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By-products for small ruminants: benefits and limitations

Anna Nudda, S. Carta, M.F. Caratzu, F. Correddu, G. Battacone, M. Lunesu, G. Pulina

Dipartimento di Agraria
University of Sassari
Sassari, Italy

Anna Nudda
anudda@uniss.it

Agro-industrial by-products

- Agriculture produces an average of 23.7 million food tons/day worldwide (FAO, 2017).
- The percentage of food lost globally after harvest on farm, transport, storage, wholesale, and processing levels was estimated at 13.2% = 1.3 billion tons/year (FAO, 2023)
- Total amount of agro-industrial by-products produced:
    - Worldwide is about **468 millions tons**
    - European Union is around **30 million tons**

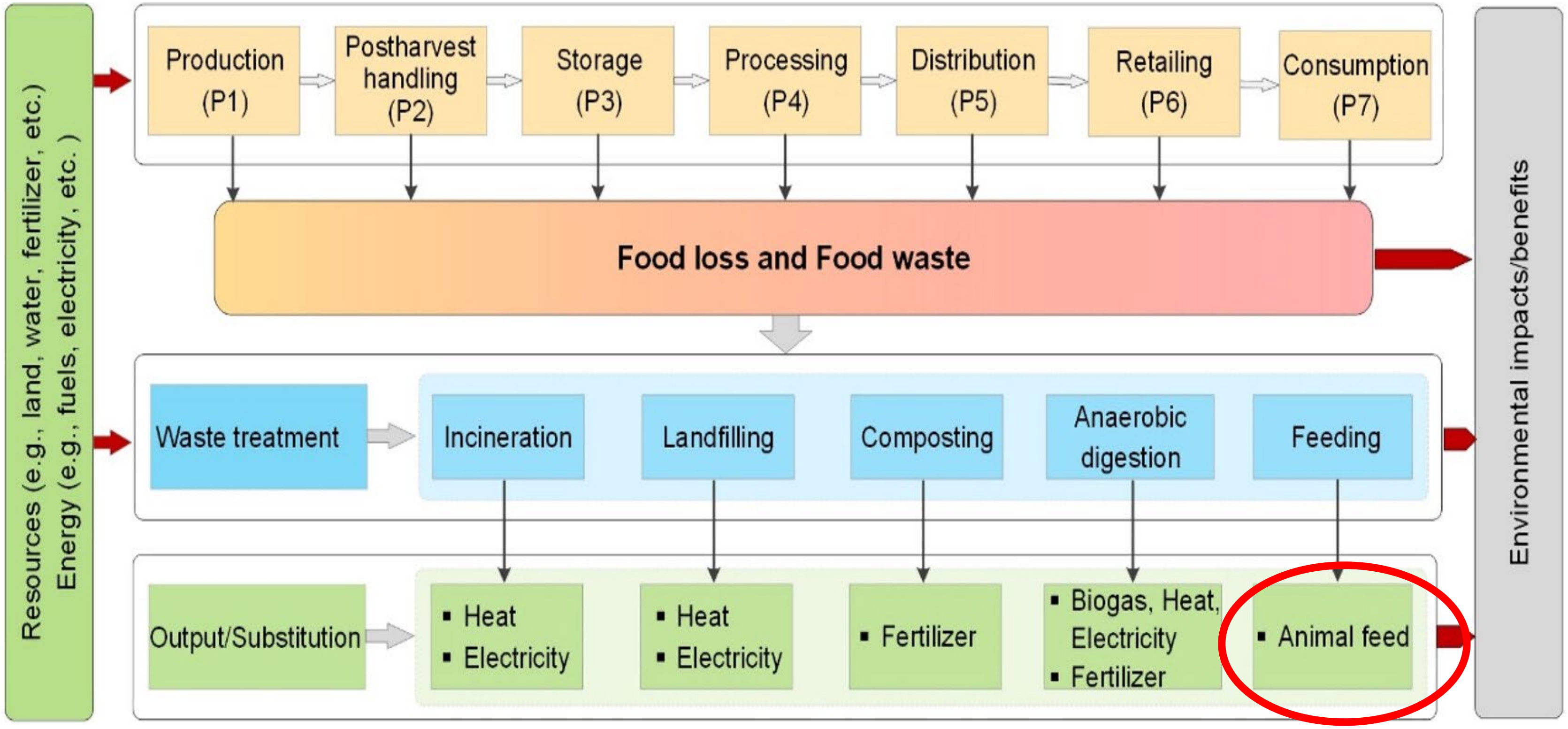
✓ Germany, Italy, France, Spain (top producers)

Management of non-human-edible biomass generated along the food chain represents a key element to mitigate environmental impact (air and water pollution, greenhouse gas emissions)

https://openknowledge.fao.org/server/api/core/bitstreams/2c3e67a7-72b4-45a3-9814-96575e4df247/content

One of the priority objectives of the Common Agricultural Policy is the Improve the circular economy to ensure that the fraction of food that could not be consumed by humans is properly recycled and re-used for energy, or in other industries and to produce feedstuffs

Food loss and waste (FLW) generation along the supply chain and associated resource use and environmental impacts (benefits) of FLW treatment.



Li Xue et al. 2024 - Environ. Sci. Technol. 2024, 58, 17, 7240–7255

https://pubs.acs.org/doi/10.1021/acs.est.3c08426?fig=fig1&ref=pdf

DOI: (10.1021/acs.est.3c08426)

Conventional (the most used) agro-industrial byproducts

By-product	Chemical composition (g/kg DM)						
	DM	**NDF**	**ADF**	**CP**	**Lignin**	**EE**	**Ash**
Barley straw	940	672	353	43	41	11	86
Beet pulp	921	488	296	89	37	0.4	47
Cottonseed hulls	895	878	664	61	224	-	27
Soybean hulls	913	621	468	140	74	22	63
Corn gluten feed	-	441	107	235	-	39	57
Linseed meal	939	231	199	248	86	270	73
Extruded linseed	927	546	361	224	25	345	45
Sunflower meal	959	356	268	355	80	18	75
Soybean meal	880	139	87	502	30	23	66
Cottonseed meal	934	248	200	431	65	16	65

Non-conventional byproducts

Chemical composition of Grape, Pomegranate, Olive, Tomato, Cocoa, Coffee, Citrus byproducts







	Grape		Pomegranate		Olive		Tomato		Cocoa		Spent coffee ground		Citrus	
	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max
By-product from processes, %	22	20-25	55.3	49.0-67.0	42.5	35-60	5	4-7.5	72.5	70-75	65		59	49-69
Moisture, %	71.2	63.0-81.7	-		44.4	32.0-60.0	87.7	78.4-97.0	80.2	-	57.6		79.8	76.7-81.9
Chemical composition														
Dry matter, % as fed	92.0	88.6-95.0	94.0	91.2-96.1	85.7	77.5-94.7	92.7	90.3-95.2	90.6	89.5-92.9	91.3		90.7	90.2-92.1
Protein, % DM	12.0	8.8-16.3	8.9	3.6-15.4	8.0	7.2-9.2	17.2	15.7-19.1	13.7	6.7-17.3	14.0	10.1-16.9	7.0	5.8-8.7
Fat, % DM	6.6	3.9-11.4	4.3	0.6-13.4	10.4	5.4-16.5	9.3	6.2-11.0	7.3	2.0-20.4	17	9.3-29.20	2.7	1.2-4.0
NDF, % DM	42.4	37.4-53.9	40.4	20.8-68.0	61.7	58.4-64.1	58.4	55.2-61.6	49.3	33-68.6	65.1	55.5-73	20.7	12.3-33.0
ADF, % DM	36.6	30.6-49.2	29.2	15.1-49.0	51.0	45.9-54.4	48.5	46.2-50.7	35.1	13.7-64.6	40.6	33.1-48	14.8	9.6-23.1
Ash, % DM	7.7	2.1-12.1	3.8	2.4-5.4	9.6	3.7-13.6	4.1	43.1-4.8	7.4	4.6-9.2	3.5	0.27-5.6	4.7	2.8-5.9
Total polyphenol, g/kg DM	35.9	3-90	52.8	27.2-95.3	10.9	4.1-17.7	4.9	2.3-6.4	28.9	9.1-43.9	12.5	10-15	10.6	2.1-57.7
Main fatty acids (% on total FA)														
Palmitic acid	9.6	5.5-12.5	3.8	3.5-4.2	13.1	9.1-17.5	13.9	11.5-15.6	24.5	22.4-26.8	33.0	31.8-33.8	24.5	17.7-29.4
Stearic acid	4.3	2.8-4.9	2.4	1.9-2.8	5.5	2.1-13.1	4.2	3.1-4.9	25.7	23.9-27.3	7.5	7.2-8.0	4.9	3.6-7.8
Oleic acid	15.2	9.6- 19.2	7.2	5.4-9.2	65.5	54.3-75.8	19.7	17.6-20.7	34.5	30.2-39.0	10.9	9.1-12.7	21	17.1-26.7
Linoleic acid	66.9	61.1-74.0	7.1	5.9-8.1	9.9	6.6-13.8	54.8	52.2-57.1	8.4	8.4-8.5	43.3	43-43.8	31.8	29.8-33.9
Alpha linolenic acid	1.4	0.2-3.7	0.2	0.1-0.4	0.9	0.3-1.46	2.9	2.6-3.2	0.6	0.5-0.7	1.1	0.8-1.5	5.7	2.6-8.2
Punicic acid	-		73.8	71.2-77.2	-		-		-		-			

Non-conventional byproducts recycle in animal nutrition






Advantages

- reduce the disposal cost
- positive effects on environmental impacts
- allows the recovery of nutrients at low/zero cost
- reduction of animal feeding cost
- contain bioactive compounds (that could be beneficial to animals)

Limitations

- high humidity
- high variability in nutrient contents
- local production
- seasonal availability
- high transport cost

Non-conventional byproducts

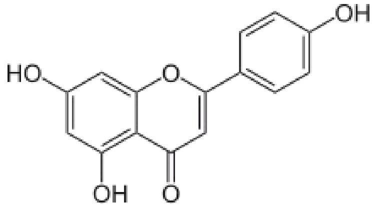






- **Grape** *(Winkler et al., 2015; Correddu et al., 2015; Guerra-Rivas et al., 2017; Nudda et al., 2019; Alba et al., 2019;)*
- **Tomato** *(Valdez-Morales et al., 2014; Silva-Beltrán et al., 2015; Nudda et al., 2019)*
- **Citrus** (Rodríguez-Rivera et al., 2014; *Pereira-Caro et al., 2015; Todaro et al., 2017; Liotta et al., 2019*)
- **Olive** *(Peng et al., 2015; Seiquer et al., 2015)*
- **Apple** *(Gogia et al., 2015; Koutsos et al., 2015)*
- **Myrtle** (Nudda et al., 2019; Correddu et al. 2017; 2019)
- **Coffee** (Carta et al., 2022; Díaz de Otálora et al., 2020)
- …

Bioactive compounds
Polyphenols

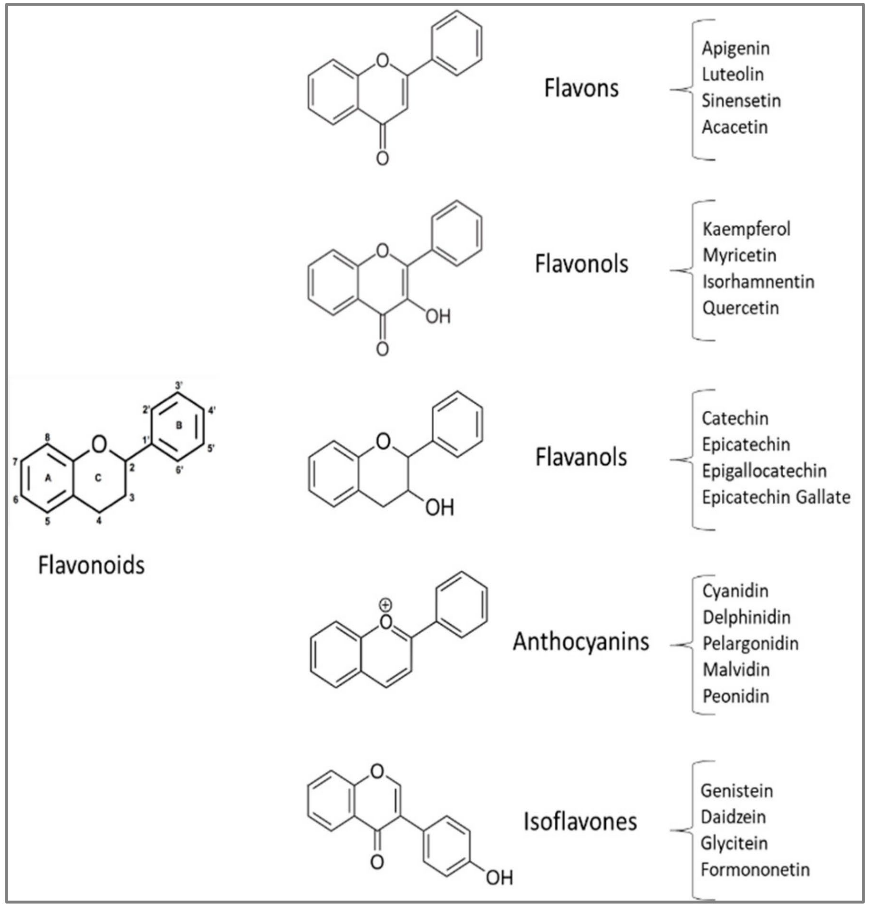


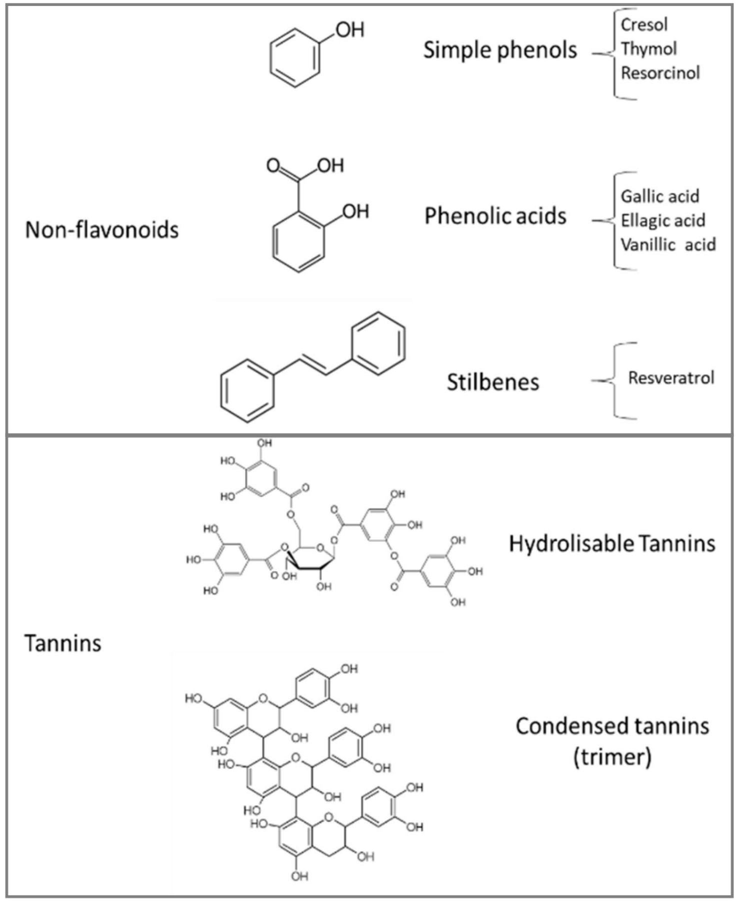
animals
MDPI
Review
Can Agro-Industrial By-Products Rich in Polyphenols be Advantageously Used in the Feeding and Nutrition of Dairy Small Ruminants?

Fabio Correddu *, Mondina Francesca Lunesu, Giovanna Buffa, Alberto Stanislao Atzori, Anna Nudda, Gianni Battacone and Giuseppe Pulina

Non-conventional byproducts

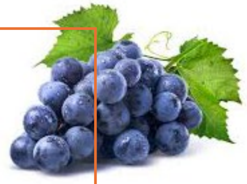
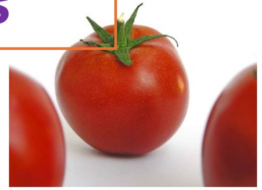
Main classes of polyphenols: flavonoids, non-flavonoids, and tannins.







Bioactive compounds
Polyphenols

Polyphenols and human health

Int. J. Mol.

ASN
American Society for Nutrition

Advances in Nutrition
AN INTERNATIONAL REVIEW JOURNAL
journal homepage: www.journals.elsevier.com/advances-in-nutrition

Review

Efficacy of Dietary Polyphenols from Whole Foods and Purified Food Polyphenol Extracts in Optimizing Cardiometabolic Health: A

Review

Polyphenols from Cocoa and Vascular Health—A Critical Review

Food Chemistry 299 (2019) 125124

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

ELSEVIER

FOOD CHEMISTRY

Review

Anti-inflammatory effects of flavonoids

Plant Foods for Human Nutrition (2022) 77:427–435
https://doi.org/10.1007/s11130-022-00983-2

ORIGINAL PAPER

Check for updates

Antioxidant and Antimicrobial Properties of Selected Fruit Juices

Review

Polyphenols and Their Impact on the Prevention of Neurodegenerative Diseases and Development

ELSEVIER

Available online at www.sciencedirect.com

SciVerse ScienceDirect

Journal of Nutritional Biochemistry 24 (2013) 1415–1422

Journal of Nutritional Biochemistry

REVIEWS: CURRENT TOPICS

Benefits of polyphenols on gut microbiota and implications in human health

Review > Curr Med Chem. 2012;19(11):1706-20. doi: 10.2174/092986712799945012

Plant polyphenols and oral health: old phytochemicals for new fields

F M Varoni [1], G Lodi, A Sardella, A Carrassi, M Iriti

molecules

Review

Polyphenols and Visual Health: Potential Effects on Degenerative Retinal Diseases

Pol Fernandez-Gonzalez †, Aina Mas-Sanchez † and Pere Garriga *

Review

Polyphenols and Their Effects on Muscle Atrophy and Muscle Health

Takeshi Nikawa *, Anayt Ulla and Iori Sakakibara

POLYPHENOLS IN RUMINANT DIETS

- Parasites (Athanasiadou et al., 2000; Zhong et al., 2014; Váradyová et al., 2018; Poli et al., 2018; Poli et al., 2021)
- Immune system (Min et al., 2005; Nudda et al., 2015; Buffa et al., 2020; Jaiswal et al., 2020; Singh et al. 2021; Xu et al. 2024)
- Biohydrogenation process (Cabiddu et al., 2009; Vasta et al., 2009; Guerreiro et al., 2021; Frutos et al., 2020)
- Rumen NH_3 production (Bhatta et al., 2009; Theodoridou et al., 2010; Correddu et al., 2015)
- CH_4 emissions (Dschaak et al., 2011; Liu et al., 2011; Carta et al., 2024)
- Milk production traits (Hymes-Fecht et al., 2013; Nudda et al., 2017; Hilario et al., 2010; Liu et al., 2013; Correddu et al., 2016;)
- Milk fatty acid profile (Turner et al., 2005; Toral et al., 2013; Abarghuei et al., 2014; Carta et al., 2024)
- Sensory properties (Caccamo et al., 2024)

The effects of polyphenols could change depending on source of polyphenols, dose, the physiological stage of the animal, etc.

