

Florence, Italy - 1/5 September 2024



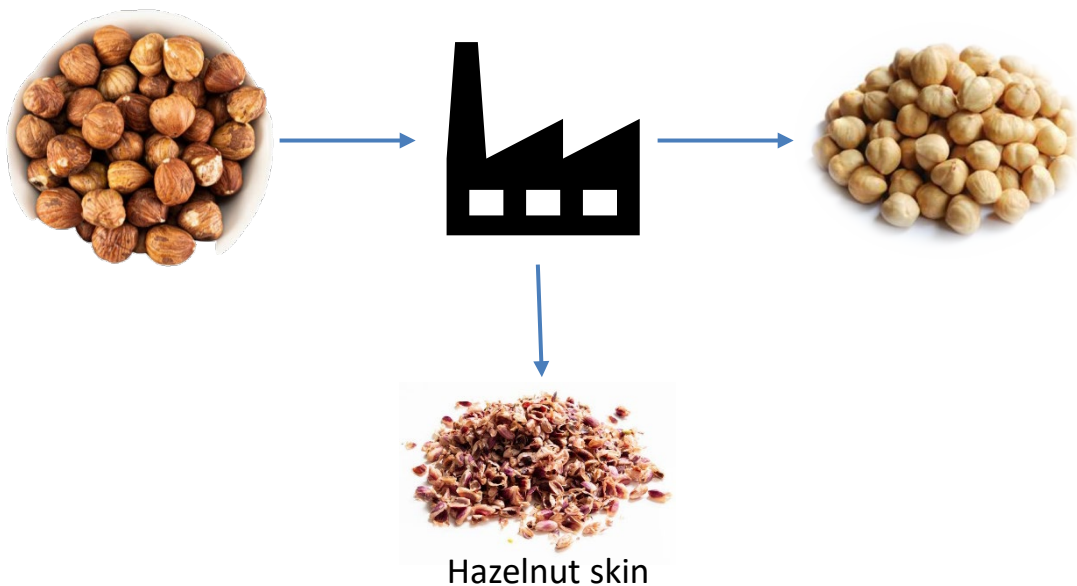
Feeding hazelnut skin and linseed to lambs: effect on meat oxidative stability

Bertino A., Musati M., Luciano G., Cannone M. S., Natalello A., Priolo A.



Introduction

- *Corylus avellana* L.
- 11 % of dried fruit world production
- 585.000 t of production in 2022/2023 (International Nut Council, 2023)
- Hazelnut skin represents 2% of total fruit weight



Hazelnut skin	
<i>Chemical composition, g/kg DM</i>	
DM, g/kg as fed	904
Crude fat	303
Crude protein	102
Ash	24.8
aNDF	355
ADF	268
ADL	146
NFC	263
Total phenols, g TANeq/kg DM	133
Total tannins, g TANeq/kg DM	78.3
<i>Individual fatty acid, g/kg DM</i>	
C14:0	0.17
C16:0	24.8
C18:0	17.5
C18:1 c9	202
C18:2 c9, c12	35.9
C18:3 c9, c12, c15	0.58
<i>Vitamins, ug/g DM</i>	
α-tocopherol	327
γ-tocopherol	347

Introduction

Animal Feed Science and Technology 272 (2021) 114794



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Fatty acid metabolism in lambs fed hazelnut skin as a partial replacer of maize

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Meat Science 202 (2023) 109218



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Meat Science

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Feeding hazelnut skin to lambs delays lipid oxidation in meat

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Dietary inclusion of 15% hazelnut skin in lambs:

