	8.03	8.07	0.122	0.880
Weight of seasoning ham, kg	5.51	5.69	0.097	0.377
Seasoning losses, %	31.35 *	29.50 *	0.452	0.037
Colour indices of fat				
<i>L</i> *	76.50	76.91	0.285	0.467
<i>a</i> *	1.12	1.17	0.243	0.925
<i>b</i> *	8.60	8.30	0.183	0.370
Colour indices of muscle				
<i>L</i> *	43.31**	40.64**	0.392	<0.001
<i>a</i> *	9.30	9.80	0.352	0.351
<i>b</i> *	8.50	8.70	0.142	0.651

[‡] n = 10; data are reported as mean ± standard error of the means (SEM); ** for *P* < 0.01; * for *P* < 0.05

1
2
3 479
4
5
6 480
7
8 481
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35 482
36 483
37
38 484
39
40
41 485
42
43 486
44
45 487
46
47 488
48
49
50 489
51
52 490
53
54 491
55
56 492
57
58 493
59
60 494

Table 4. Chemical parameters of dry cured ham Speck from pigs fed control (CON) or antioxidant mixture (AOX) supplemented diet.

	Dietary treatment			
Item ‡	CON	AOX	SEM	<i>P-value</i>
<i>Whole slice</i>				
Moisture, g kg ⁻¹	420.9	415.5	9.55	0.602
Crude Protein, g kg ⁻¹	278.9	261.9	7.42	0.262
Ether extract, g kg ⁻¹	239.8	262.1	15.1	0.479
Ash, g kg ⁻¹	56.0	50.7	2.05	0.203
<i>Slice without external fat</i>				
Moisture, g kg ⁻¹	494.9	491.7	6.20	0.545
Crude Protein, g kg ⁻¹	341.3	330.1	4.06	0.174
Ether extract, g kg ⁻¹	94.4	101.7	8.51	0.398
Ash, g kg ⁻¹	67.3	64.8	1.82	0.523

‡The data are reported as g kg⁻¹ on wet weight. n = 10; data are reported as mean ± standard error of the means (SEM).

Table 5. Volatile compounds extracted from dry cured ham Speck from pigs fed with a control diet (CON) and diet supplemented with without natural extract (AOX).

Item ‡	RI	Methods of identification	Dietary treatment		SEM	<i>P</i> -value
			CON	AOX		
Acids			17.77	14.86	1.824	0.446
Acetic acid	608	MS RI	13.46	12.86	1.687	0.865
3-butenic acid	652	MS	4.28	2.00	0.725	0.115
Aldehydes			571.95	636.96	76.514	0.683
Acetaldehyde		MS	22.13	24.39	5.190	0.452
Butanal	550	MS RI ST	10.33	18.94	1.268	0.462
3-methylbutanal	644	MS RI	430.6	490.7	15.31	0.673
2-methylbutanal	655	MS RI	17.54	21.01	4.712	0.425
Hexanal	801	MS RI ST	84.85	78.65	2.146	0.756
Nonanal	1100	MS RI ST	6.45	3.23	2.215	0.105
Alcohols			171.46	211.99	8.794	0.620
Ethyl alcohol		MS	146.54	191.69	8.823	0.581
Isobutanol	664	MS RI	6.75	7.66	1.290	0.444
1-penten-3-ol	678	MS RI	5.67	4.91	1.512	0.591
1-octen-3-ol	982	MS RI	12.48 *	7.71 *	2.487	0.028
Furans			7.55	4.93	2.235	0.193
Furfuryl alcohol	864	MS RI	7.55	4.93	2.235	0.193
Hydrocarbons			229.13	191.43	5.742	0.479
Pentane	500	MS RI ST	81.55	27.39	3.816	0.114
Heptane	700	MS RI ST	6.30	3.51	2.528	0.227
2-Methyl-2-butene	728	MS RI	31.71	28.19	1.463	0.797
2-Ethyl-3-methyl-1-pentene	787	MS RI	8.21	10.34	2.525	0.364
2,2,4,6,6-Pentamethylheptane	989	MS RI	51.45	76.56	6.261	0.417
Decane	1000	MS RI ST	4.71	5.77	0.269	0.667
2,2,7,7 tetramethyloctane	1025	MS RI	10.0	8.23	0.864	0.816
Cyclodecane	1034	MS RI	8.43	7.36	0.482	0.812
2,5,9-Trimethyldecane	1038	MS	1.87	3.22	0.296	0.628
6-Methyltridecane	1049	MS	2.27	1.66	1.694	0.697
2,6-Dimethyloctane	1053	MS	4.91	3.01	0.445	0.644
2-Undecene-9-methyl	1115	MS	8.67	7.58	0.271	0.674
Dodecane	1200	MS RI ST	5.04	4.26	0.400	0.767
Tridecane	1300	MS RI ST	3.85	4.29	0.492	0.792
Ketones			94.03	129.11	3.20	0.234