Topics that will presented

Characteristics of some non conventional agro-industrial BP containing polyphenols

- ✓ Grape, Olive, Pomegranate, Tomato, Coffee, Cocoa, Citrus

Effects of BP inclusion in diets of dairy sheep and goats on:

- ✓ Milk production traits
- ✓ Milk FA profile
- ✓ Oxidative status of animals and milk
- ✓ Somatic cell count
- ✓ …

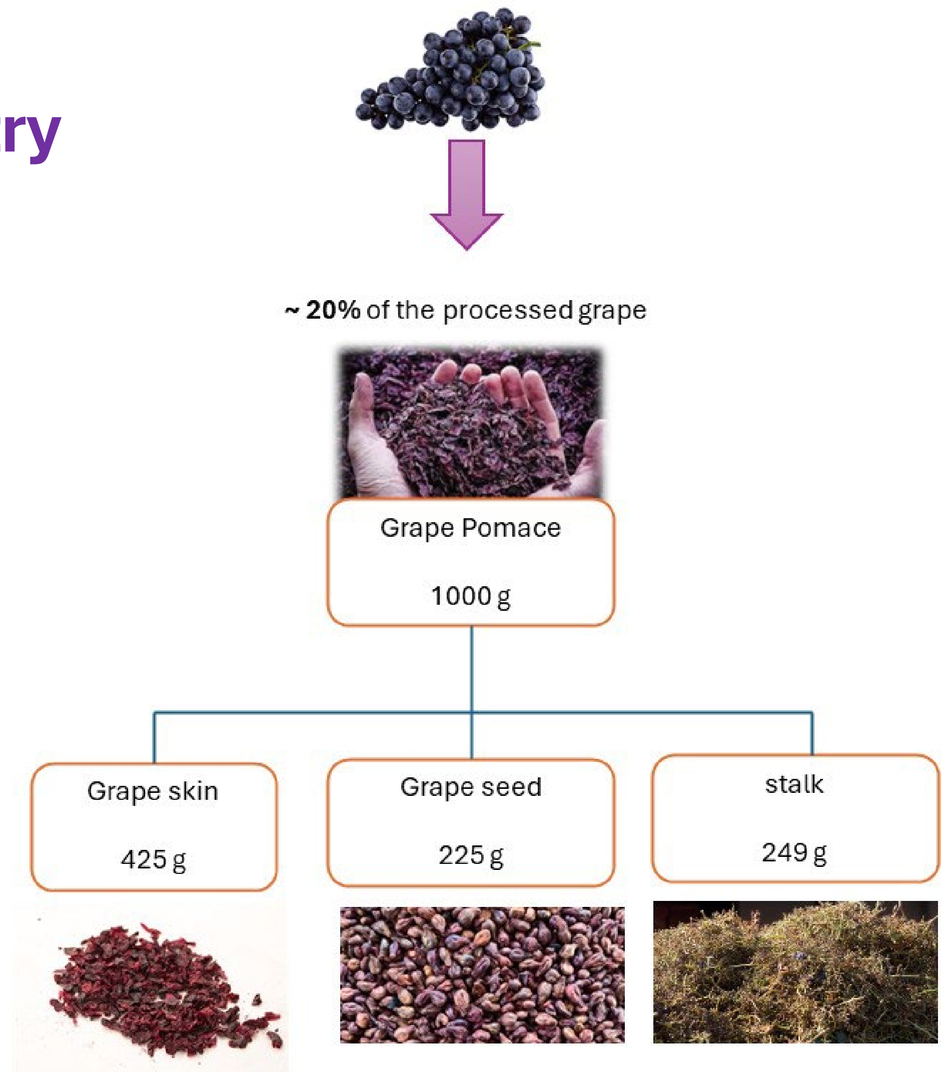
Final remarks

1. Grape pomace by-product of wine industry

Primary product (agroindustrial by-product)	Grape (grape pomace) *tons*
Primary product (tons)*	25,669,000
AIBP (%) from processing **	21%
AIBP, tons (FM)	**5,390,490**
AIBP, tons (DM)	1,563,242
Available protein (tons)	184,968
Available NDF (tons)	677,646

* FAOSTAT, 2022 (data for EU27); ** literature available;

Correddu et al. 2022 (EAAP Portugal)



Non-conventional byproducts: GRAPE

Chemical composition of Grape, Pomegranate, Olive, Tomato, Cocoa, Coffee, Citrus byproducts







	Grape		Pomegranate		Olive		Tomato		Cocoa		Spent coffee ground		Citrus	
	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max
By-product from processes, %	**22**	20-25	55.3	49.0-67.0	42.5	35-60	5	4-7.5	72.5	70-75	65		59	49-69
Moisture, %	**71.2**	63.0-81.7	-		44.4	32.0-60.0	87.7	78.4-97.0	80.2	-	57.6		79.8	76.7-81.9
Chemical composition														
Dry matter, % as fed	**92.0**	88.6-95.0	94.0	91.2-96.1	85.7	77.5-94.7	92.7	90.3-95.2	90.6	89.5-92.9	91.3		90.7	90.2-92.1
Protein, % DM	**12.0**	8.8-16.3	8.9	3.6-15.4	8.0	7.2-9.2	17.2	15.7-19.1	13.7	6.7-17.3	14.0	10.1-16.9	7.0	5.8-8.7
Fat, % DM	**6.6**	3.9-11.4	4.3	0.6-13.4	10.4	5.4-16.5	9.3	6.2-11.0	7.3	2.0-20.4	17	9.3-29.20	2.7	1.2-4.0
NDF, % DM	**42.4**	37.4-53.9	40.4	20.8-68.0	61.7	58.4-64.1	58.4	55.2-61.6	49.3	33-68.6	65.1	55.5-73	20.7	12.3-33.0
ADF, % DM	**36.6**	30.6-49.2	29.2	15.1-49.0	51.0	45.9-54.4	48.5	46.2-50.7	35.1	13.7-64.6	40.6	33.1-48	14.8	9.6-23.1
Ash, % DM	**7.7**	2.1-12.1	3.8	2.4-5.4	9.6	3.7-13.6	4.1	43.1-4.8	7.4	4.6-9.2	3.5	0.27-5.6	4.7	2.8-5.9
Total polyphenol, g/kg DM	**35.9**	3-90	52.8	27.2-95.3	10.9	4.1-17.7	4.9	2.3-6.4	28.9	9.1-43.9	12.5	10-15	10.6	2.1-57.7
Main fatty acids (% on total FA)														
Palmitic acid	**9.6**	5.5-12.5	3.8	3.5-4.2	13.1	9.1-17.5	13.9	11.5-15.6	24.5	22.4-26.8	33.0	31.8-33.8	24.5	17.7-29.4
Stearic acid	**4.3**	2.8-4.9	2.4	1.9-2.8	5.5	2.1-13.1	4.2	3.1-4.9	25.7	23.9-27.3	7.5	7.2-8.0	4.9	3.6-7.8
Oleic acid	**15.2**	9.6- 19.2	7.2	5.4-9.2	65.5	54.3-75.8	19.7	17.6-20.7	34.5	30.2-39.0	10.9	9.1-12.7	21	17.1-26.7
Linoleic acid	**66.9**	61.1-74.0	7.1	5.9-8.1	9.9	6.6-13.8	54.8	52.2-57.1	8.4	8.4-8.5	43.3	43-43.8	31.8	29.8-33.9
Alpha linolenic acid	**1.4**	0.2-3.7	0.2	0.1-0.4	0.9	0.3-1.46	2.9	2.6-3.2	0.6	0.5-0.7	1.1	0.8-1.5	5.7	2.6-8.2
Punicic acid	**-**		73.8	71.2-77.2	-		-		-		-			

Polyphenols in grape pomace

	Mean	min-max
Total polyphenol, g/kg DM	35.9	3–90

Polyphenol, mg/kg of DM	Means	± SD
Catechin [a]	**122.05**	**15.86**
Gallic acid[a]	**112.21**	**16.48**
Quercetin[b]	70.89	0.73
Syringic acid [a]	42.59	4.06
Vanillic acid [a]	17.33	0.16
Isorhamnetin[b]	13.86	1.82
Kampferol[b]	9.97	0.91
Malvidin-3-*O*-glucoside[c]	49.62	11.49
Petunidin-3-*O*-glucoside[c]	28.84	3.50
Peonidin-3-*O*-glucoside[c]	21.02	4.53
Delfidin-3-*O*-acetilglucoside[c]	4.64	0.74
Cyanidin-3-p-coumaroylglucoside[c]	4.58	0.54
Malvidin-3-*O*-acetiglucoside[c]	4.36	1.42
Peonidin-3-p-coumaroylglucoside[c]	**201.91**	**32.82**
Petunidin-3-p-coumaroylglucoside[c]	55.90	16.91
Malvidin-3-p-coumaroylglucoside[c]	52.90	18.69

flavanols

Phenolic acid

antocyanins

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

Small amounts of agro-industrial byproducts in dairy ewes diets affects milk production traits and hematological parameters

A. Nudda[a,*], G. Buffa[a], A.S. Atzori[a], M.G. Cappai[b], P. Caboni[c], G. Fais[c], G. Pulina[a]

Major FA (g/100 g of total FA)	
C12:0	0.24
C16:0	12.1
C18:0	5.44
C18:1*cis*-9	17.6
C18:1*cis*-11	0.82
C18:2 *n*-6	50.6
C20:0	0.67
C18:3 *n*-3	1.56

C18:2 cis-9 cis-12 is the main FA

These bioactive molecules (catechin, gallic acid, peonidin) have several biological activities, for instance, antioxidant, anti-inflammatory, antiparasitic, and antitumor capacity

Parasitology Research (2023) 122:2287–2299
https://doi.org/10.1007/s00436-023-07929-w

RESEARCH

Gallic acid and Catechin induce morphological alterations on the zoonotic parasite *Hymenolepis diminuta*

Chandrani Mondal[1] · Sudeshna Mandal[1] · Samiparna Saha[1] · Mou Singha Ray[1] · Larisha M. Lyndem[1]

Food Research International 180 (2024) 114068
Contents lists available at ScienceDirect
Food Research International
journal homepage: www.elsevier.com/locate/foodres

Review

Dietary gallic acid as an antioxidant: A review of its food industry applications, health benefits, bioavailability, nano-delivery systems, and drug interactions

Zedong Xiang, Huida Guan, Xiang Zhao, Qi Xie, Zhejun Xie, Fujie Cai, Rui Dang, Manlin Li *, Changhong Wang *

Review

The Role of Catechins in Cellular Responses to Oxidative Stress

ORIGINAL PAPER

Virtual Prediction of the Delphinidin-3-O-glucoside and Peonidin-3-O-glucoside as Anti-inflammatory of TNF-α

frontiers in Immunology

Impact of Gallic Acid on Gut Health: Focus on the Gut Microbiome, Immune Response, and Mechanisms of Action

Kang Yang[1], Limeng Zhang[1], Pinfeng Liao[1], Zaili Xiao[1], Fan Zhang[1], Daniel Sindaye[1], Zhongquan Xin[1], Chengquan Tan[1], Jinping Deng[1], Yulong Yin[1,2*] and Baichuan Deng[1*]

Review

Crit Rev Food Sci Nutr. 2020;60(3):515-528. doi: 10.1080/10408398.2018.1549534. Epub 2019 Jan 11.

Catechins enhance skeletal muscle performance

Article

Peonidin-3-*O*-glucoside and Resveratrol Increase the Viability of Cultured Human hFOB Osteoblasts and Alter the Expression of Genes Associated with Apoptosis, Osteoblast Differentiation and Osteoclastogenesis

Keila C. Ostos Mendoza[1,2,†], Karen D. Garay Buenrostro[1,2,†], Pinal N. Kanabar[3], Mark Maienschein-Cline[3], Nina S. Los[4], Zarema Arbieva[4], Nishikant A. Raut[5,6], Temitope O. Lawal[5,7], Alice M. López[2,8], Paulina Cabada-Aguirre[2,8], Diego A. Luna-Vital[9] and Gail B. Mahady[2,*]

RESEARCH ARTICLE

Molecular Nutrition Food Research
www.mnf-journal.com

Gallic Acid

Gallic Acid Improves Health-Associated Biochemical Parameters and Prevents Oxidative Damage of DNA in Type 2 Diabetes Patients: Results of a Placebo-Controlled Pilot Study

*Franziska Ferk, Michael Kundi, Helmut Brath, Thomas Szekeres, Halh Al-Serori, Miroslav Mišík, Philipp Saiko, Rodrig Marculescu, Karl-Heinz Wagner, and Siegfried Knasmueller**

Effect of Grape by products on milk traits

Data are expressed as difference (in percentage) between treatment and control group


foods
MDPI

Review

Grape, Pomegranate, Olive, and Tomato By-Products Fed to Dairy Ruminants Improve Milk Fatty Acid Profile without Depressing Milk Production

Fabio Correddu, Maria Francesca Caratzu, Mondina Francesca Lunesu, Silvia Carta, Giuseppe Pulina and Anna Nudda *

Species	breed	By product inclusion g/kg of DMI	By product form*	MY	Fat	Protein
Sheep	Sarda	41.1	pomace	**+16.5**	**-12.8**	**-6.8**
	Sarda	118.3	**seed**	*2.0*	*4.0*	*-1.5*
	Friesian	196.0	pomace	*-1.1*	4.0	-6.8
	crossbreed	50***	pomace	*-7.8*	*-4.1*	*2.4*
Goats	Saanen	50	pomace	3.9	-4.5	-3.5
	Saanen	100	pomace	-5.2	-14.5	-2.1
	Saanen	150	pomace	**-12.0**	-9.0	-3.1
	Alpine	188	pomace	-1.3	2.3	-0.3

Badiee Baghsiyah et al., 2023

(Nudda et al., 2019; Bennato et al., 2022; Nudda et al., 2015; Tsiplakou & Zervas, 2008; Badiee Baghsiyah et al., 2023; Tsiplakou & Zervas, 2008)

foods
MDPI
Review
Grape, Pomegranate, Olive, and Tomato By-Products Fed to Dairy Ruminants Improve Milk Fatty Acid Profile without Depressing Milk Production
Fabio Correddu, Maria Francesca Caratzu, Mondina Francesca Lunesu, Silvia Carta, Giuseppe Pulina and Anna Nudda *

Grape by products improve milk fatty acids profile

Data are expressed as difference (in percentage) between treatment and control group


Species	Breeds	By-product inclusion g/kg of DMI1	By-product form2	Fatty acids					Groups of fatty acids		
				OA	Trans-VA	RA	LA	LNA	SFA	MUFA	PUFA
sheep	Sarda	41	GP	8.9	11.8	13.9	**20.7**	0.0	-3.2	6.4	**13.2**
	crossbreed	50*	GP	8.5	291.1	9.1	33.5	-3.5	-3.8	**17.1**	21.8
	Sarda	118	GS	**33.6**	**190.3**	**150.7**	**73.7**	-23.0	-15.2	**42.5**	**56.7**
	Friesian	196	GP	14.5	**41.8**	56.3	**19.3**	15.2	-10.8	14.2	**27.1**
	Churra			-6.0	12.9	13.5	2.2	-7.3	0.7	-3.2	5.3
	Churra			-5.2	24.0	27.0	10.3	-11.9	-1.8	1.1	12.5
goats	Alpine	188	GP	17.3	-9.9	50.5	26.6	-12.5	-4.5	10.4	25.0
	Camosciata delle Alpi	150 g/d		-10.1	-9.5	**-16.4**	1.1	-9.8	0.9	-8.2	-0.33

OA
VA
LA
RA
MUFA
PUFA

- sheep

SFA


Tsiplakou and Zervas, 2008; Nudda et al., 2015; Manso et al., 2016; Nudda et al., 2019; Bennato et al., 2022; Renna et al., 2023.

foods MDPI

Review

Grape, Pomegranate, Olive, and Tomato By-Products Fed to Dairy Ruminants Improve Milk Fatty Acid Profile without Depressing Milk Production

Fabio Correddu, Maria Francesca Caratzu, Mondina Francesca Lunesu, Silvia Carta, Giuseppe Pulina and Anna Nudda *

Grape by products on milk fatty acids profile

Data are expressed as difference (in percentage) between treatment and control group

Species	Breeds	By-product inclusion g/kg of DMI1	By-product form2	OA	Trans-VA	RA	LA	LNA	SFA	MUFA	PUFA
				Fatty acids							
sheep	Sarda	41	GP	8.9	11.8	13.9	**20.7**	0.0	-3.2	6.4	**13.2**
	crossbreed	50*	GP	8.5	**291.1**	9.1	**33.5**	-3.5	-3.8	**17.1**	21.8
	Sarda	118	GS	**33.6**	**190.3**	**150.7**	**73.7**	-23.0	-15.2	**42.5**	**56.7**
	Friesian	196	GP	14.5	**41.8**	**56.3**	**19.3**	15.2	-10.8	14.2	**27.1**
	Churra			-6.0	12.9	13.5	2.2	-7.3	0.7	-3.2	5.3
	Churra			-5.2	24.0	27.0	10.3	-11.9	-1.8	1.1	12.5
goats	Alpine	188	GP	17.3	-9.9	50.5	26.6	-12.5	-4.5	10.4	25.0
	Camosciata delle Alpi	150 g/d		-10.1	-9.5	**-16.4**	1.1	-9.8	0.9	-8.2	-0.33

OA

VA

LA

RA

MUFA

PUFA

- sheep

SFA

Tsiplakou and Zervas, 2008; Nudda et al., 2015; Manso et al., 2016; Nudda et al., 2019; Bennato et al., 2022; Renna et al., 2023.