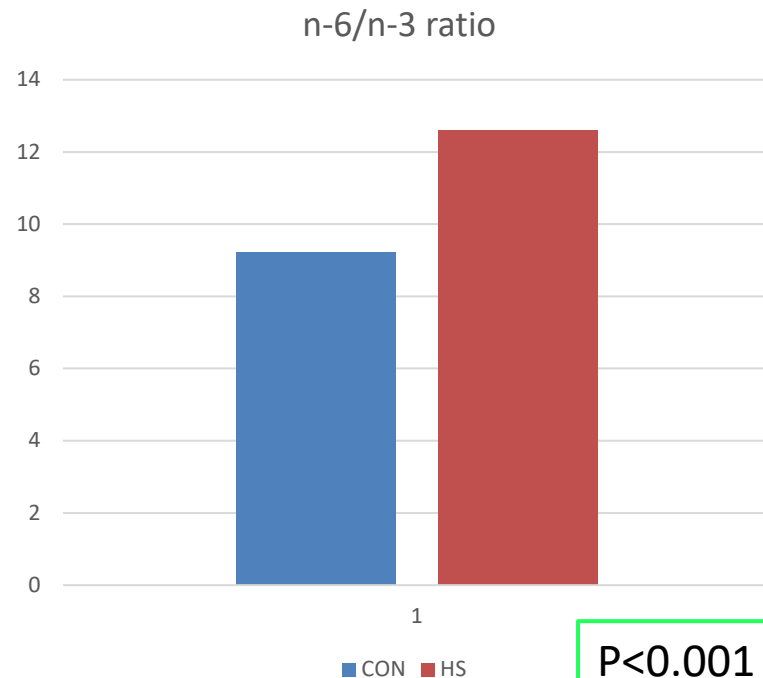
- Did not affect animal performance (BW, DMI, ADG);
- PUFA content > HS group
- α and γ tocopherol content > HS group;
- PUFA n-6/n-3 ratio > HS group;
- No differences were observed in hydrophilic antioxidant capacity (TEAC, FRAP, FOLIN assays).

Priolo et al. (2021), Menci et al. (2023)

Health guidelines

Simopoulos A. P., (2006)

$$\frac{\omega-6}{\omega-3} < 4$$



Introduction

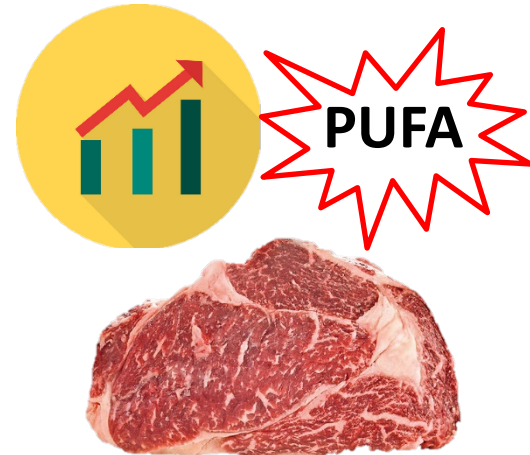
Linseed



- PUFA source



- Inclusion in animal feeds

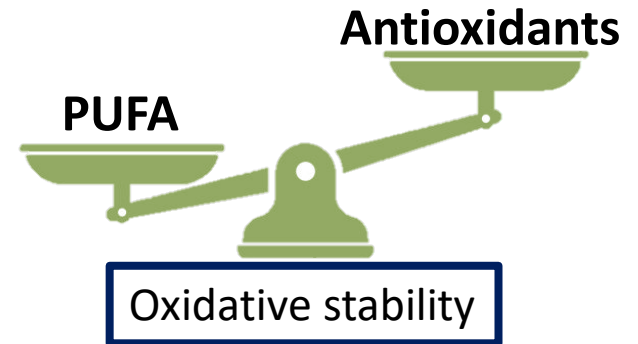


Mele et al. (2014)

Introduction

PUFA = Highly sensitive to oxidation

Quality and shelf-life



Aim of the study



Hazelnut skin
(Antioxidants source)



Linseed
(Omega-3 source)



● FA composition

● Antioxidant content

● Antioxidant capacity

● Lipid oxidation

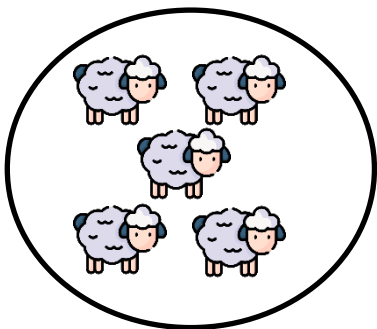
● Colour stability

Materials and methods

Experimental diets

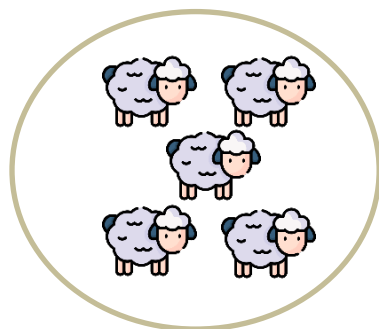
40 Valle del Belice × Comisana male lambs:

CON



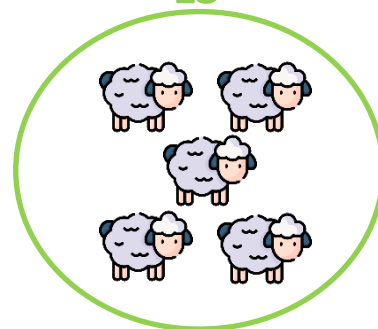
Control (CON), maize-barley based concentrate diet

HS



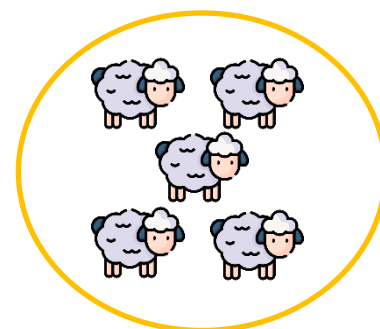
Hazelnut skin (HS), CON diet with 15% of hazelnut skin as partial replacement of maize

LS



Linseeds (LS), CON diet with 8% extruded linseed as partial replacement of maize and soybean meal

H+L

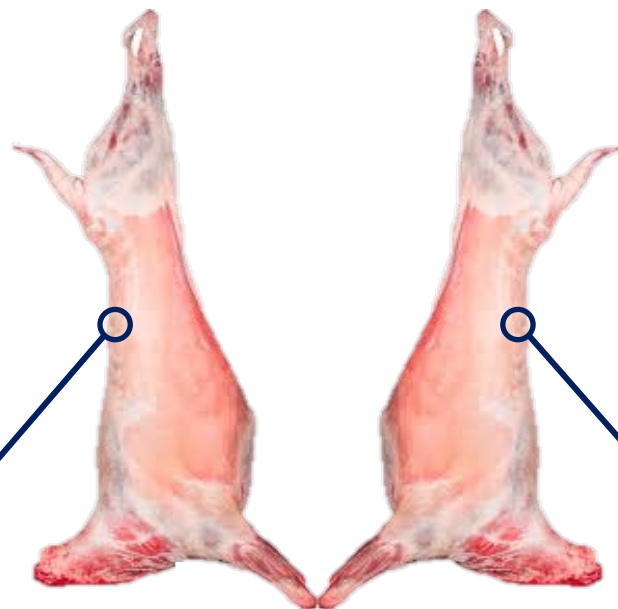


Hazelnut and linseed in combination (H+L), CON diet with 7.5% of hazelnut skin and 4% of extruded linseed as partial replacement of maize

Materials and methods

Experimental diets

- Trial duration: 60 days
- *Longissimus thoracis et lumborum* (LTL) was collected



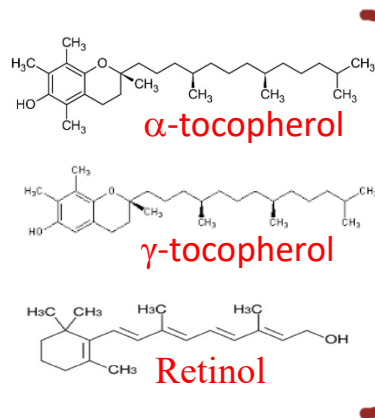
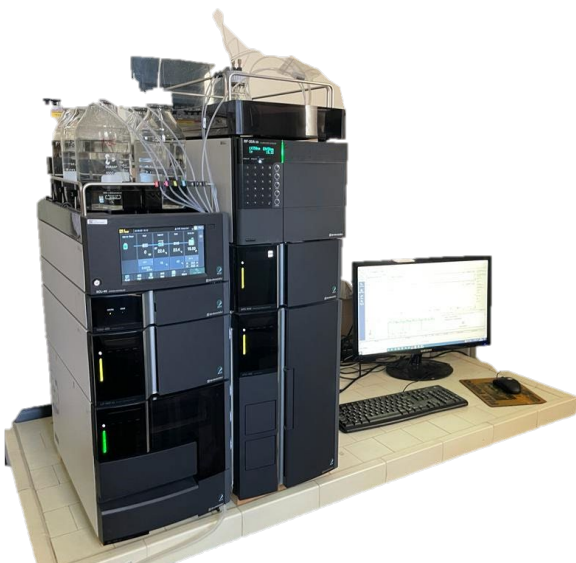
- ☐ Colour measurements
- ☐ Lipid oxidation analysis