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Acetone		MS	57.81	107.45	2.91	0.055
2 -Pentanone	685	MS RI	12.23	7.84	1.09	0.226
2 -Heptanone	893	MS RI	20.26	10.37	3.44	0.134
2 -Nonanone	1089	MS RI	3.71	3.44	0.286	0.918
Nitrogen compounds			16.07	14.95	3.847	0.635
3 -Aminopyrrolidine	597	MS	14.79	12.48	2.259	0.268
1,3-Dimethylurea	697	MS RI	1.28	2.47	0.161	0.426
Phenols			114.29	91.86	18.683	0.186
Phenol	987	MS RI	10.34	9.58	2.192	0.709
Phenol 2 methoxy	1085	MS	68.12	52.91	10.55	0.109
Sulfur compounds			5.50	6.52	2.662	0.682
Allyl methyl sulfide	695	MS RI	5.50	6.52	2.662	0.682
Terpens			1194.65 *	666.18 *	73.579	0.019
Alfa Phellandrene	927	MS RI	43.49	23.00	13.825	0.082
Alfa Pinene	933	MS RI	256.14	172.11	7.559	0.223
Camphene	947	MS RI	9.88	9.18	5.664	0.778
Beta Phellandrene	973	MS RI	124.30	58.94	2.899	0.075
Beta Pinene	975	MS RI	124.30 **	58.94 **	3.116	0.008
Beta Myrcene	992	MS RI	44.89 *	17.93 *	1.451	0.034
3-Carene	1007	MS RI	141.10 *	51.92 *	2.152	0.054
Alfa Terpinene	1014	MS RI	8.59 **	2.59 **	2.617	0.007
O-Cymene	1023	MS RI	38.42	20.89	6.487	0.072
Limonene	1027	MS RI	146.66	66.15	3.532	0.007
Eucalyptol	1029	MS RI	28.67	22.42	5.749	0.234
Gamma Terpinene	1057	MS RI	23.67	12.23	8.434	0.133
Beta-Terpineol	1065	MS RI	5.53	3.66	0.257	0.261
Linalool	1096	MS RI	190.51	127.34	4.879	0.146
Camphor	1143	MS RI	16.93	14.45	4.630	0.564
Terpinen-4-ol	1179	MS RI	14.94	11.42	3.780	0.312
2,6 -Dimethoxytoluene	1242	MS RI	1.01	2.14	0.322	0.440
Eugenol	1356	MS RI	8.17 *	3.78 *	0.313	0.043
Caryophyllene	1420	MS RI	6.74	1.25	0.315	0.050

*n = 10; data are reported as total area counts x 10⁻⁵ as mean ± standard error of the means (SEM); RI, Retention Index; MS, Mass Spectra; ST, Standard Values. ** for *P* < 0.01; * for *P* < 0.05.

Table 6. The F value and statistical significance of treatments (CON and AOX), judges (n = 8), replicates (n = 3) and their interaction for each sensory descriptor.

Descriptors	F value					
	Treatments	Judges	Replicates	T x J	T x R	J x R
Red colour	1.18	7.10**	3.06	0.76	0.94	1.83
White colour	0.44	10.26***	0.12	1.03	5.28 *	0.87
Marbling	0.02	6.56 **	1.64	0.67	2.74	0.56
Seasoned aroma	1.20	3.92 ***	1.28	3.44 *	3.59	1.15
Smoky aroma	0.25	5.31**	0.03	1.35	2.34	0.81
Pepper aroma	1.34	7.85 ***	0.46	2.05	1.36	1.84
Sweet	5.3*	11.48 ***	0.16	1.13	1.75	0.93
Salty	8.35 *	10.27 ***	0.70	1.42	2.14	1.23
Seasoned flavor	2.26	11.16 ***	0.25	1.07	0.11	0.71
Smoky flavor	0.01	10.49 ***	3.03	0.32	1.24	1.76
Pepper flavor	0.56	11.56 ***	0.30	0.44	1.06	1.02
Juniper flavor	0.45	34.50 ***	0.08	0.89	0.63	0.76
Tender	0.01	10.65 ***	3.08	1.27	0.10	1.06
Juicy	0.10	3.62 *	1.69	0.83	0.06	0.35
Fibrous	0.91	3.42 *	0.41	0.66	3.74*	0.37

CON, control diet; AOX, antioxidant mixture T x J, treatments * judges; T x R, treatment * replicates; J x R, judges x replicates.

*** for $P < 0.001$; ** for $P < 0.01$; for * $P < 0.05$.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Figure 1. Spider plot of the sensory profile of dry cured ham Speck fed control diet (CON) or diet supplemented with antioxidant mixture (AOX). N=8; * Significant at $P < 0.05$

Figure 2. Data on consumer's test of dry cured ham Speck fed control diet (CON) or diet supplemented with antioxidant mixture (AOX). N=80; * Significant at $P < 0.05$; ** Significant at $P < 0.01$.

For Peer Review

Figure 1. Spider plot of the sensory profile of dry cured ham Speck fed control diet (CON) or diet supplemented with antioxidant mixture (AOX). N=8; * Significant at P < 0.05

238x139mm (96 x 96 DPI)

Figure 2. Data on consumer’s test of dry cured ham Speck fed control diet (CON) or diet supplemented with antioxidant mixture (AOX). N=80; * Significant at P < 0.05; ** Significant at P < 0.01.

32x18mm (800 x 800 DPI)