Dietary *trans* vaccenic acid (TVA) from ruminant derived food directly promotes anti-tumour immunity in vivo.

Diet-derived nutrients are inextricably linked to human physiology by providing energy and biosynthetic building blocks and by functioning as regulatory molecules. However, the mechanisms by which circulating nutrients in the human body influence specific physiological processes remain largely unknown. Here we use a blood nutrient compound library-based screening approach to demonstrate that dietary *trans*-vaccenic acid (TVA) directly promotes effector $CD8^+$ T cell function and anti-tumour immunity in vivo. TVA is the predominant form of *trans*-fatty acids enriched in human milk, but the human body cannot produce TVA endogenously[1]. Circulating TVA in humans is mainly from ruminant-derived foods including beef, lamb and dairy products such as milk and butter[2,3], but only around 19% or 12% of dietary TVA is converted to rumenic acid by humans or mice, respectively[4,5]. Mechanistically, TVA inactivates the cell-surface receptor GPR43, an immunomodulatory G protein-coupled receptor activated by its short-chain fatty acid ligands[6–8]. TVA thus antagonizes the short-chain fatty acid agonists of GPR43, leading to activation of the cAMP–PKA–CREB axis for enhanced $CD8^+$ T cell function. These findings reveal that diet-derived TVA represents a mechanism for host-extrinsic reprogramming of $CD8^+$ T cells as opposed to the intrahost gut microbiota-derived short-chain fatty acids. TVA thus has translational potential for the treatment of tumours.

Article

Trans-vaccenic acid reprograms $CD8^+$ T cells and anti-tumour immunity

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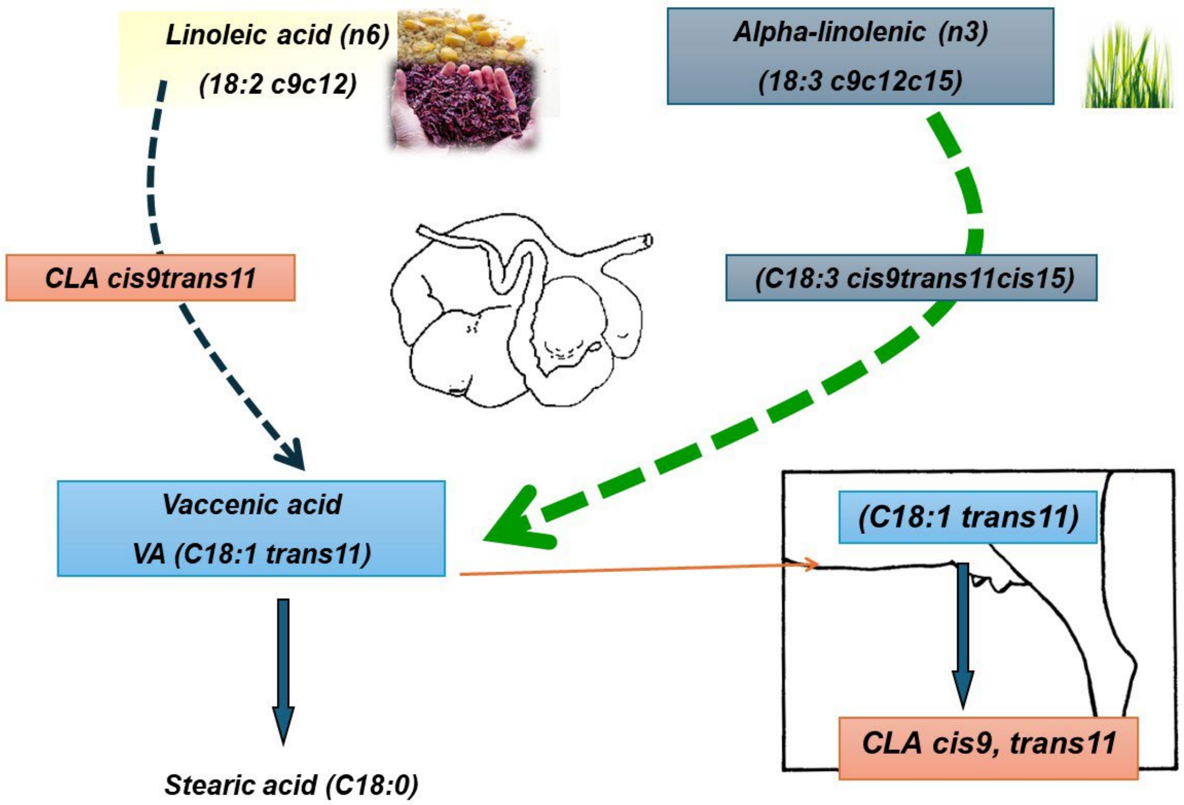
Hao Fan[1,2,3,13], Siyuan Xia[1,2,11,13], Junhong Xiang[4,13], Yuancheng Li[2,5], Matthew O. Ross[4], Seon Ah Lim[6], Fan Yang[4], Jiayi Tu[3], Lishi Xie[3], Urszula Dougherty[3], Freya Q. Zhang[3], Zhong Zheng[4], Rukang Zhang[1,2,3], Rong Wu[1,2,3], Lei Dong[7], Rui Su[7], Xiufen Chen[3], Thomas Althaus[3], Peter A. Riedell[3], Patrick B. Jonker[8], Alexander Muir[8], Gregory B. Lesinski[1,2], Sarwish Rafiq[1,2], Madhav V. Dhodapkar[1,2], Wendy Stock[3], Olatoyosi Odenike[3], Anand A. Patel[3], Joseph Opferman[6], Takemasa Tsuji[9], Junko Matsuzaki[9], Hardik Shah[3], Brandon Faubert[3], Shannon E. Elf[8], Brian Layden[10], B. Marc Bissonnette[3], Yu-Ying He[3], Justin Kline[3], Hui Mao[2,5], Kunle Odunsi[9], Xue Gao[1,2,3,12], Hongbo Chi[6]✉, Chuan He[4]✉ & Jing Chen[1,2,3]✉

Grape BP influence rumen microbial community

rumen biohydrogenation of PUFA

Rumen bioydrogenation of dietary UFA



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Effects of grape seed supplementation, alone or associated with linseed, on ruminal metabolism in Sarda dairy sheep

ITALIAN JOURNAL OF ANIMAL SCIENCE
2020, VOL. 19, NO. 1, 1462–1471
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OPEN ACCESS

Agroindustrial by-products from tomato, grape and myrtle given at low ... ota

Research Article

Received: 16 November 2015 Revised: 25 July 2016 Accepted article published: 10 August 2016 Published online in Wiley Online Library: 7 September 2016

(wileyonlinelibrary.com) DOI 10.1002/jsfa.7991

Evaluation of grape pomace from red wine by-product as feed for sheep

Cristina Guerra-Rivas,[a] Beatriz Gallardo,[a] Ángel R Mantecón,[b] María del Álamo-Sanza[a] and Teresa Manso[a*]

PAPER

OPEN ACCESS

Effects of País grape marc inclusion in high and low forage diets: ruminal fermentation, methane production and volatile fatty acids

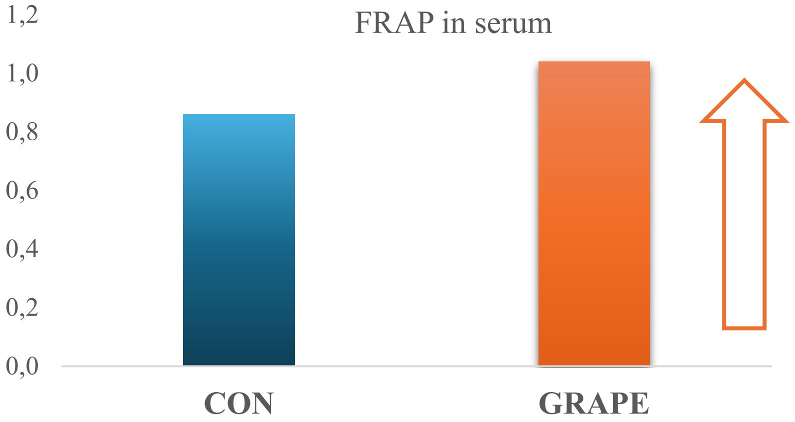
Sandra Tatiana Suescun-Ospina[a,b], Nelson Vera[a], Rita Astudillo[a], Constanza Yunda[d], Pamela Williams[c], Rodrigo Allende[a] and Jorge Ávila-Stagno[a]

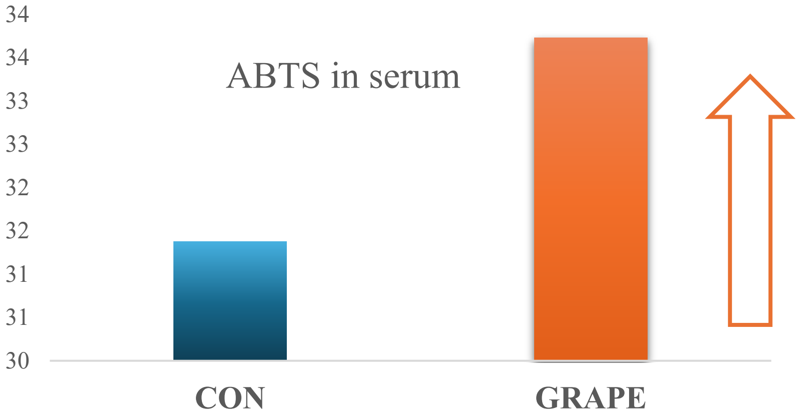
J. Dairy Sci. 102:3781–3804
https://doi.org/10.3168/jds.2018-14985

Invited review: Plant polyphenols and rumen microbiota responsible for fatty acid biohydrogenation, fiber digestion, and methane emission: Experimental evidence and methodological approaches

V. Vasta,[1] M. Daghio,[2] A. Cappucci,[3] A. Buccioni,[2] A. Serra,[3] C. Viti,[2] and M. Mele[3,4*]
[1]Food Scientist, viale delle Alpi 40, 90144, Palermo, Italy
[2]Dipartimento di Scienze delle Produzioni Agro-Alimentari e dell'Ambiente, University of Florence, Piazzale delle Cascine 18, 50144 Firenze, Italy
[3]Dipartimento di Scienze Agrarie, Alimentari e Agro-ambientali, University of Pisa, Via del Borghetto 80, 56124 Pisa, Italy
[4]Centro di Ricerche Agro-ambientali "E. Avanzi," University of Pisa, Via Vecchia di Marsina, 6, 56100 Pisa, Italy

Grape byproducts improve the antioxidant status of blood ewes and milk





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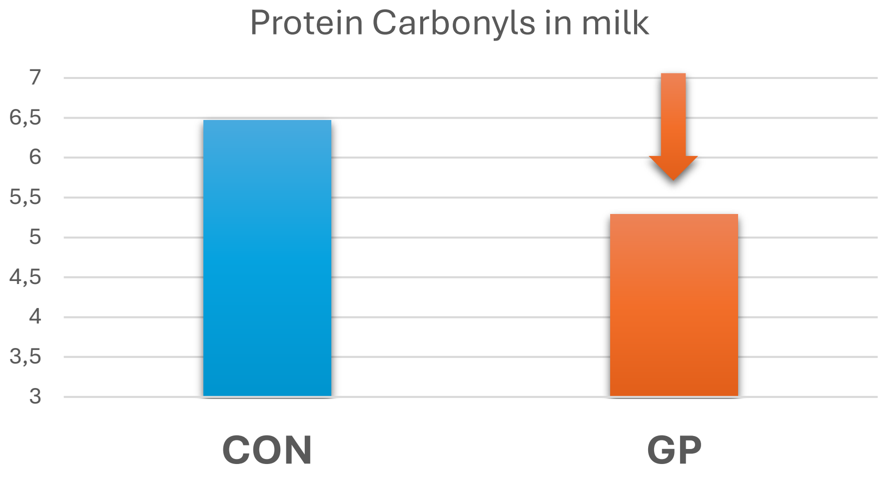
DOI: 10.1111/jpn.13315

ORIGINAL ARTICLE

WILEY

Supplementation of by-products from grape, tomato and myrtle affects antioxidant status of dairy ewes and milk fatty acid profile

Giovanna Buffa[1] | Eleni Tsiplakou[2] | Christina Mitsiopoulou[2] | Giuseppe Pulina[1] | Anna Nudda[1]



The inclusion of a 50 g/d of GP in late gestation ewes improve IgG content in colostrum and in serum of lambs

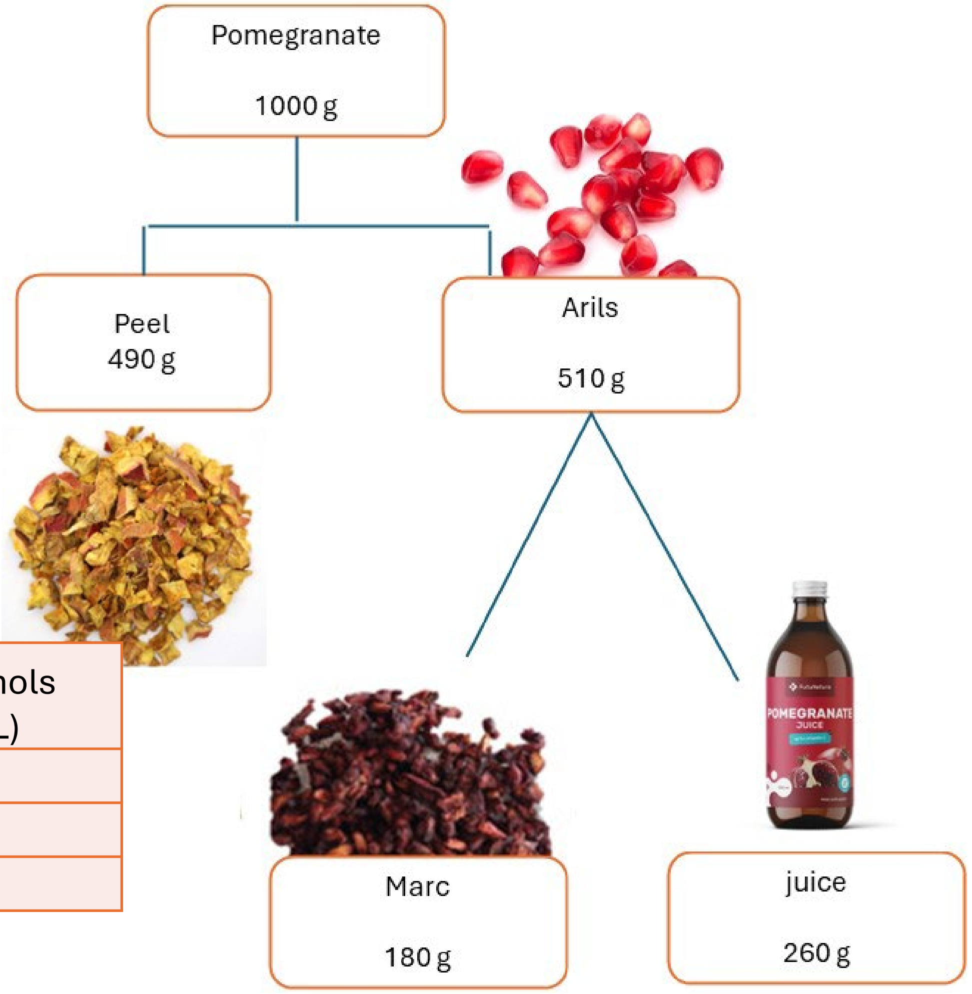
	CON	GRAPE	P-value
Colostrum IgG, g/L	36.5	58.3	0.04
Serum of lamb IgG, g/L	22.4	32.8	0.05

Nudda et al., 2024- EAAP Congress - Session 77 Room Romagnola h 10:45

Pomegranade by-product

Primary product (agroindustrial coproduct)	Pomegranate (peel)
Primary product (tons)*	142,000
AIBP (%) **	50
AIBP, tons (FM)	71,000
AIBP, tons (DM)	20,590
Available protein (tons)	741
Available NDF (tons)	4,283

66% of BP



	Total Polyphenols (mg/100 mL)
Peel	2703
Marc	154
Juice	47

Fawole and Opara, 2016

*Louw Pienaar and Vanessa Barends-Jones 2021 (Western Cape Department of Agriculture)
**United Nations Economic Commission for Europe (UNECE)
***Fernández- Zamudio et al. 2015;
Viuda-Martos et al., 2010
estimation from available data

Main phenolic compounds in pomegranate byproduct

PHENOLIC COMPOUNDS IN POMEGRANATE PEEL BY-PRODUCTS

Hydrolyzable tannins	Phenolic acids	Flavan-3-ols	Flavonols	Flavanones	Flavones	Anthocyanins	Procyanidins
• Punicalagin (α & β) • Punicalin • Corilagin • Granatin B • Galloyl-O-punicalin	• Gallic acid • Ellagic acid • Thymol • Olivetronide	• Catechin • Epitecatechin • Gallocatechin • Epigallocatechin	• Rutin • Isoquercitrin • Kaempferol-3-O-Glu • Kaempferol-3-O-Arabinoside • Quercetin-3-0-Glu	• Naringenin-7-O-Glu • Eriodictyol-7-O-Glu	• Luteolin-7-O-Glu • Apigenin-7-0-Glu • Luteolin-4`-O-Glu • Luteolin-3-O-Arabinoside	• Cyanidin • Cy-3-O-Glu • Cy-3-O-Gal • Cy-3,5-di-O-Glu • Dph-3-Glu • Pg-3-O-Glu • Pt-3-Gal	• Procyanidin B1 • Procyanidin B2 • Procyanidin C1

foods MDPI

Review

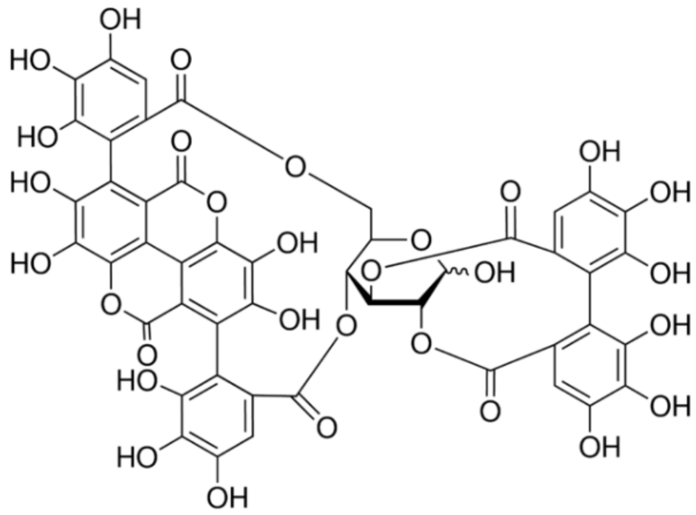
From Pomegranate Byproducts Waste to Worth: A Review of Extraction Techniques and Potential Applications for Their Revalorization

Marina Cano-Lamadrid [1], Lorena Martínez-Zamora [1,2], Noelia Castillejo [1] and Francisco Artés-Hernández [1,*]

Table 1. The major phenolic compounds in pomegranate peel.