- ☐ Fatty acids profile
- ☐ Lipophilic vitamins
- ☐ Hydrophilic antioxidant capacity

Materials and methods

FA profile and Vitamins

- Intramuscular fat was extracted according to Folch et al. (1957)
- FA methyl esters (FAME) profile was determined by a GC-FID

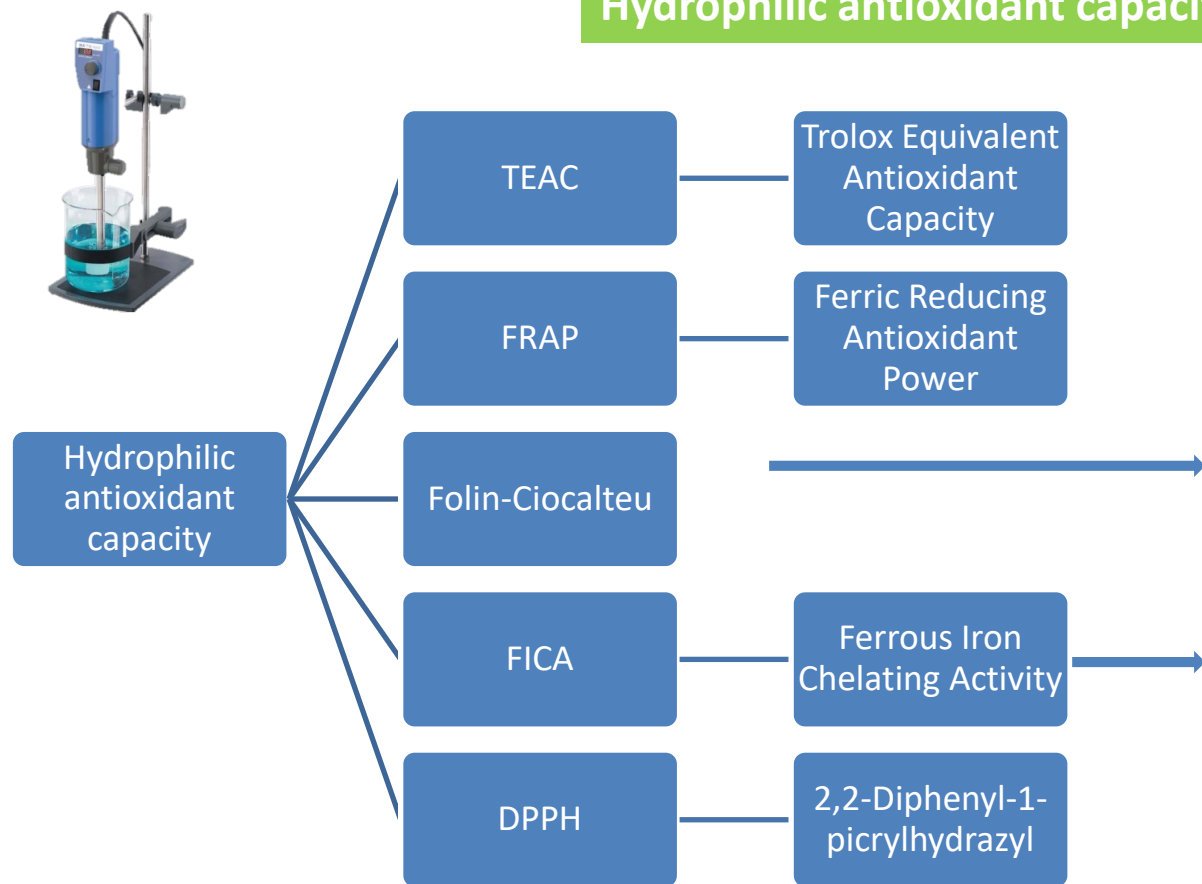


Bertolín et al. (2018)