Compound Name	Molecular Formula	Content (mg/g)
Punicalagin	$C_{48}H_{28}O_{30}$	10–50
Ellagic acid	$C_{14}H_6O_8$	1.2–5.8
Punicalin	$C_{34}H_{22}O_{22}$	2–8
Catechin	$C_{15}H_{14}O_6$	0.2–0.9
Chlorogenic acid	$C_{16}H_{18}O_9$	0.4–3
Gallic acid	$C_7H_6O_5$	0.2–4
Epicatechin	$C_{15}H_{14}O_6$	0.9–2
Caffeic acid	$C_9H_8O_4$	0.3–0.7
Ferulic acid	$C_{10}H_{10}O_4$	0.46
Vanillic acid	$C_{14}H_{18}O_9$	0.07
Rutin	$C_{27}H_{30}O_{16}$	0.0045

Xu et al. 2023



Punicalagin and its health-beneficial properties

Activity of Punicalagin	Model	Experimental Outcome	Ref.
Antioxidant	L-NAME induced hypertension pregnant rats	Punicalagin supplement decreased the levels of oxidative stress	[42]
	CCl_4-induced mice liver injury	Punicalagin decreased MDA level, increased SOD, GPX activities and Nrf2 expression	[43]
Anti-viral	Epithelial Vero host cell	Punicalagin reduction the virucidal plaque of HSV-1	[44]
Anti-microbial	*Aspergillus flavus* CECT2686, *Aspergillus parasiticus* CECT 2947, etc.	Pomegranate peel methanolic extracts inhibited the growth of *Aspergillus flavus*, *Fusarium verticillioides*, *Alternaria alternata* and *Botrytis cinerea*.	[45]
	Staphylococcus aureus	Punicalagin increased potassium efflux and exerted inhibitory effect on biofilm formation of *Staphylococcus aureus*.	[47]
Anti-cancer	Colorectal cancer cell HCT116	Punicalagin exhibits selective cytotoxicity on HCT116 compared to CCD841, exerts anti-cancer effect by downregulated Anx-A1 protein.	[49]

Anti-cancer	apoptosis of cancer cell in colon, cervical, lung, gastric, breast, osteosarcoma	Sun 2023; Xie 2022; Fang 2021; Sun 2024; Abd-Rabou 2022; Wang 2020.
Anti-viral	inhibitory activity against omicron variants of SARS-CoV-2 infection	Chen 2023
cancer prevention	inhibitory activity of oral cancer cell	Dioguardi 2022

antioxidants MDPI

Review

Punicalagin Regulates Signaling Pathways in Inflammation-Associated Chronic Diseases

Jie Xu [1], Ke Cao [1], Xuyun Liu [1], Lin Zhao [1], Zhihui Feng [2] and Jiankang Liu [1,3,*]

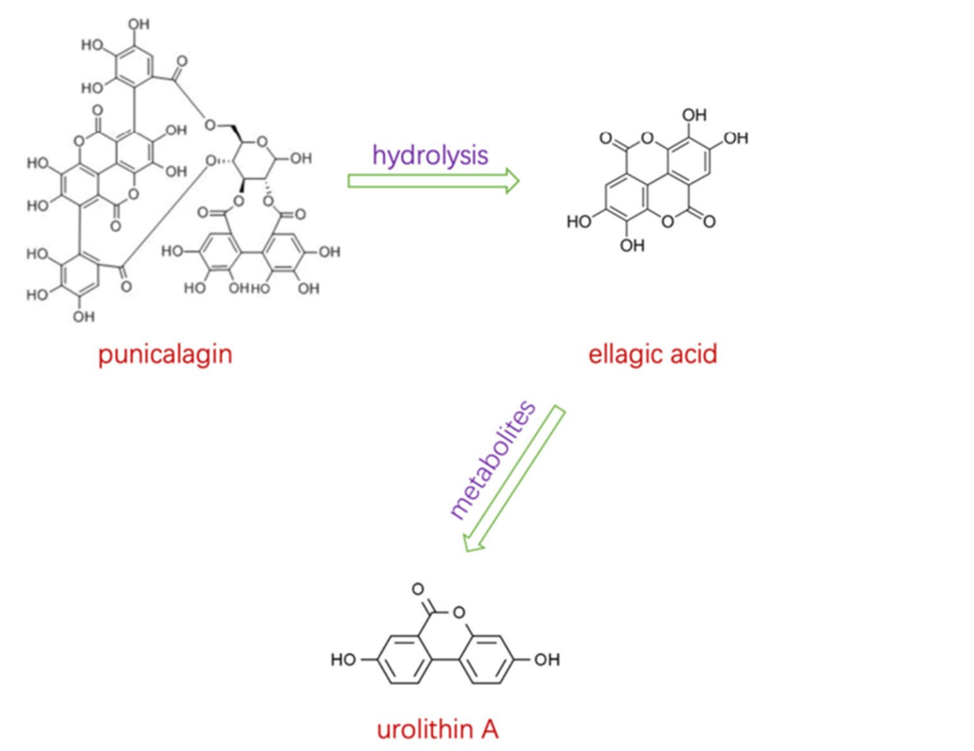


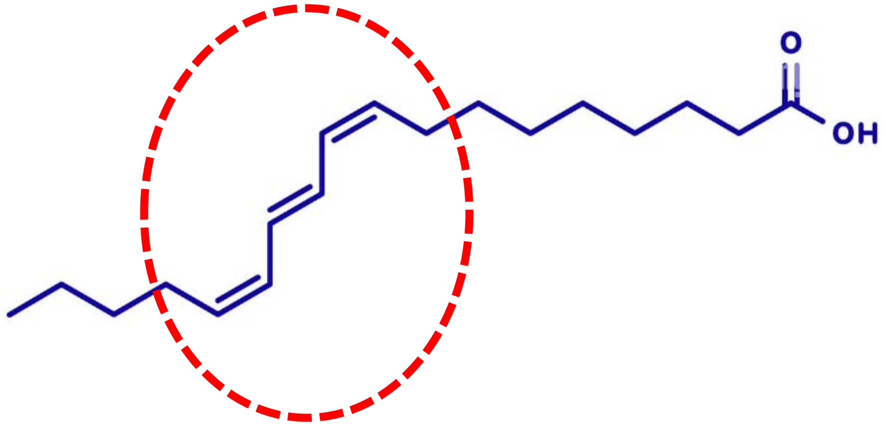
Figure 1. Punicalagin is hydrolyzed into ellagic acid in the small intestine, and is then metabolized to urolithin A.

Punicic acid

(omega-5)

- *Coniugated linolenic acid with three coniugated double bonds*

***cis*-9 *trans*-11 *cis*-13 CLnA**



FA	% of TFA
C14:0	0.09
C16:0	3.29
C16:1 c9	0.12
C18:0	2.13
C18:1 c9	8.66
LA	5.80
ALA	0.06
PnA	**78.7**

HEALTH BENEFITS

- Reducing the risk of cognitive decline [Mizrahi 2014; Binyamin 2019]
- Reducing chronic inflammation [Mannino 2023; Boussetta 2009; Khozoei 2023; Bassaganya-Riera 2011]
- Improving insulin sensitivity [Anusree 2018; Vroegrijk 2011; Olvera-Sandoval 2021]
- Acting as an antioxidant to help prevent damage to cells [Kaseke et al., 2021]
- substance to combat metabolic syndromes in humans [Shabbir et al., 2017]
- …

Effect of Pomegranate by products on milk traits

Data are expressed as difference (in percentage) between treatment and control group

Species	Breeds	By-Product Inclusion g/kg of DMI [1]	By-Product Form [2]	Milk Traits		
				Yield	Fat	Protein
Dairy sheep	Comisana	70	PP	2.3	0.1	−1.2
Crossbreed goat	Mahabadi	25	PSO	6.2	**7.3**	0.0
	southern Khorasan crossbred	60	PSP	−6.5	**14.6**	−2.6
	southern Khorasan crossbred	120	PSP	−6.9	**17.1**	−5.3
	Saanen	120	PSP	−2.0	**10.8**	4.2

- No effect of the **Pomegranate Pulp** (*peels, seeds, membranes, and portion of arils*) supplementation to ewes on MY and its composition

Valenti et al., 2019; Argov-Argaman et al., 2020; Modaresi et al., 2011; Razzaghi et al., 2015; Emami et al., 2016

Effect of Pomegranate by products on milk traits

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	Saanen	120	PSP	−2.0	**10.8**	4.2

PSO = pomegranate seed oil
PSP = pomegranate seed pulp

- Pomegranate byproducts increased significantly the milk fat content

FAT and MY PROTEIN

Valenti et al., 2019; **Argov-Argaman et al., 2020; Modaresi et al., 2011; Razzaghi et al., 2015; Emami et al., 2016**

Effect of Pomegranate by products on milk fatty acids profile

Data are expressed as difference (in percentage) between treatment and control group

Species	Breeds	By-Product Inclusion g/kg of DMI [1]	By-Product Form [2]	Fatty Acids [3]						Groups of Fatty Acids [4]					
				OA	VA	RA	LA	LNA	PnA	SFA	MUFA	PUFA	n3	n6	n6/n3
Dairy sheep	Comisana	30	CPE	−2.1	-	-	12.5	3.4	-	-	-	-	-	-	-
	Assaf	70	PP	0.0	**39.4**	**85.5**	8.4	**13.5**	>1000 *	**−3.9**	1.7	**20.0**	**11.8**	6.8	−4.5
Crossbreed goat	Mahabadi	25	PSO	3.8	**47.0**	**162.9**	4.2	**121.2**	**312.5**	**−6.7**	**7.6**	**52.2**	**91.1**	8.9	**−44.8**
	southern Khorasan crossbred	60	PSP	−6.7	9.5	18.2	−9.6	1.3	206.7	-	-	-	-	-	-
	southern Khorasan crossbred	120	PSP	−4.1	**80.0**	**163.6**	−7.3	**75.7**	**693.3**	-	-	-	-	-	-
	Saanen	120	PSP	−0.9	**121.1**	-	−25.4	**55.3**	**745.5**	−1.1	3.6	**30.9**	-	-	-

- Pomegranate byproducts increased the nutritional quality of milk fat

PnA

Effect of Pomegranate by products on milk fatty acids profile

Data are expressed as difference (in percentage) between treatment and control group

Species	Breeds	By-Product Inclusion g/kg of DMI [1]	By-Product Form [2]	Fatty Acids [3]					Groups of Fatty Acids [4]						
				OA	VA	RA	LA	LNA	PnA	SFA	MUFA	PUFA	n3	n6	n6/n3
Dairy sheep	Comisana	30	CPE	−2.1	-	-	12.5	3.4	-	-	-	-	-	-	-
	Assaf	70	PP	0.0	**39.4**	**85.5**	8.4	**13.5**	>1000 *	**−3.9**	1.7	**20.0**	**11.8**	6.8	−4.5
Crossbreed goat	Mahabadi	25	PSO	3.8	**47.0**	**162.9**	4.2	**121.2**	**312.5**	**−6.7**	**7.6**	**52.2**	**91.1**	8.9	**−44.8**
	southern Khorasan crossbred	60	PSP	−6.7	9.5	18.2	−9.6	1.3	206.7	-	-	-	-	-	-
	southern Khorasan crossbred	120	PSP	−4.1	**80.0**	**163.6**	−7.3	**75.7**	**693.3**	-	-	-	-	-	-
	Saanen	120	PSP	−0.9	**121.1**	-	−25.4	**55.3**	**745.5**	−1.1	3.6	**30.9**	-	-	-

- Pomegranate byproducts increased the nutritional quality of milk fat

VA

LNA

RA

PnA

Pomegranate has been tested in ewes naturally infected with GI nematodes

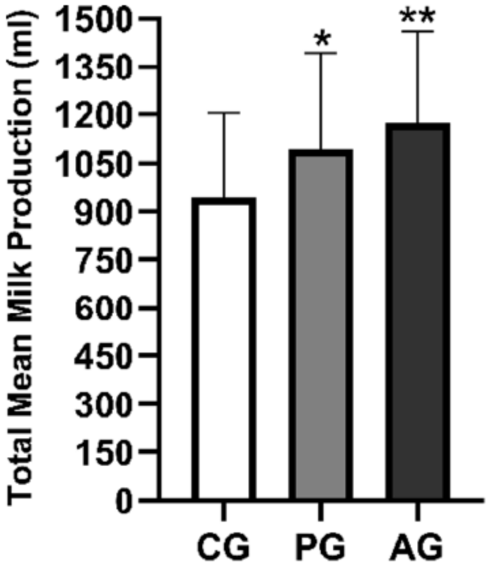

FIGURE 4
Mean of quantitative milk production in the three study groups for the duration of the entire study. *Value of $p < 0.05$ versus CG, **value of $p < 0.01$ versus CG. CG, control group; PG, *P. granatum* group; AG, albendazole group.

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TYPE Original Research
PUBLISHED 07 February 2024
DOI 10.3389/fvets.2024.1347151

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EDITED BY
Gracia Merino,
University of León, Spain

REVIEWED BY
Stefania Perrucci,
University of Pisa, Italy
Joan M. Burke,
United States Department of Agriculture,
United States

*CORRESPONDENCE
Ernesto Palma
palma@unicz.it

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Effect of pomegranate (*Punica granatum*) anthelmintic treatment on milk production in dairy sheep naturally infected with gastrointestinal nematodes

Fabio Castagna[1,2], Roberto Bava[1], Ernesto Palma[1,3]*, Valeria Morittu[1], Antonella Spina[1], Carlotta Ceniti[1], Carmine Lupia[2,4], Giuseppe Cringoli[5], Laura Rinaldi[5], Antonio Bosco[5], Stefano Ruga[1], Domenico Britti[1,6] and Vincenzo Musella[1,6]

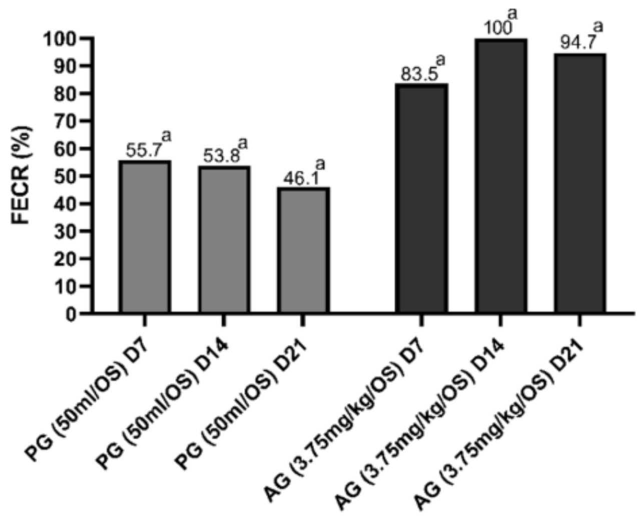


FIGURE 3
Percentage of fecal egg count reduction (FECR) in sheep. [a]Value of $p < 0.001$ versus CG. CG, control group; PG, *P. granatum* group; AG, albendazole group.

CG = control group
PG = pomegranate group
AG = albendazole group

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10879392/pdf/fvets-11-1347151.pdf

The percentage of fecal eggs was significantly reduced in sheep supplemented with *P. granatum* extract (PG) or with albendazole (AG) compared the untreated sheep (CG)

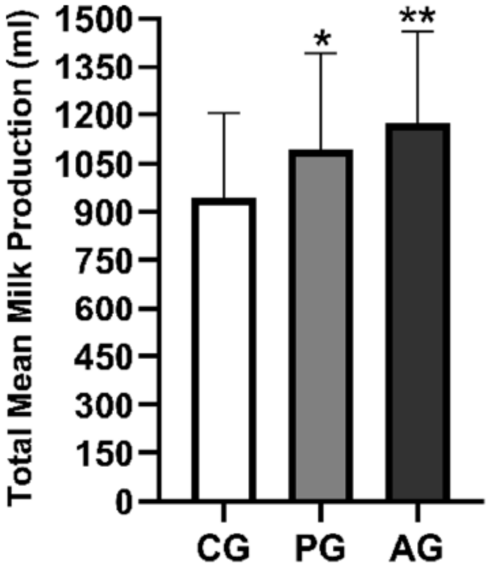
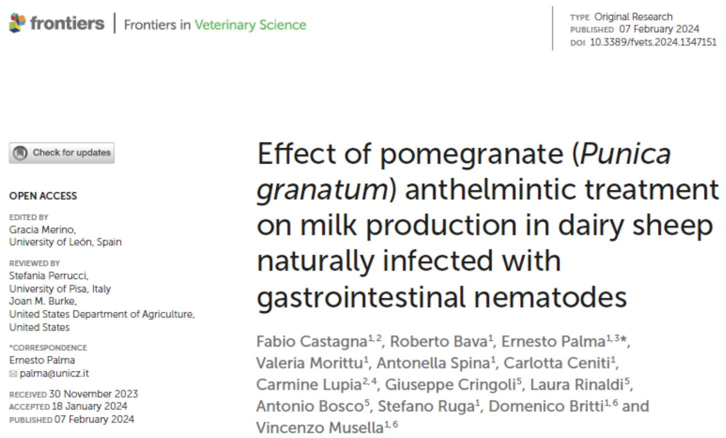


FIGURE 4
Mean of quantitative milk production in the three study groups for the duration of the entire study. *Value of $p < 0.05$ versus CG, **value of $p < 0.01$ versus CG. CG, control group; PG, *P. granatum* group; AG, albendazole group.



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Gracia Merino,
University of León, Spain

REVIEWED BY
Stefania Perrucci,
University of Pisa, Italy
Joan M. Burke,
United States Department of Agriculture,
United States

*CORRESPONDENCE
Ernesto Palma
palma@unicz.it

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Effect of pomegranate (*Punica granatum*) anthelmintic treatment on milk production in dairy sheep naturally infected with gastrointestinal nematodes

Fabio Castagna[1,2], Roberto Bava[1], Ernesto Palma[1,3*], Valeria Morittu[1], Antonella Spina[1], Carlotta Ceniti[1], Carmine Lupia[2,4], Giuseppe Cringoli[5], Laura Rinaldi[5], Antonio Bosco[5], Stefano Ruga[1], Domenico Britti[1,6] and Vincenzo Musella[1,6]

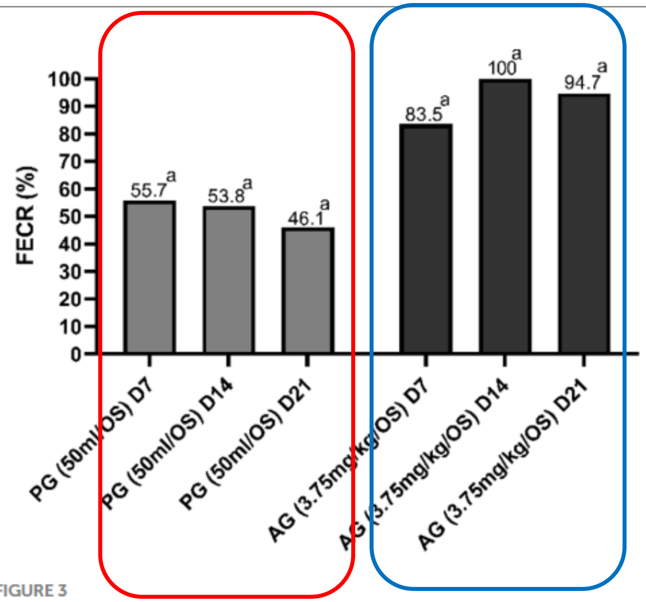


FIGURE 3
Percentage of fecal egg count reduction (FECR) in sheep. [a]Value of $p < 0.001$ versus CG. CG, control group; PG, *P. granatum* group; AG, albendazole group.

CG = control group
PG = pomegranate group
AG = albendazole group

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10879392/pdf/fvets-11-1347151.pdf

Lower infection … higher milk yield

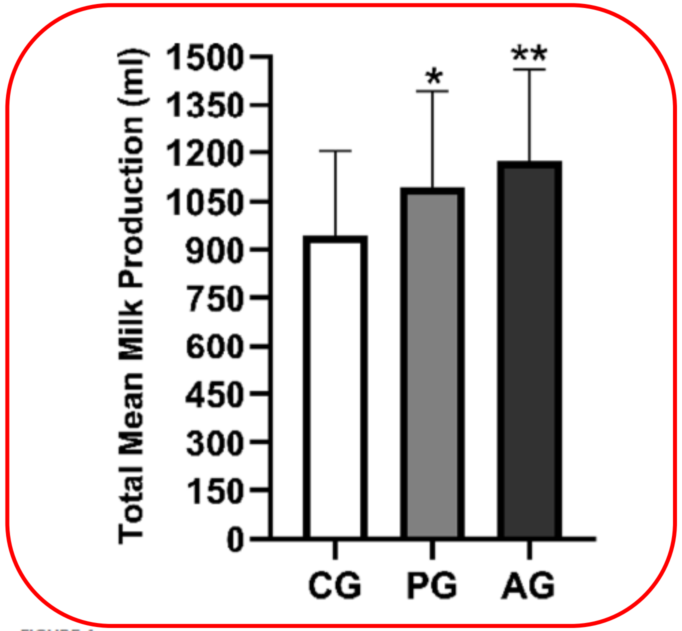
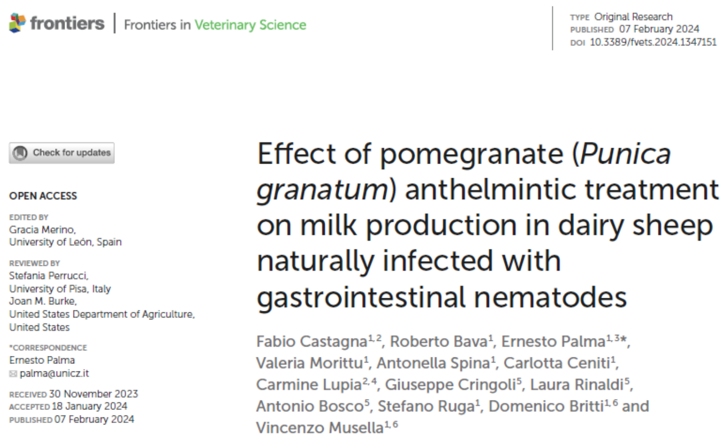


FIGURE 4
Mean of quantitative milk production in the three study groups for the duration of the entire study. *Value of $p < 0.05$ versus CG, **value of $p < 0.01$ versus CG. CG, control group; PG, *P. granatum* group; AG, albendazole group.



frontiers | Frontiers in Veterinary Science

TYPE Original Research
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EDITED BY
Gracia Merino,
University of León, Spain

REVIEWED BY
Stefania Perrucci,
University of Pisa, Italy
Joan M. Burke,
United States Department of Agriculture,
United States

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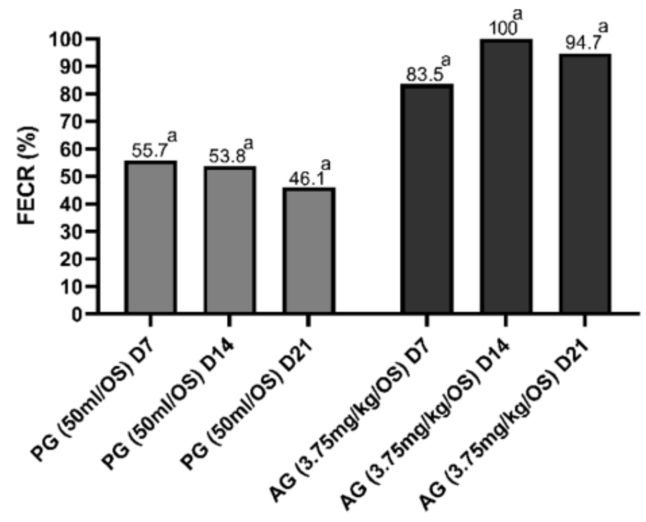

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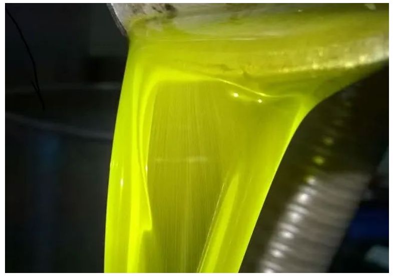
Olive by-products

Primary product (agroindustrial by-product)	Olive (olive cake)
Primary product (tons)*	12,888,000
AIBP (%) from processing **	40%
AIBP, tons (FM)	**5,284,080**
AIBP, tons (DM)	2,937,948
Available protein (tons)	233,934
Available NDF (tons)	1,874,901

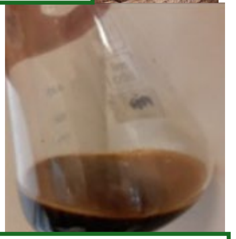
* FAOSTAT, 2022 (data for EU27); ** literature available;

Correddu et al. 2022 EAAP Portugal

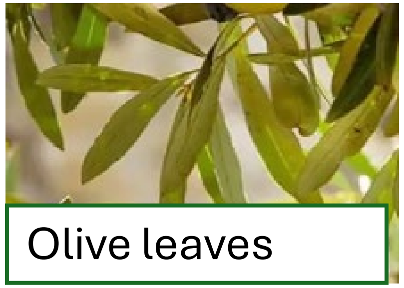
Extra virgin olive oil



Olive cake



Olive mill waste water



Olive leaves

Non-conventional byproducts: OLIVE

Chemical composition of Grape, Pomegranate, Olive, Tomato, Cocoa, Coffee, Citrus byproducts







	Grape		Pomegranate		Olive		Tomato		Cocoa		Spent coffee ground		Citrus	
	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max
By-product from processes, %	**22**	20-25	55.3	49.0-67.0	42.5	35-60	5	4-7.5	72.5	70-75	65		59	49-69
Moisture, %	**71.2**	63.0-81.7	-		44.4	32.0-60.0	87.7	78.4-97.0	80.2	-	57.6		79.8	76.7-81.9
Chemical composition														
Dry matter, % as fed	**92.0**	88.6-95.0	94.0	91.2-96.1	85.7	77.5-94.7	92.7	90.3-95.2	90.6	89.5-92.9	91.3		90.7	90.2-92.1
Protein, % DM	**12.0**	8.8-16.3	8.9	3.6-15.4	8.0	7.2-9.2	17.2	15.7-19.1	13.7	6.7-17.3	14.0	10.1-16.9	7.0	5.8-8.7
Fat, % DM	**6.6**	3.9-11.4	4.3	0.6-13.4	10.4	5.4-16.5	9.3	6.2-11.0	7.3	2.0-20.4	17	9.3-29.20	2.7	1.2-4.0
NDF, % DM	**42.4**	37.4-53.9	40.4	20.8-68.0	61.7	58.4-64.1	58.4	55.2-61.6	49.3	33-68.6	65.1	55.5-73	20.7	12.3-33.0
ADF, % DM	**36.6**	30.6-49.2	29.2	15.1-49.0	51.0	45.9-54.4	48.5	46.2-50.7	35.1	13.7-64.6	40.6	33.1-48	14.8	9.6-23.1
Ash, % DM	**7.7**	2.1-12.1	3.8	2.4-5.4	9.6	3.7-13.6	4.1	43.1-4.8	7.4	4.6-9.2	3.5	0.27-5.6	4.7	2.8-5.9
Total polyphenol, g/kg DM	**35.9**	3-90	52.8	27.2-95.3	10.9	4.1-17.7	4.9	2.3-6.4	28.9	9.1-43.9	12.5	10-15	10.6	2.1-57.7
Main fatty acids (% on total FA)														
Palmitic acid	**9.6**	5.5-12.5	3.8	3.5-4.2	13.1	9.1-17.5	13.9	11.5-15.6	24.5	22.4-26.8	33.0	31.8-33.8	24.5	17.7-29.4
Stearic acid	**4.3**	2.8-4.9	2.4	1.9-2.8	5.5	2.1-13.1	4.2	3.1-4.9	25.7	23.9-27.3	7.5	7.2-8.0	4.9	3.6-7.8
Oleic acid	**15.2**	9.6- 19.2	7.2	5.4-9.2	65.5	54.3-75.8	19.7	17.6-20.7	34.5	30.2-39.0	10.9	9.1-12.7	21	17.1-26.7
Linoleic acid	**66.9**	61.1-74.0	7.1	5.9-8.1	9.9	6.6-13.8	54.8	52.2-57.1	8.4	8.4-8.5	43.3	43-43.8	31.8	29.8-33.9
Alpha linolenic acid	**1.4**	0.2-3.7	0.2	0.1-0.4	0.9	0.3-1.46	2.9	2.6-3.2	0.6	0.5-0.7	1.1	0.8-1.5	5.7	2.6-8.2
Punicic acid	**-**		73.8	71.2-77.2	-		-		-		-			

Olive by-products

Extra virgin olive oil
20%

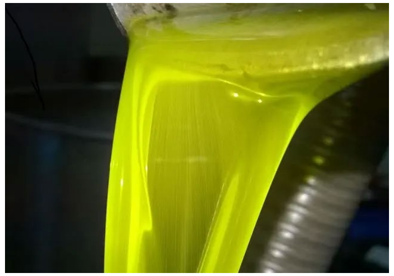


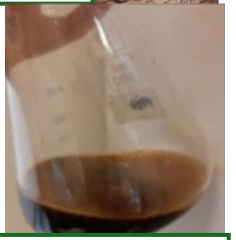
Table 1. Composition of the different olive by-products for feeding trials.

Olive by-Product	Dry Matter (%)	Ether Extract (%)	Crude Protein (%)	NDF (%)	SFAs (%)	MUFAs (%)	PUFAs (%)	Total Phenols (%)
Olive cake (OC)	85–91	4–9	8–11	60–66	18–25	68–70	7–12	14
Partly destoned OC	89–92	1–5	3–13	54–68	47	45	8	0.65 mg GAE */g
Olive mill wastewater	-	0.2–1	-	-	-	-	-	0–1.2
Olive leaves (OL)	95	3–4	10–13	30–40	40	22	38	25

* gallic acid equivalent.

Tzamaloukas O. et al. 2021 - Animals

Olive cake

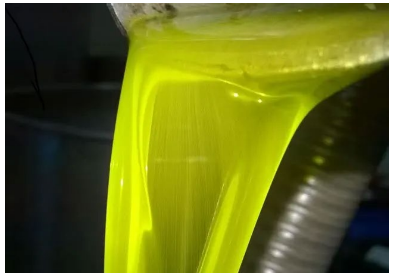


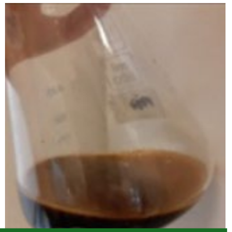
Olive mill waste water

C18:1 cis9 (oleic acid)
~ 65% of total FA

Olive by-products

Extra virgin olive oil
20%





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* gallic acid equivalent.

Tzamaloukas et al. 2021 - Animals

C18:3 c9c12c15 ω3

~ 35-42% of total FA

Polyphenols in Olive by-products

J. Dairy Sci. 101:4992–5005
https://doi.org/10.3168/jds.2017-13757

Effect of increasing amounts of olive crude phenolic concentrate in the diet of dairy ewes on rumen liquor and milk fatty acid composition

Alice Cappucci,*[1] Susana P. Alves,† Rui J. B. Bessa,† Arianna Buccioni,‡ Federica Mannelli,‡ Mariano Pauselli,§ Carlo Viti,‡ Roberta Pastorelli,# Valentina Roscini,§ Andrea Serra,* Giuseppe Conte,* and Marcello Mele*

Table 2. Phenolic compounds content in the experimental concentrates administrated to ewes

	Experimental concentrate[1]			
Item (mg/kg of DM)	L0	L0.6	L0.8	L1.2
3,4-DHPEA[2]	—	107.87	111.50	146.32
p-HPEA[2]	—	52.07	69.64	103.74
Verbascoside	—	248.18	354.87	530.07
3,4-DHPEA-EDA[2]	—	236.29	291.67	397.83
Total phenolic compounds	—	644.41	827.68	1,177.96

[1]L0 = control diet; L0.6 = control diet plus 0.6 g/kg of olive crude phenolic concentrate (OCPC); L0.8 = control diet plus 0.8 g/kg of OCPC; L1.2 = control diet plus 1.2 g/kg of OCPC.
[2]Hydroxytyrosol (3,4-DHPEA), tyrosol (p-HPEA), and oleuropein-aglycone di-aldehyde (3,4-DHPEA-EDA).