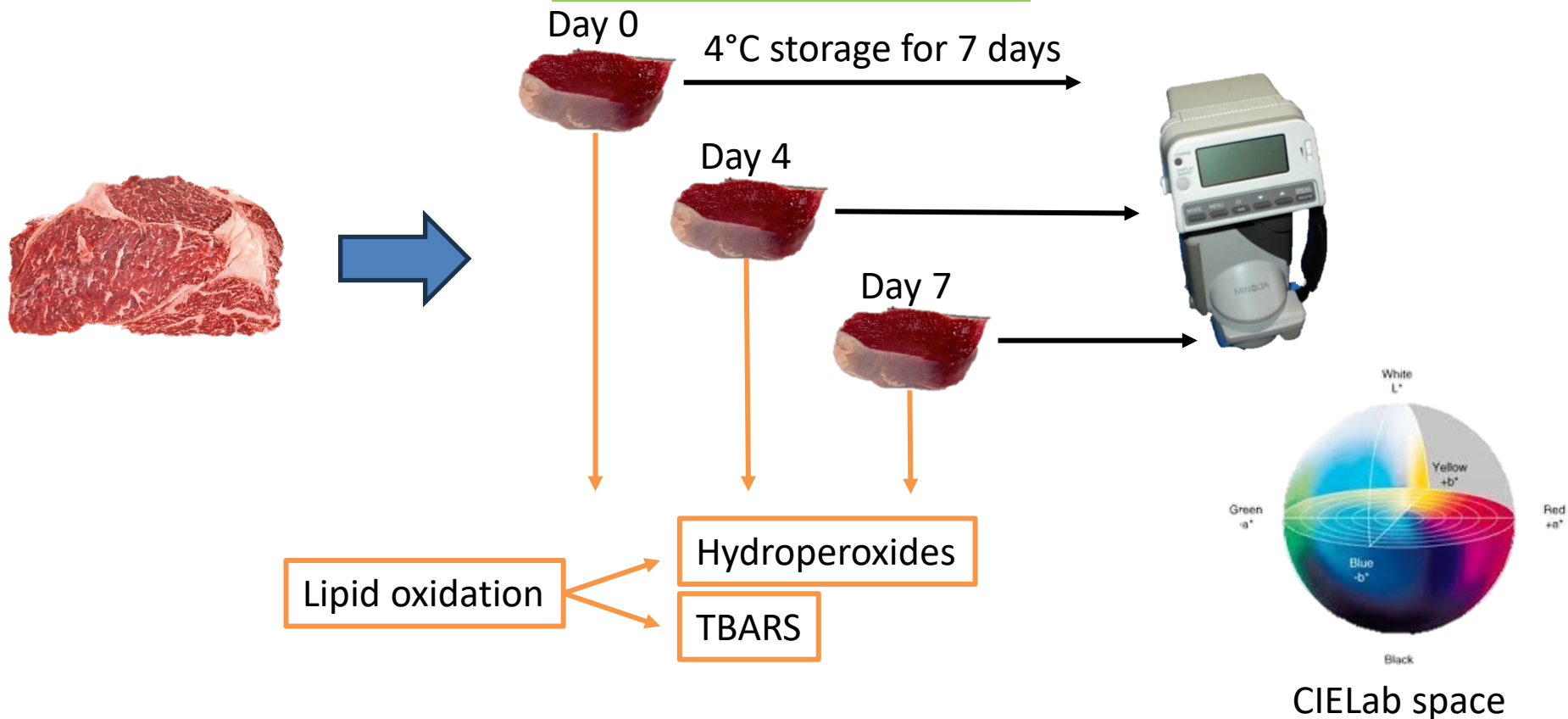
Materials and methods

Hydrophilic antioxidant capacity



Materials and methods

Colour and Lipid oxidation



Results

Experimental diets

Effect of dietary treatment on animal performance.