Polyphenols in (

nutrients MDPI

Review

Health Effects of Phenolic Compounds Found in Extra-Virgin Olive Oil, By-Products, and Leaf of *Olea europaea* L.

nutrients MDPI

Review

Hydroxytyrosol in the Prevention of the Metabolic Syndrome and Related Disorders

J. Dairy Sci. 101:4992–
https://doi.org/10.3168/
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**Effect of increasing amo
in the diet of dairy ewes**

Alice Cappucci,*[1] Susana P. Alves
Mariano Pauselli,§ Carlo Viti,‡ Rol
and Marcello Mele*

JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY
pubs.acs.org/JAFC Review

Efficacy and Mechanisms of Oleuropein in Mitigating Diabetes and Diabetes Complications

Shujuan Zheng, Kunlun Huang,* and Tao Tong*

Pharmaceutical Biology
http://informahealthcare.com/phb
ISSN 1388-0209 print/ISSN 1744-5116 online
Editor-in-Chief: John M. Pezzuto
Pharm Biol, 2016; 54(2): 338–346
© 2015 Informa Healthcare USA, Inc. DOI: 10.3109/13880209.2015.1042980
informa healthcare

ORIGINAL ARTICLE

Olive oil and its phenolic compounds (hydroxytyrosol and tyrosol) ameliorated TCDD-induced heptotoxicity in rats via inhibition of oxidative stress and apoptosis

Antitumor Perspectives of Oleuropein and Its Metabolite Hydroxytyrosol: Recent Updates

International Journal of *Molecular Sciences* MDPI

Article

Hydroxytyrosol–Donepezil Hybrids Play a Protective Role in an In Vitro Induced Alzheimer's Disease Model and in Neuronal Differentiated Human SH-SY5Y Neuroblastoma Cells

Biological effects of verbascoside and its anti-inflammatory activity on oral mucositis: a review of the literature

Nigro, Olga; Tuzi, Alessandro; Tartaro, Tiziana; Giaquinto, Alice; Vallini, Ilaria; Pinotti, Graziella
Author Information

Anti-Cancer Drugs 31(1):p 1-5, January 2020. | *DOI:* 10.1097/CAD.0000000000000818

International Journal of *Molecular Sciences* MDPI

Article

The Olive Biophenols Oleuropein and Hydroxytyrosol Selectively Reduce Proliferation, Influence the Cell Cycle, and Induce Apoptosis in Pancreatic Cancer Cells

Table 2. P

Item (mg/k				L1.2
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[2]Hydroxytyrosol (3,4-DHPEA), tyrosol (p-HPEA), and oleuropein-aglycone di-aldehyde (3,4-DHPEA-ED

International Journal of *Molecular Sciences* MDPI

Review

Bioactivity of Olive Oil Phenols in Neuroprotection

Cristina Angeloni [1], Marco Malaguti [2], Maria Cristina Barbalace [2] and Silvana Hrelia [2,*]

Effect of Olive by products on milk traits

Data are expressed as difference (in percentage) between treatment and control group


foods

MDPI

Review

Grape, Pomegranate, Olive, and Tomato By-Products Fed to Dairy Ruminants Improve Milk Fatty Acid Profile without Depressing Milk Production

Fabio Correddu, Maria Francesca Caratzu, Mondina Francesca Lunesu, Silvia Carta, Giuseppe Pulina and Anna Nudda *

Species	Breeds	By-product inclusion g/kg of DMI[1]	By-product form[2]	Milk traits		
				Yield	Fat	Protein
sheep	Chios	72	EOC	-2.1	-2.1	-
	Chios	100	EOC	*1.4*	*-2.0*	*1.6*
	Chios	142	EOC	14.9	-4.2	-
	Chios	199	EOC	*5.4*	*-3.6*	*-0.2*
	Comisana	64	OC	**19.0**	*1.4*	*-1.5*
	Crossbreed	98	OC	-	*10.0*	*0.0*
	Awassi	200	OC	*-3.5*	*-12.1*	*-2.0*
	Crossbreed	244	OC	-	*-5.0*	*-4.1*
	Awassi	298	OC	**-8.0**	*2.4*	-4.0
	Awassi	300	OC	*-5.8*	*0.1*	*-2.1*
	Friesian	751	OL	*-1.33*	*-0.57*	*1.42*
goats	Saanen	100	EOC	*4.9*	*2.6*	*0.0*
	Beni Arouss	200	OC	*-12.8*	-	-
	Saanen	200	EOC	*-2.0*	*20.5*	*0.0*
	Murciano-Granadina	202	EOBP	*-8.7*	**26.7**	9.6
	Alpine	702	OL	*-2.13*	*1.17*	*1.27*

OC = olive cake
EOC = ensiled olive cake
OL = olive leaves
OBSD = olive by-product silage

Abbeddou et al., 2015; Abbeddou et al., 2011; Arco-Perez et al., 2017; ; Cappucci et al., 2018; Chiofalo et al., 2004; El Otmani et al., 2020; Keles et al., 2016; Symeou et al., 2019; Symeou et al., 2021; Shdaifat et al., 2013; Vargas-Bello-Pérez et al., 2013.

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foods

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	Crossbreed	98	OC	-	10.0	0.0
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	Crossbreed	244	OC	-	-5.0	-4.1
	Awassi	298	OC	**-8.0**	2.4	-4.0
	Awassi	300	OC	-5.8	0.1	-2.1
	Friesian	751	OL	-1.33	-0.57	1.42
	Saanen	100	EOC	4.9	2.6	0.0
	Beni Arouss	200	OC	-12.8	-	-
goats	Saanen	200	EOC	-2.0	20.5	0.0
	Murciano-Granadina	202	EOBP	-8.7	**26.7**	9.6
	Alpine	702	OL	-2.13	1.17	1.27

OC = olive cake
EOC = ensiled olive cake
OL = olive leaves
OBSD = olive by-product silage;

The olive leaves did not change milk production and composition compared to control diet both in sheep and goats (~700 g/kg DMI), because had conveniently replaced the forage of the control diet (alfalfa hay and wheat straw).

Effect of Olive by products on milk fatty acids profile

Data are expressed as difference (in percentage) between treatment and control group

Species	Breeds	By-Product Inclusion g/kg of DMI [1]	By-Product Form [2]	Fatty Acids [3]					Groups of Fatty Acids [4]					
				OA	VA	RA	LA	LNA	SFA	MUFA	PUFA	n3	n6	n6/n3
Sheep	Comisana	64	OC	-	-	-	4.1	−20.5	−5.7	21.8	−5	-	-	-
	Chios	72	EOC	-	-	22.2	2.5	−10.5	−7.1	30.3	3.2	-	-	-
	Crossbreed	98	OC	31.0	33.5	-	13.3	−8.3	−8.1	26.5	15	-	-	-
	Chios	100	EOC	17.3	18.7	42.7	12.9	−6.4	−6.9	15.7	5	-	-	-
	Chios	142	EOC	-	-	47.2	17.2	−8.8	−11.3	45.6	17.4	-	-	-
	Chios	199	EOC	18.3	14.2	61.3	19.5	−6.4	−11.1	23.5	11.5	-	-	-
	Crossbreed	244	OC	55.6	66.5	-	42.0	−23.3	−14.9	48.2	22.3	-	-	-
	Awassi	298	OC	25.9	0.0	2.7	−18.1	−5.3	−6.3	22	−10.2	−6.1	2.1	13.4
	Awassi	300	OC	72.9	−19.2	4.3	−19.9	−5.7	−10.7	53.8	−13.5	−5.6	−16.0	−11.1
	Friesian	751	OL	30.3	24.9	71.1	121.9	121.7	−50.3	37.6	97.4	-	-	-
Goats	Saanen	100	OCS	9.3	-	-	−17.3	3.6	−2.2	11.1	−6.8	-	-	-
	Chios	142	EOC	-	-	47.2	17.2	−8.8	−11.3	45.6	17.4	-	-	-
	Alpine	702	OL	34.4	2.4	21.0	36.5	282.9	−6.5	23.1	55.3	-	-	-

- Olive byproducts increased the nutritional quality of milk fat

SFA

Effect of Olive by products on milk fatty acids profile

Data are expressed as difference (in percentage) between treatment and control group

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	Comisana	64	OC	-	-	-	4.1	−20.5	−5.7	21.8	−5	-	-	-
	Chios	72	EOC	-	-	22.2	2.5	−10.5	−7.1	30.3	3.2	-	-	-
	Crossbreed	98	OC	31.0	33.5	-	13.3	−8.3	−8.1	26.5	15	-	-	-
	Chios	100	EOC	17.3	18.7	42.7	12.9	−6.4	−6.9	15.7	5	-	-	-
 sheep	Chios	142	EOC	-	-	47.2	17.2	−8.8	−11.3	45.6	17.4	-	-	-
	Chios	199	EOC	18.3	14.2	61.3	19.5	−6.4	−11.1	23.5	11.5	-	-	-
	Crossbreed	244	OC	55.6	66.5	-	42.0	−23.3	−14.9	48.2	22.3	-	-	-
	Awassi	298	OC	25.9	0.0	2.7	−18.1	−5.3	−6.3	22	−10.2	−6.1	2.1	13.4
	Awassi	300	OC	72.9	−19.2	4.3	−19.9	−5.7	−10.7	53.8	−13.5	−5.6	−16.0	−11.1
	Friesian	751	OL	30.3	24.9	71.1	121.9	121.7	−50.3	37.6	97.4	-	-	-
	Saanen	100	OCS	9.3	-	-	−17.3	3.6	−2.2	11.1	−6.8	-	-	-
 goats	Chios	142	EOC	-	-	47.2	17.2	−8.8	−11.3	45.6	17.4	-	-	-
	Alpine	702	OL	34.4	2.4	21.0	36.5	282.9	−6.5	23.1	55.3	-	-	-

- Olive byproducts increased the nutritional quality of milk fat:

OA

MUFA

Dose range from 98-300 g/kg of DMI of Olive cake increased MUFA mainly OA

Effect of Olive by products on milk fatty acids profile

Data are expressed as difference (in percentage) between treatment and control group

Species	Breeds	By-Product Inclusion g/kg of DMI [1]	By-Product Form [2]	Fatty Acids [3]					Groups of Fatty Acids [4]					
				OA	VA	RA	LA	LNA	SFA	MUFA	PUFA	n3	n6	n6/n3
sheep	Comisana	64	OC	-	-	-	4.1	−20.5	−5.7	21.8	−5	-	-	-
	Chios	72	EOC	-	-	22.2	2.5	−10.5	−7.1	30.3	3.2	-	-	-
	Crossbreed	98	OC	31.0	33.5	-	13.3	−8.3	−8.1	26.5	15	-	-	-
	Chios	100	EOC	17.3	18.7	42.7	12.9	−6.4	−6.9	15.7	5	-	-	-
	Chios	142	EOC	-	-	47.2	17.2	−8.8	−11.3	45.6	17.4	-	-	-
	Chios	199	EOC	18.3	14.2	61.3	19.5	−6.4	−11.1	23.5	11.5	-	-	-
	Crossbreed	244	OC	55.6	66.5	-	42.0	−23.3	−14.9	48.2	22.3	-	-	-
	Awassi	298	OC	25.9	0.0	2.7	−18.1	−5.3	−6.3	22	−10.2	−6.1	2.1	13.4
	Awassi	300	OC	72.9	−19.2	4.3	−19.9	−5.7	−10.7	53.8	−13.5	−5.6	−16.0	−11.1
	Friesian	751	OL	30.3	24.9	71.1	121.9	121.7	−50.3	37.6	97.4	-	-	-
goats	Saanen	100	OCS	9.3	-	-	−17.3	3.6	−2.2	11.1	−6.8	-	-	-
	Chios	142	EOC	-	-	47.2	17.2	−8.8	−11.3	45.6	17.4	-	-	-
	Alpine	702	OL	34.4	2.4	21.0	36.5	282.9	−6.5	23.1	55.3	-	-	-

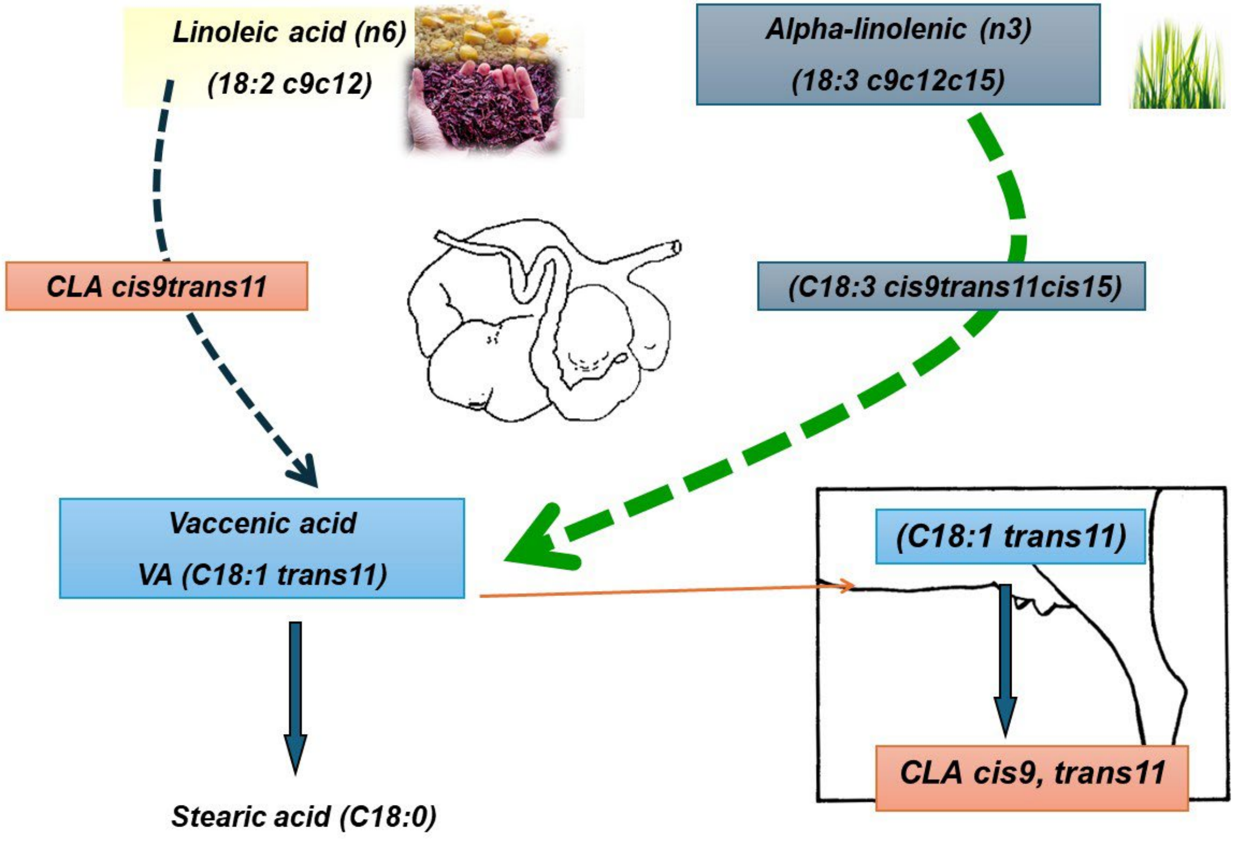
- Olive byproducts increased the nutritional quality of milk fat

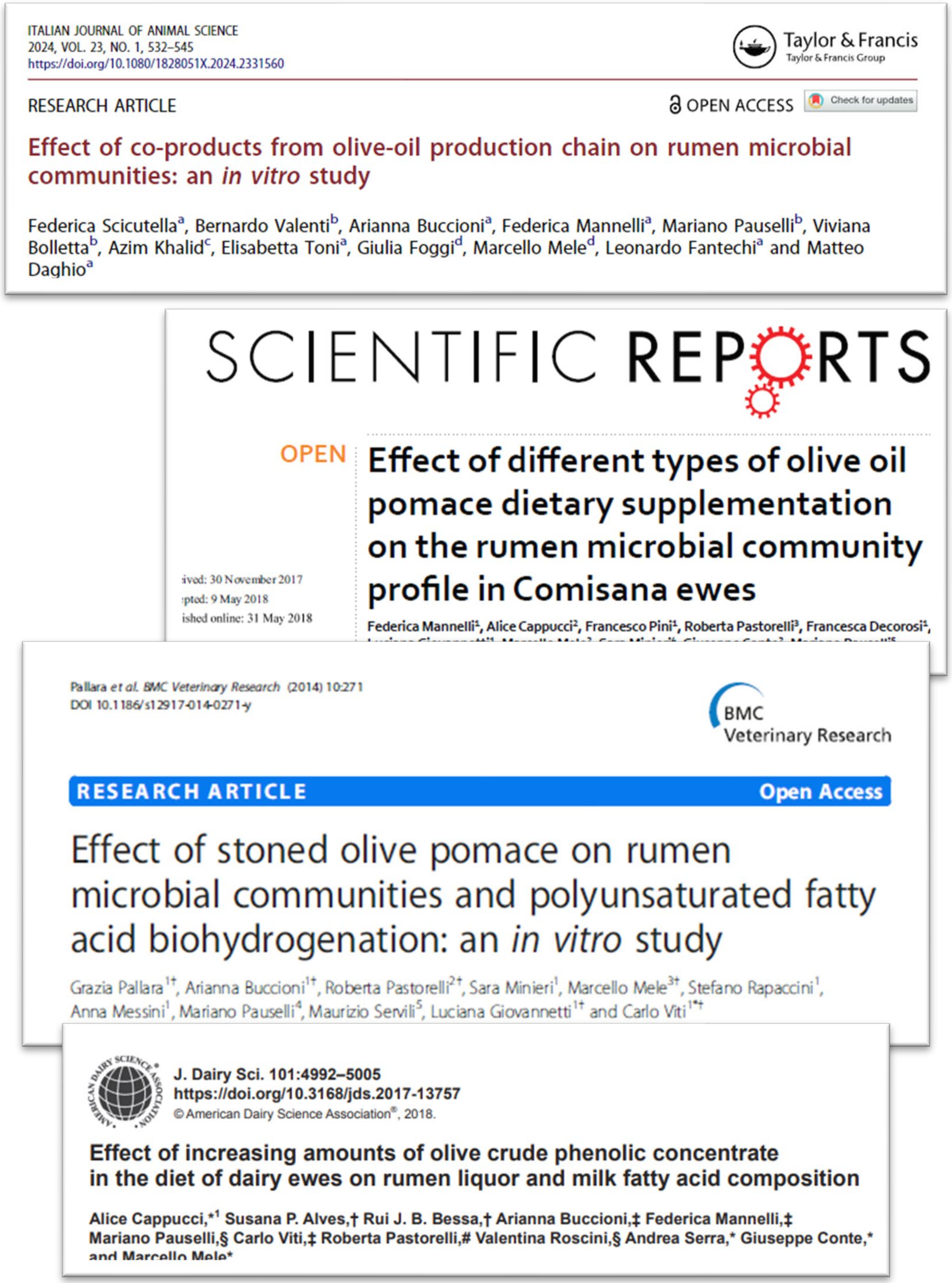
VA (C18:1 t11)

RA (C18:2 c9t11)

Olive BP induce changes in microbial populations including bacteria responsible for VA and RA hydrogenation to C18:0

Rumen bioydrogenation of dietary UFA





ITALIAN JOURNAL OF ANIMAL SCIENCE
2024, VOL. 23, NO. 1, 532–545
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RESEARCH ARTICLE

OPEN ACCESS

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Effect of co-products from olive-oil production chain on rumen microbial communities: an *in vitro* study

Federica Scicutella[a], Bernardo Valenti[b], Arianna Buccioni[a], Federica Mannelli[a], Mariano Pauselli[b], Viviana Bolletta[b], Azim Khalid[c], Elisabetta Toni[a], Giulia Foggi[d], Marcello Mele[d], Leonardo Fantechi[a] and Matteo Daghio[a]