	Experimental diets ¹				SED	<i>P</i> -value
	C	HS	LS	H+L		
Final BW (kg)	30.9	28.5	31.4	29.9	2.13	0.555
Carcass weight (kg)	14.1	13.1	14.4	14.3	1.19	0.691
ADG (g/d)	227	193	237	214	24.8	0.323
FCR	4.3	5.17	4.07	5.03	0.531	0.118
DMI (g/d)	831	862	852	893	77.4	0.87

¹C: Control diet; HS: Hazelnut skin diet; LS: Linseed diet; H+L: Hazelnut skin + Linseed diet.

Results

FA profile

Effect of dietary treatment on the intramuscular fat of meat.

	Experimental diets ¹				SED	P-value
	C	HS	LS	H+L		
Intramuscular fat (g/100g meat)	2.4	1.91	2.41	2.42	0.251	0.124
<i>Fatty acid (mg/100 g meat)</i>						
Saturated	679 ^{ab}	<u>511^b</u>	667 ^{ab}	<u>783^a</u>	93.9	<u>0.043</u>
Monounsaturated	797	599	796	873	110.25	0.087
Polyunsaturated	<u>142^b</u>	<u>146^b</u>	159 ^{ab}	192 ^a	13.7	<u>0.003</u>
n-6 PUFA	122 ^{ab}	127 ^{ab}	<u>105^b</u>	<u>138^a</u>	9.53	0.014
n-3 PUFA	<u>14.8^b</u>	<u>14.1^b</u>	<u>47.3^a</u>	<u>45.2^a</u>	4.29	<0.001
n-6/n-3 Ratio	8.30 ^a	9.21 ^a	2.24 ^b	3.14 ^b	0.454	<u>< 0.001</u>

¹C: Control diet; HS: Hazelnut skin diet; LS: linseed diet; H+L: Hazelnut skin + Linseed diet.

Results

Vitamins

Effect of dietary treatment on the vitamins content of meat.

	Experimental diets ¹				SED	<i>P-value</i>
	C	HS	LS	H+L		
<i>Fat-soluble vitamins (mg/kg)</i>						
Total tocopherols	<u>0.746^b</u>	<u>1.76^a</u>	<u>0.830^b</u>	<u>1.34^a</u>	0.185	<0.001
α-tocopherol (%)	89.7 ^a	81.3 ^b	78.4 ^b	77.7 ^b	2.35	<0.001
γ-tocopherol (%)	10.3 ^b	18.7 ^a	21.6 ^a	22.4 ^a	2.35	<0.001
Retinol	0.067	0.057	0.065	0.055	0.006	0.143

¹C: Control diet; HS: Hazelnut skin diet; LS: linseed diet; H+L: Hazelnut skin + Linseed diet.

Results

Hydrophilic antioxidant capacity

Effect of dietary treatment on the antioxidant capacity of meat.

	Experimental diets ¹				SED	P-value
	C	HS	LS	H+L		
<i>Antioxidant capacity (mg/g)</i>						
TEAC (Trolox eq)	64.1	58.1	67.9	62.9	4.3	0.162
FRAP (Fe ²⁺ eq)	20.7	19.8	22	20.3	0.99	0.178
Folin-Ciocalteu (TA eq)	0.295	0.286	0.307	0.29	0.009	0.111
FICA (EDTA eq)	0.767	0.795	0.751	0.767	0.032	0.574
DPPH (Trolox eq)	0.707	0.661	0.751	0.734	0.040	0.105

¹C: Control diet; HS: Hazelnut skin diet; LS: linseed diet; H+L: Hazelnut skin + Linseed diet.

Results

Colour

Effect of dietary treatment on colour stability in lamb over 7 days of refrigerated storage.

	Experimental diets (D) ¹				Time (T), d			SED	<i>P-value</i>	
	C	HS	LS	H+L	0	4	7		D	T
<i>Colour stability</i>										
L * (lightness)	45.7	44.8	44.9	44.3	44.4 ^y	45.6 ^x	44.7 ^y	1.17	0.691	0.001
a * (redness)	15.3	14.4	14.8	14.5	<u>16.7^x</u>	<u>15.0^y</u>	<u>12.6^z</u>	0.401	0.106	<0.001
b * (yellowness)	13.5	12.8	12.7	12.5	<u>13.3^x</u>	<u>13.2^x</u>	<u>12.2^y</u>	0.49	0.235	0.001
C (saturation)	20.5	19.3	19.5	19.2	<u>21.4^x</u>	<u>19.9^y</u>	<u>17.6^z</u>	0.61	0.165	<0.001
h _{ab} (Hue angle; deg)	41.5	41.7	40.7	40.9	<u>38.2^z</u>	<u>41.3^y</u>	<u>44.1^x</u>	0.531	0.211	<0.001
Metmyoglobin (%)	49.2	49.5	48.5	48.6	<u>45.7^z</u>	<u>48.8^y</u>	<u>52.3^x</u>	0.825	0.562	<0.001

¹C: Control diet; HS: Hazelnut skin diet; LS: linseed diet; H+L: Hazelnut skin + Linseed diet.

Results

Lipid oxidation

Effect of dietary treatment on lipid oxidation in lamb over 7 days of refrigerated storage.

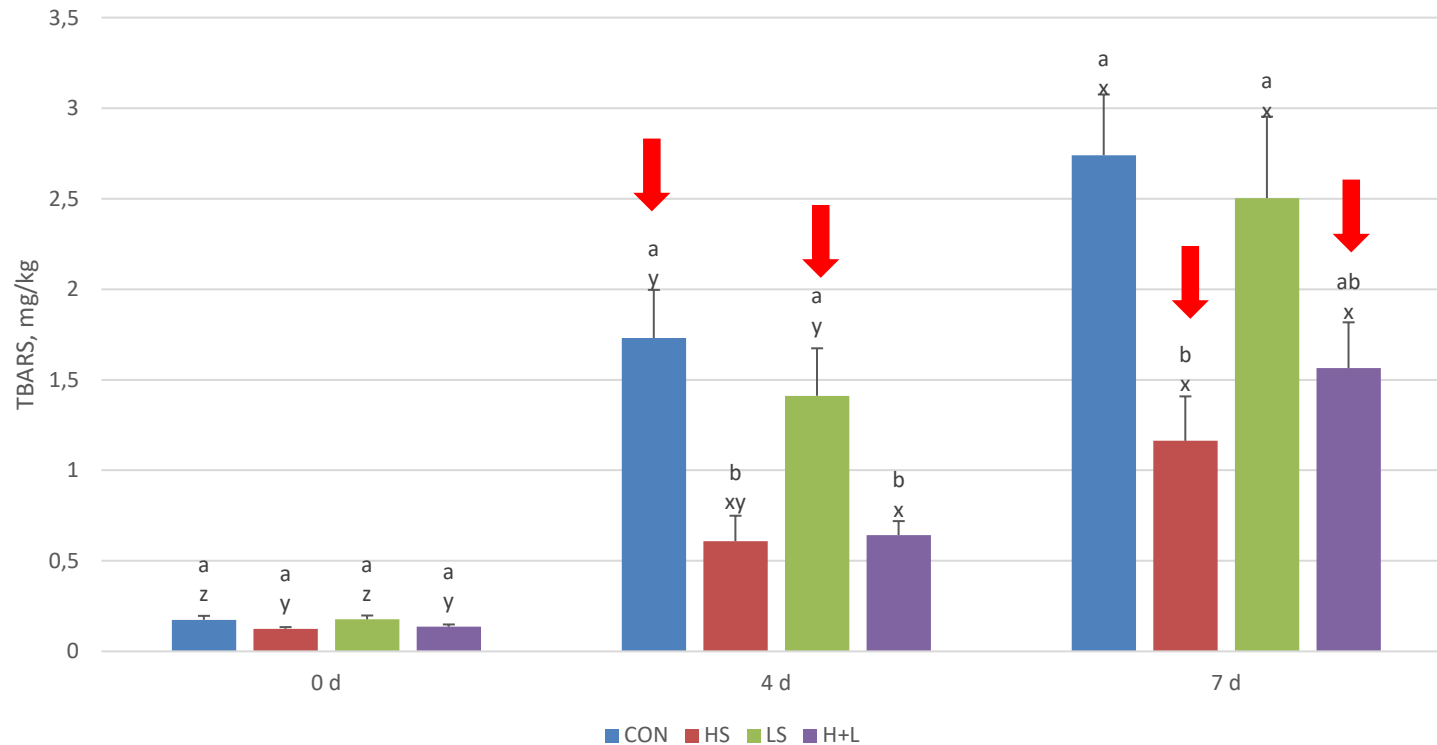
	Experimental diets (D) ¹				Time (T), d			SED	<i>P</i> -value		
	C	HS	LS	H+L	0	4	7		D	T	D×T
<i>Lipid oxidation, mg/kg meat</i>											
Hydroperoxide	3.77	3.56	3.3	3.61	3.56	3.87	3.25	0.531	0.845	0.135	0.87
TBARS	1.55 ^a	0.632 ^c	1.36 ^{ab}	0.781 ^{bc}	0.153 ^z	1.10 ^y	1.99 ^x	0.239	0.001	<0.001	<0.001