SCIENTIFIC REPORTS

OPEN

ived: 30 November 2017
pted: 9 May 2018
ished online: 31 May 2018

Effect of different types of olive oil pomace dietary supplementation on the rumen microbial community profile in Comisana ewes

Federica Mannelli[1], Alice Cappucci[2], Francesco Pini[1], Roberta Pastorelli[3], Francesca Decorosi[1],

Pallara et al. BMC Veterinary Research (2014) 10:271
DOI 10.1186/s12917-014-0271-y

BMC Veterinary Research

RESEARCH ARTICLE Open Access

Effect of stoned olive pomace on rumen microbial communities and polyunsaturated fatty acid biohydrogenation: an *in vitro* study

Grazia Pallara[1†], Arianna Buccioni[1†], Roberta Pastorelli[2†], Sara Minieri[1], Marcello Mele[3†], Stefano Rapaccini[1], Anna Messini[1], Mariano Pauselli[4], Maurizio Servili[5], Luciana Giovannetti[1†] and Carlo Viti[1*†]

J. Dairy Sci. 101:4992–5005
https://doi.org/10.3168/jds.2017-13757
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Effect of increasing amounts of olive crude phenolic concentrate in the diet of dairy ewes on rumen liquor and milk fatty acid composition

Alice Cappucci,*[1] Susana P. Alves,† Rui J. B. Bessa,† Arianna Buccioni,‡ Federica Mannelli,‡ Mariano Pauselli,§ Carlo Viti,‡ Roberta Pastorelli,# Valentina Roscini,§ Andrea Serra,* Giuseppe Conte,* and Marcello Mele*

Effect of Olive leaves on milk fatty acids profile

Data are expressed as difference (in percentage) between treatment and control group

Species	Breeds	By-Product Inclusion g/kg of DMI [1]	By-Product Form [2]	Fatty Acids [3]					Groups of Fatty Acids [4]					
				OA	VA	RA	LA	LNA	SFA	MUFA	PUFA	n3	n6	n6/n3
	Comisana	64	OC	-	-	-	4.1	−20.5	**−5.7**	**21.8**	−5	-	-	-
	Chios	72	EOC	-	-	22.2	2.5	−10.5	−7.1	30.3	3.2	-	-	-
	Crossbreed	98	OC	**31.0**	33.5	-	13.3	−8.3	**−8.1**	**26.5**	15	-	-	-
	Chios	100	EOC	**17.3**	18.7	**42.7**	**12.9**	−6.4	**−6.9**	**15.7**	**5**	-	-	-
	Chios	142	EOC	-	-	47.2	17.2	−8.8	−11.3	45.6	17.4	-	-	-
	Chios	199	EOC	**18.3**	14.2	**61.3**	**19.5**	−6.4	**−11.1**	**23.5**	**11.5**	-	-	-
	Crossbreed	244	OC	**55.6**	**66.5**	-	**42.0**	**−23.3**	**−14.9**	**48.2**	**22.3**	-	-	-
	Awassi	298	OC	**25.9**	0.0	2.7	**−18.1**	−5.3	−6.3	**22**	**−10.2**	−6.1	2.1	**13.4**
	Awassi	300	OC	**72.9**	−19.2	4.3	**−19.9**	−5.7	**−10.7**	**53.8**	−13.5	−5.6	**−16.0**	**−11.1**
	Friesian	751	OL	**30.3**	**24.9**	**71.1**	**121.9**	**121.7**	**−50.3**	**37.6**	**97.4**	-	-	-
	Saanen	100	OCS	9.3	-	-	−17.3	3.6	−2.2	11.1	−6.8	-	-	-
	Chios	142	EOC	-	-	47.2	17.2	−8.8	−11.3	45.6	17.4	-	-	-
	Alpine	702	OL	**34.4**	2.4	21.0	36.5	282.9	−6.5	23.1	**55.3**	-	-	-

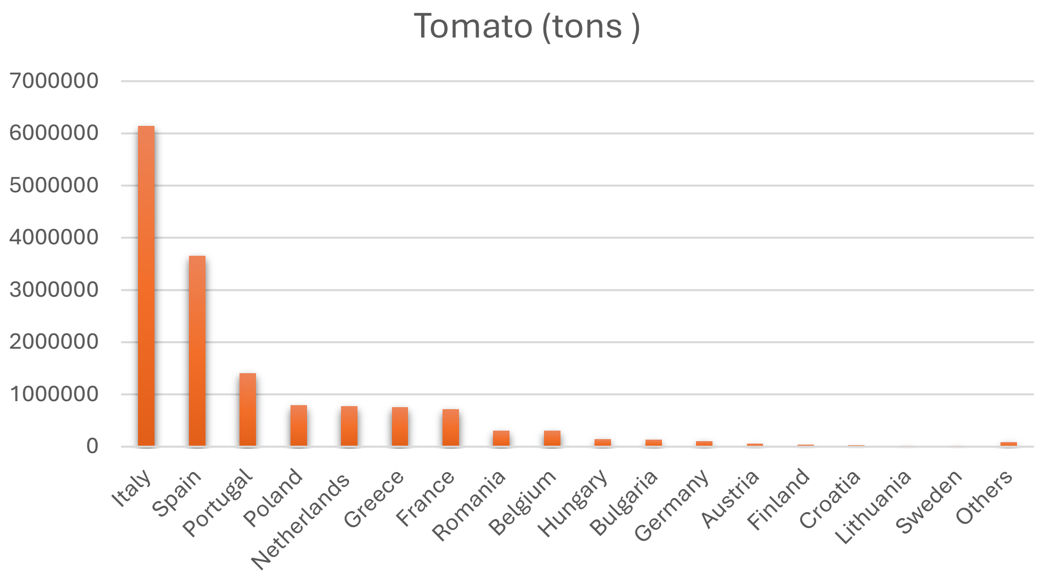
- Olive byproducts increased the nutritional quality of milk fat

Olive leaves increased LNA in sheep (+122%) and goat (+282%)

TOMATO by-product

Primary product (agroindustrial by-product)	Tomato (tomato pomace)
Primary product (tons)*	15,416,020
AIBP (%) from raw material**	5
AIBP, tons (FM)	770,801
AIBP, tons (DM)	94,809
Available protein (tons)	17,824
Available NDF (tons)	52,619

* FAOSTAT, 2022 (data for EU27); ** literature available;



FAOSTAT, 2022 (data for EU27)

Non-conventional byproducts: TOMATO

Chemical composition of Grape, Pomegranate, Olive, Tomato, Cocoa, Coffee, Citrus byproducts







	Grape		Pomegranate		Olive		Tomato		Cocoa		Spent coffee ground		Citrus	
	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max
By-product from processes, %	22	20-25	55.3	49.0-67.0	42.5	35-60	**5**	4-7.5	72.5	70-75	65		59	49-69
Moisture, %	71.2	63.0-81.7	-		44.4	32.0-60.0	**87.7**	78.4-97.0	80.2	-	57.6		79.8	76.7-81.9
Chemical composition														
Dry matter, % as fed	92.0	88.6-95.0	94.0	91.2-96.1	85.7	77.5-94.7	**92.7**	90.3-95.2	90.6	89.5-92.9	91.3		90.7	90.2-92.1
Protein, % DM	12.0	8.8-16.3	8.9	3.6-15.4	8.0	7.2-9.2	**17.2**	15.7-19.1	13.7	6.7-17.3	14.0	10.1-16.9	7.0	5.8-8.7
Fat, % DM	6.6	3.9-11.4	4.3	0.6-13.4	10.4	5.4-16.5	**9.3**	6.2-11.0	7.3	2.0-20.4	17	9.3-29.20	2.7	1.2-4.0
NDF, % DM	42.4	37.4-53.9	40.4	20.8-68.0	61.7	58.4-64.1	**58.4**	55.2-61.6	49.3	33-68.6	65.1	55.5-73	20.7	12.3-33.0
ADF, % DM	36.6	30.6-49.2	29.2	15.1-49.0	51.0	45.9-54.4	**48.5**	46.2-50.7	35.1	13.7-64.6	40.6	33.1-48	14.8	9.6-23.1
Ash, % DM	7.7	2.1-12.1	3.8	2.4-5.4	9.6	3.7-13.6	**4.1**	43.1-4.8	7.4	4.6-9.2	3.5	0.27-5.6	4.7	2.8-5.9
Total polyphenol, g/kg DM	35.9	3-90	52.8	27.2-95.3	10.9	4.1-17.7	**4.9**	2.3-6.4	28.9	9.1-43.9	12.5	10-15	10.6	2.1-57.7
Main fatty acids (% on total FA)														
Palmitic acid	9.6	5.5-12.5	3.8	3.5-4.2	13.1	9.1-17.5	**13.9**	11.5-15.6	24.5	22.4-26.8	33.0	31.8-33.8	24.5	17.7-29.4
Stearic acid	4.3	2.8-4.9	2.4	1.9-2.8	5.5	2.1-13.1	**4.2**	3.1-4.9	25.7	23.9-27.3	7.5	7.2-8.0	4.9	3.6-7.8
Oleic acid	15.2	9.6- 19.2	7.2	5.4-9.2	65.5	54.3-75.8	**19.7**	17.6-20.7	34.5	30.2-39.0	10.9	9.1-12.7	21	17.1-26.7
Linoleic acid	66.9	61.1-74.0	7.1	5.9-8.1	9.9	6.6-13.8	**54.8**	52.2-57.1	8.4	8.4-8.5	43.3	43-43.8	31.8	29.8-33.9
Alpha linolenic acid	1.4	0.2-3.7	0.2	0.1-0.4	0.9	0.3-1.46	**2.9**	2.6-3.2	0.6	0.5-0.7	1.1	0.8-1.5	5.7	2.6-8.2
Punicic acid	-		73.8	71.2-77.2	-		-		-		-			

Effect of Tomato by products on milk traits


foods MDPI

Review

Grape, Pomegranate, Olive, and Tomato By-Products Fed to Dairy Ruminants Improve Milk Fatty Acid Profile without Depressing Milk Production

Fabio Correddu, Maria Francesca Caratzu, Mondina Francesca Lunesu, Silvia Carta, Giuseppe Pulina and Anna Nudda *

Data are expressed as difference (in percentage) between treatment and control group

Species	Breeds	By-Product Inclusion g/kg of DMI [1]	By-Product Form [2]	Milk Traits		
				Yield	Fat	Protein
Dairy sheep	Sarda	39	TP	−2.2	−6.2	−6.5
	Awassi	300	TP	−5.8	−2.4	−5.1
Dairy goats	Murciano-Granadina	134	TP	−7.4	1.1	−2.3
	Saanen	200	TP	22.5	18.1	3.4
	Murciano-Granadina	202	TS	−3.0	13.1	−3.6
	Saanen	240	TP	−2.0	6.0	3.5
	Saanen	400	TP	28.3	25.1	9.2
	Saanen	600	TP	−13.3	8.6	2.4

Abbedou et al., 2011; Arco-Pérez et al., 2017; Mizael et al., 2020; Nudda et al.,2019; Romero-Huelva et al., 2012; Razzaghi et al., 2015

The tomato pomace in small ruminant diets evidenced a significant depressive effect on milk production traits only in goats at the highest dose tested (600 g/kg of DMI)

Effect of Tomato by products on milk fatty acids profile

Data are expressed as difference (in percentage) between treatment and control group

Species	Breeds	By-Product Inclusion g/kg of DMI [1]	By-Product Form [2]	Fatty Acids [3]					Groups of Fatty Acids [4]					
				OA	VA	RA	LA	LNA	SFA	MUFA	PUFA	n3	n6	n6/n3
Dairy sheep	Awassi	300	TP	**92.2**	25.6	**76.5**	**−10.4**	17.0	**−15.0**	**68.0**	5.5	−1.9	7.4	9.5
	Sarda	39	TP	4.9	27.0	17.4	2.3	**−13.3**	−1.8	4.4	3.4	**−11.4**	2.9	**13.8**
Dairy goats	Murciano-Granadina	13	TP	1.3	8.5	8.8	**11.9**	**38.5**	−1.7	3.0	**14.7**	-	-	-
	Murciano-Granadina	202	TS	3.6	**188.4**	**32.0**	9.9	−12.2	**−4.6**	**12.4**	4.9	**−18.8**	4.0	**28.0**
	Saanen	240	TP	**22.9**	**100.0**	-	−24.0	5.3	**−5.1**	**23.8**	−3.2	-	-	-

Abbedou et al., 2011; Arco-Pérez et al., 2017; Buffa et al., 2020; Romero-Huelva et al., 2012; Razzaghi et al., 2015

TS = tomato silage
TP = tomato pomace

VA

RA

SFA

LA

Tomato BP evidenced an overall decrease in SFA and LA and an increase in VA and RA as consequence of extensive biohydrogenation of LA to RA or to VA

Received: 3 October 2019 | Revised: 18 December 2019 | Accepted: 31 December 2019
DOI: 10.1111/jpn.13315

ORIGINAL ARTICLE

WILEY

Supplementation of by-products from grape, tomato and myrtle affects antioxidant status of dairy ewes and milk fatty acid profile

Giovanna Buffa[1] | Eleni Tsiplakou[2] | Christina Mitsiopoulou[2] | Giuseppe Pulina[1] | Anna Nudda[1]

Tomato by-products improve the antioxidant status of ewes

	Diet		P-value		
	CON	TP	D	S	D x S
FRAP, µmol ascorbic acid	0.86	0.95	*	**	NS
ABTS, % inhibition	31.38	33.69	**	***	NS
GST, Units/ml	0.234	0.229	NS	NS	NS
GR, Units/ml	0.050	0.053	NS	NS	NS
GPx, Units/ml	0.061	0.077	**	NS	*
SOD, Units/ml	13.339	13.312	NS	NS	NS
MDA, µM	0.476	0.594	**	NS	NS
PC, nmol/ml	7.403	7.449	NS	NS	NS

- Tomato byproducts improve the total antioxidant capacity of blood (> FRAP, >ABTS and >GPx)
- The MDA was higher in TP ewes probably related to oxidation of lipid in tomato BP during drying process

Non-conventional byproducts: COCOA

Chemical composition of Grape, Pomegranate, Olive, Tomato, Cocoa, Coffee, Citrus byproducts







	Grape		Pomegranate		Olive		Tomato		Cocoa		Spent coffee ground		Citrus	
	Mean	**Min-Max**	**Mean**	**Min-Max**	**Mean**	**Min-Max**	**Mean**	**Min-Max**	**Mean**	**Min-Max**	**Mean**	**Min-Max**	**Mean**	**Min-Max**
By-product from processes, %	22	20-25	55.3	49.0-67.0	42.5	35-60	5	4-7.5	**72.5**	70-75	**65**		59	49-69
Moisture, %	71.2	63.0-81.7	-		44.4	32.0-60.0	87.7	78.4-97.0	**80.2**	-	**57.6**		79.8	76.7-81.9
Chemical composition														
Dry matter, % as fed	92.0	88.6-95.0	94.0	91.2-96.1	85.7	77.5-94.7	92.7	90.3-95.2	**90.6**	89.5-92.9	**91.3**		90.7	90.2-92.1
Protein, % DM	12.0	8.8-16.3	8.9	3.6-15.4	8.0	7.2-9.2	17.2	15.7-19.1	**13.7**	6.7-17.3	**14.0**	10.1-16.9	7.0	5.8-8.7
Fat, % DM	6.6	3.9-11.4	4.3	0.6-13.4	10.4	5.4-16.5	9.3	6.2-11.0	**7.3**	2.0-20.4	**17.0**	9.3-29.20	2.7	1.2-4.0
NDF, % DM	42.4	37.4-53.9	40.4	20.8-68.0	61.7	58.4-64.1	58.4	55.2-61.6	**49.3**	33-68.6	**65.1**	55.5-73	20.7	12.3-33.0
ADF, % DM	36.6	30.6-49.2	29.2	15.1-49.0	51.0	45.9-54.4	48.5	46.2-50.7	**35.1**	13.7-64.6	**40.6**	33.1-48	14.8	9.6-23.1
Ash, % DM	7.7	2.1-12.1	3.8	2.4-5.4	9.6	3.7-13.6	4.1	43.1-4.8	**7.4**	4.6-9.2	**3.5**	0.27-5.6	4.7	2.8-5.9
Total polyphenol, g/kg DM	35.9	3-90	52.8	27.2-95.3	10.9	4.1-17.7	4.9	2.3-6.4	**28.9**	9.1-43.9	**12.5**	10-15	10.6	2.1-57.7
Main fatty acids (% on total FA)														
Palmitic acid	9.6	5.5-12.5	3.8	3.5-4.2	13.1	9.1-17.5	13.9	11.5-15.6	**24.5**	22.4-26.8	**33.0**	31.8-33.8	24.5	17.7-29.4
Stearic acid	4.3	2.8-4.9	2.4	1.9-2.8	5.5	2.1-13.1	4.2	3.1-4.9	**25.7**	23.9-27.3	**7.5**	7.2-8.0	4.9	3.6-7.8
Oleic acid	15.2	9.6- 19.2	7.2	5.4-9.2	65.5	54.3-75.8	19.7	17.6-20.7	**34.5**	30.2-39.0	**10.9**	9.1-12.7	21	17.1-26.7
Linoleic acid	66.9	61.1-74.0	7.1	5.9-8.1	9.9	6.6-13.8	54.8	52.2-57.1	**8.4**	8.4-8.5	**43.3**	43-43.8	31.8	29.8-33.9
Alpha linolenic acid	1.4	0.2-3.7	0.2	0.1-0.4	0.9	0.3-1.46	2.9	2.6-3.2	**0.6**	0.5-0.7	**1.1**	0.8-1.5	5.7	2.6-8.2
Punicic acid	-		73.8	71.2-77.7	-		-		**-**		**-**			

J. Dairy Sci. 103:1553–1558
https://doi.org/10.3168/jds.2019-17550

Short communication: **Cocoa husks can effectively replace soybean hulls in dairy sheep diets—Effects on milk production traits and hematological parameters**

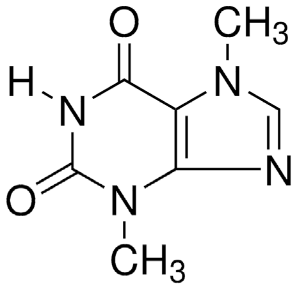
S. Carta,[1] A. Nudda,[1*] M. G. Cappai,[2] M. F. Lunesu,[1] A. S. Atzori,[1] G. Battacone,[1] and G. Pulina[1]
[1]Dipartimento di Agraria, Sezione di Scienze Zootecniche, Università degli studi di Sassari, 07100, Sassari, Italy
[2]Dipartimento di Medicina Veterinaria, Università degli studi di Sassari, 07100, Sassari, Italy

Cocoa husks contain Theobromine

- ✓ Pure alkaloid naturally present in cocoa products
- ✓ Has been found to be toxic to animals when ingested in large amounts
- ✓ **The limit of 300 mg of theobromine/kg of feedstuffs is imposed by EU legislation**

Theobroma cacao L.