¹C: Control diet; HS: Hazelnut skin diet; LS: linseed diet; H+L: Hazelnut skin + Linseed diet.

Results

Lipid oxidation

Interaction between diet and storage time on TBARS (mg/kg) development in lambs



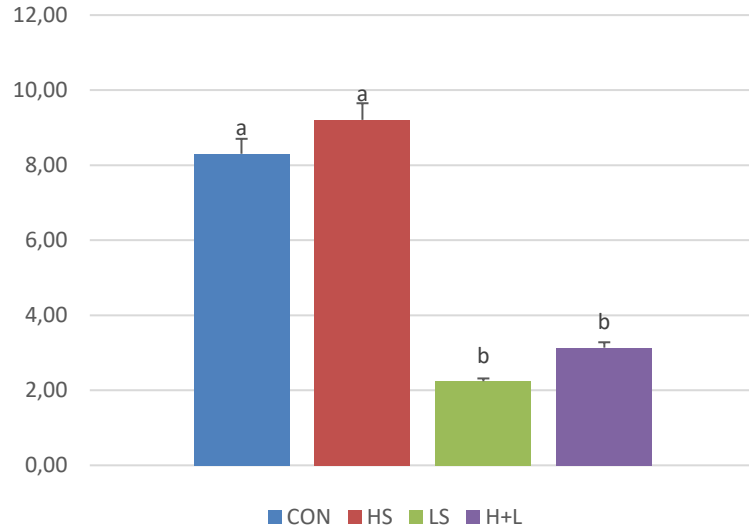
a, b Within each day of storage, different superscripts indicate differences between dietary treatments ($P \leq 0.05$).

x, y, z Within each dietary treatment, different superscripts indicate differences between days of storage ($P \leq 0.05$).

Conclusion

The combined inclusion of 7.5% of hazelnut skin and 4% of extruded linseed in lambs' diet:

n-6/n-3 ratio



- Decreased ω -6/ ω -3 PUFA ratio improving FA profile
- Increased the resistance of meat to lipid oxidation
- Did not affect the growth performance
- Did not affect the meat colour

Florence, Italy - 1/5 September 2024

Thank you for the attention



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Experimental diets composition

	Experimental diets			
	CON	HS	LS	H+L
Ingredients, g/100 g FM				
Maize	26	11	21	14.5
Barley	26	26	26	26
Soybean meal	16	16	13	16
Alfalfa hay	20	20	20	20
Wheat bran	7	7	7	7
Molasses	3	3	3	3
Mineral mix	2	2	2	2
Hazelnut skins	0	15	0	7.5
Extruded linseeds	0	0	8	4