Item	CH
Theobromine (mg/kg DM)	6850
Total polyphenol (g GAE/100 of DM)	3.36



Cocoa husks can replace soybean hulls (control) in dairy sheep diets without affect the milk production traits

	Group			
Item	SBH	CH50	CH100	P-value
Intake of DM/d	1.78	1.85	1.85	0.85
Yield (g/d)	1322	1303	1332	0.98
Milk composition				
Fat (%)	5.53	5.76	5.97	0.48
Protein (%)	5.95	5.77	5.98	0.74
Casein (%)	4.57	4.44	4.62	0.78
Lactose (%)	4.81	4.85	4.64	0.16
Urea (mg/dL)	43.20	46.73	42.28	0.36
Log SCC (×1,000 cell/mL)	2.29	2.09	2.00	0.58

J. Dairy Sci. 103:1553–1558
https://doi.org/10.3168/jds.2019-17550

***Short communication:* Cocoa husks can effectively replace soybean hulls in dairy sheep diets—Effects on milk production traits and hematological parameters**

S. Carta,[1] A. Nudda,[1*] M. G. Cappai,[2] M. F. Lunesu,[1] A. S. Atzori,[1] G. Battacone,[1] and G. Pulina[1]
[1]Dipartimento di Agraria, Sezione di Scienze Zootecniche, Università degli studi di Sassari, 07100, Sassari, Italy
[2]Dipartimento di Medicina Veterinaria, Università degli studi di Sassari, 07100, Sassari, Italy

Theobromine content:
- 130 mg/kg in CH50 diet
- 252 mg/kg in CH100 diet

hematological parameters were within the physiological range for the sheep

Item[1]	Reference values[2]	Group[3]			SEM	P-value[4]		
		SBH	CH50	CH100		D	S	D × S
White blood cell count (10^9/L)	5.10–15.80	9.02	8.97	10.47	0.37	NS	NS	NS
Neutrophil granulocytes (10^9/L)	1.32–8.96	2.67	3.28	3.74	0.19	NS	NS	NS
Lymphocytes (10^9/L)	2.01–7.80	5.22^{b}	4.76^{b}	5.69^{a}	0.18	*	†	NS
Monocytes (10^9/L)	0.00–1.52	0.53	0.50	0.57	0.04	NS	†	NS
Eosinophil granulocytes (10^9/L)	0.00–1.08	0.56	0.75	0.85	0.07	NS	NS	NS
Basophil granulocytes (10^9/L)	0.00–0.17	0.27^{a}	0.06^{b}	0.08^{b}	0.04	*	*	*
Neutrophil granulocytes (%)	0.215–0.680	0.19	0.24	0.23	0.01	†	NS	NS
Lymphocytes (%)	0.280–0.645	0.41	0.36	0.38	0.01	NS	NS	NS
Monocytes (%)	0.000–0.143	0.06	0.05	0.05	0.00	NS	*	NS
Eosinophil granulocytes (%)	0.000–0.080	0.05	0.06	0.06	0.00	NS	NS	NS
Basophil granulocytes (%)	0.000–0.015	0.02^{a}	0.01^{b}	0.01^{b}	0.00	*	†	*
Red blood cell count (10^{12}/L)	5.50–14.20	8.24	8.86	8.84	0.15	NS	NS	NS
Hemoglobin (g/L)	63–132	88.66	91.37	94.12	1.39	NS	†	NS
Hematocrit (%)	20–39	19	19	20	0.23	NS	NS	NS
MCH (pg)	8.00–12.30	11.08	10.53	10.87	0.10	†	†	*
MCHC (g/L)	290–360	328	327	326	1.72	NS	***	NS
RDW-CV (%)	0.17–0.26	0.14	0.13	0.13	0.00	NS	NS	NS
RDW-SD (fL)	20.00–35.00	27.89	25.98	25.84	0.35	†	**	NS
Platelet (10^9/L)	100–800	474	480	575	24.7	NS	†	*
Mean platelet volume (fL)	3.50–6.00	4.20	4.46	4.32	0.05	NS	***	NS
Platelet distribution width (fL)	12.0–17.5	15.13	15.19	15.17	0.04	NS	NS	NS
Plateletcrit (mL/L)	0.50–4.20	2.18	2.29	2.67	0.12	NS	NS	*
Electrophoretic profile								
Total protein (g/L)	60.0–79.0	70.0	70.1	70.1	1.12	NS	NS	NS
Albumin (g/L)	24.0–30.0	28.9	29.1	29.5	0.16	NS	NS	NS
α-Globulins (g/L)	3.0–6.0	4.53	4.28	4.05	0.97	NS	NS	NS
β_1-Globulins (g/L)	7.0–12.0	8.29	8.50	8.39	0.99	NS	NS	NS
β_2-Globulins (g/L)	4.0–14.0	12.2	10.8	11.2	5.52	NS	***	NS
γ-Globulins (g/L)	9.0–33.0	17.9	17.4	16.9	3.03	NS	***	NS

Cocoa husks in dairy sheep diets improve the antioxidant power of blood

Item	Diet			P-value
	SBH	CH50	CH100	
FRAP, μmol ascorbic acid	0.82	0.85	0.94	0.13
ABTS, % inhibition	40.9	40.6	41.1	0.97
GSTS, units/ml	0.17	0.19	0.12	0.54
GR, units/ml	0.03	0.03	0.03	0.67
GPx, units/ml	0.07	0.07	0.08	0.45
SOD, units/ml	**19.0**	**19.4**	**23.0**	**0.09**
MDA, μM	0.53	0.44	0.43	0.16
PC, nmol/ml	**2.9**	**2.7**	**2.2**	**<0.01**

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Cocoa husks fed to lactating dairy ewes affect milk fatty acid profile and oxidative status of blood and milk

Silvia Carta [a], Eleni Tsiplakou [b], Christina Mitsiopoulou [b], Giuseppe Pulina [a], Anna Nudda [a]

Cocoa husks (116.7 g/kg DM) can partially replace corn and barley of the CTRL concentrate in dairy sheep diets without affect the milk production traits

Effect of the inclusion of cocoa bean shell in the diet of lactating ewes on milk yield and milk and cheese composition.

Items	Dietary treatment[1] (D)		SEM	P-value[2]		
	CTRL	CBS		D	Time (T)	D × T
DM Intake (g/day)	2 080	2 070	22.9	0.823	0.165	0.998
Milk Yield (g/day)	628	627	78.36	0.989	0.011	0.289
FPCM[3] (g/day)	627	651	86.90	0.674	0.005	0.128
Milk composition (%)						
Fat	6.47	6.87	0.490	0.135	0.282	0.028
Protein	6.07	5.87	0.134	0.125	0.005	0.447
Lactose	4.39	4.25	0.071	0.095	0.001	0.040
Casein	4.72	4.54	0.118	0.085	0.005	0.382
Casein index[4]	77.8	77.3	0.427	0.055	0.005	0.551
Urea (mg/dl)	38.6	34.9	2.973	0.033	0.001	0.251
Linear Score[5]	4.21	3.81	1.05	0.665	0.009	0.278
Cheese composition (%)						
Moisture	35.7	34.8	0.687	0.390	<0.001	0.184
Fat	30.3	33.3	0.472	<0.001	0.009	0.012
Protein	25.8	23.7	0.414	0.003	0.260	0.360
Sodium chloride	2.24	2.22	0.069	0.907	0.016	0.387
Ash	5.89	5.96	0.099	0.751	0.198	0.838

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Cocoa byproduct inclusion in dairy sheep diet: Effects on sensory, volatile, and antioxidant properties of cheese

M. Caccamo,[1] G. Luciano,[2] T. Rapisarda,[1] V. M. Marino,[1] C. Pasta,[1] A. Natalello,[2]* G. Mangione,[2] B. Valenti,[3] A. Campione,[3] G. Marino,[1] and M. Pauselli[3]
[1]Consorzio per la Ricerca nel settore della Filiera Lattiero-Casearia e dell'agroalimentare (CoRFiLaC), Regione Siciliana, 97100 Ragusa, Italy
[2]Department of Agriculture, Food and Environment (Di3A), University of Catania, 95123 Catania, Italy
[3]Department of Agricultural, Food and Environmental Sciences (DSA3), University of Perugia, 06121 Perugia, Italy

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Inclusion of cocoa by-product in the diet of dairy sheep: Effect on the fatty acid profile of ruminal content and on the composition of milk and cheese

A. Campione[a], M. Pauselli[a], A. Natalello[b], B. Valenti[a,*], C. Pomente[a], M. Avondo[b], G. Luciano[b], M. Caccamo[c], L. Morbidini[a]

Non-conventional byproducts: COFFEE

Chemical composition of Grape, Pomegranate, Olive, Tomato, Cocoa, Coffee, Citrus byproducts

      

	Grape		Pomegranate		Olive		Tomato		Cocoa		Spent coffee ground		Citrus	
	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max
By-product from processes, %	22	20-25	55.3	49.0-67.0	42.5	35-60	5	4-7.5	72.5	70-75	**65**		59	49-69
Moisture, %	71.2	63.0-81.7	-		44.4	32.0-60.0	87.7	78.4-97.0	80.2	-	**57.6**		79.8	76.7-81.9
Chemical composition														
Dry matter, % as fed	92.0	88.6-95.0	94.0	91.2-96.1	85.7	77.5-94.7	92.7	90.3-95.2	90.6	89.5-92.9	**91.3**		90.7	90.2-92.1
Protein, % DM	12.0	8.8-16.3	8.9	3.6-15.4	8.0	7.2-9.2	17.2	15.7-19.1	13.7	6.7-17.3	**14.0**	10.1-16.9	7.0	5.8-8.7
Fat, % DM	6.6	3.9-11.4	4.3	0.6-13.4	10.4	5.4-16.5	9.3	6.2-11.0	7.3	2.0-20.4	**17.0**	9.3-29.20	2.7	1.2-4.0
NDF, % DM	42.4	37.4-53.9	40.4	20.8-68.0	61.7	58.4-64.1	58.4	55.2-61.6	49.3	33-68.6	**65.1**	55.5-73	20.7	12.3-33.0
ADF, % DM	36.6	30.6-49.2	29.2	15.1-49.0	51.0	45.9-54.4	48.5	46.2-50.7	35.1	13.7-64.6	**40.6**	33.1-48	14.8	9.6-23.1
Ash, % DM	7.7	2.1-12.1	3.8	2.4-5.4	9.6	3.7-13.6	4.1	43.1-4.8	7.4	4.6-9.2	**3.5**	0.27-5.6	4.7	2.8-5.9
Total polyphenol, g/kg DM	35.9	3-90	52.8	27.2-95.3	10.9	4.1-17.7	4.9	2.3-6.4	28.9	9.1-43.9	**12.5**	10-15	10.6	2.1-57.7
Main fatty acids (% on total FA)														
Palmitic acid	9.6	5.5-12.5	3.8	3.5-4.2	13.1	9.1-17.5	13.9	11.5-15.6	24.5	22.4-26.8	**33.0**	31.8-33.8	24.5	17.7-29.4
Stearic acid	4.3	2.8-4.9	2.4	1.9-2.8	5.5	2.1-13.1	4.2	3.1-4.9	25.7	23.9-27.3	**7.5**	7.2-8.0	4.9	3.6-7.8
Oleic acid	15.2	9.6- 19.2	7.2	5.4-9.2	65.5	54.3-75.8	19.7	17.6-20.7	34.5	30.2-39.0	**10.9**	9.1-12.7	21	17.1-26.7
Linoleic acid	66.9	61.1-74.0	7.1	5.9-8.1	9.9	6.6-13.8	54.8	52.2-57.1	8.4	8.4-8.5	**43.3**	43-43.8	31.8	29.8-33.9
Alpha linolenic acid	1.4	0.2-3.7	0.2	0.1-0.4	0.9	0.3-1.46	2.9	2.6-3.2	0.6	0.5-0.7	**1.1**	0.8-1.5	5.7	2.6-8.2
Punicic acid	-		73.8	71.2-77.2	-		-		-		**-**			

Phenolic profile of spent ground coffee

Polyphenols	mg/kg
Caffeic acid	885
Catechol	141
5-Caffeoylquinic acid	158
1,2,4 benzenetriol	<0.1
Trigonellin	12.5
Ferulic acid	**12393**
Niacin	0.75

Alkaloids	mg/kg
Caffeine	894
Theobromine/Theophylline	283

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> Dis Markers. 2022 Oct 11:2022:4607966. doi: 10.1155/2022/4607966. eCollection 2022.

Ferulic Acid Mitigates Growth and Invasion of Esophageal Squamous Cell Carcinoma through Inducing Ferroptotic Cell Death

Ferulic Acid Stabilizes a Solution of Vitamins C and E and Doubles its Photoprotection of Skin

Fu-Hsiung Lin,* Jing-Yi Lin,† Ravindra D. Gupta,* Joshua A. Tournas,* James A. Burch,* M. Angelica Selim,* Nancy A. Monteiro-Riviere,‡ James M. Grichnik,* Jan Zielinski,§ and Sheldon R. Pinnell*
*Duke University Medical Center, Durham, North Carolina, USA; †Chang Gung Memorial Hospital, Taipei, Taiwan; ‡North Carolina State University, Raleigh, North Carolina, USA; §Zielinski Research, San Diego, California, USA

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Ferulic acid nanocapsules as a promising treatment modality for colorectal cancer: Preparation and *in vitro/in vivo* appraisal

Review > Front Pharmacol. 2023 May 31:14:1207999. doi: 10.3389/fphar.2023.1207999. eCollection 2023.

Molecular mechanism and research progress on pharmacology of ferulic acid in liver diseases

> Oncol Rep. 2016 Jul;36(1):271-8. doi: 10.3892/or.2016.4804. Epub 2016 May 12.

Ferulic acid exerts antitumor activity and inhibits metastasis in breast cancer cells by regulating epithelial to mesenchymal transition

Xiang Zhang [1], Dan Lin [2], Rong Jiang [3], Hongzhong Li [4], Jingyuan Wan [2], Hongyuan Li [1]

> Tumour Biol. 2016 Feb;37(2):1933-40. doi: 10.1007/s13277-015-3984-z. Epub 2015 Sep 3.

Anti-proliferative and anti-invasive effects of ferulic acid in TT medullary thyroid cancer cells interacting with URG4/URGCP

Spent ground coffee in the sheep and goat diets

Milk yield and composition, intake, dry matter digestibility, average daily weight gain and body conditioning score of dairy ewes fed with increasing levels of coffee grounds in the concentrate.

Item	SCG inclusion level (g/kg DM)					Polynomial contrast	
	0	30	50	100	SEM	*L*	*Q*
Yield (g/day)							
Milk	1982	1984	2203	1987	12.5	0.14	< 0.001
FPCM	1650	1741	1831	1828	48.8	0.099	0.14
Fat	101	108	114	119	3.9	0.002	0.36
Protein	86.0	92.2	95.8	93.2	2.00	< 0.001	0.043
Lactose	100	103	110	101	2.4	0.66	0.007
Efficiency							
Milk yield per kg DMI (g/kg)	924	957	1042	921	32.5	0.95	0.011
FPCM per kg DMI (g/kg)	761	804	846	833	28.7	0.077	0.18
Milk composition (g/kg)							
Protein	44.0	45.4	45.9	46.8	0.49	< 0.001	0.038
Fat	50.7	57.4	53.4	60.0	1.13	< 0.001	0.89
Lactose	50.3	50.8	52.4	51.5	0.40	0.021	0.012
Intake (kg DM/day)							
Forage	1.39	1.31	1.32	1.34	0.319	0.80	0.60
Total	2.28	2.26	2.22	2.23	0.319	0.80	0.60

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valorisation of spent coffee grounds as functional feed improves productive performance of Latxa dairy ewes

X. Díaz de Otálora[a,*], R. Ruiz[a], I. Goiri[a], J. Rey[a], R. Atxaerandio[a], D. M. Orive[b], B. Iñarra[b], J. Zufia[b], J. Urkiza[c], A. García-Rodríguez[a]

Effect of dietary supplementation of two doses of spent coffee ground on goat milk yield and composition.

Items	Diet			SEM	*P*-value	
	CON	SCG50	SCG100		L	Q
Yield (g/d)						
Milk	3 680.9	3 592.0	3815.5	58.12	0.669	0.508
Fat	115.65	107.70	114.21	1.88	0.900	0.343
Protein	111.08	103.98	110.10	1.63	0.910	0.333
Lactose	162.05	156.45	164.25	2.66	0.866	0.549
Urea	1.37	1.30	1.29	0.02	0.082	0.615
Milk composition						
Fat (%)	3.16	3.01	3.02	0.04	0.521	0.740
Protein (%)	3.03	2.92	2.89	0.02	0.273	0.688
Lactose (%)	4.41	4.36	4.29	0.02	0.205	0.848
Urea (mg/dl)	37.53	36.61	33.73	0.53	0.411	0.671
Log SCC (1 000 cell/ml)	2.66	2.46	2.89	0.04	0.074	<0.001
NaCl	302.50	325.57	334.16	3.08	0.051	0.666

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S. Carta[a], E. Tsiplakou[b], P. Nicolussi[c], G. Pulina[a], A. Nudda[a,*]

Spent ground coffee supplementation to goats increased the antioxidant parameters of blood

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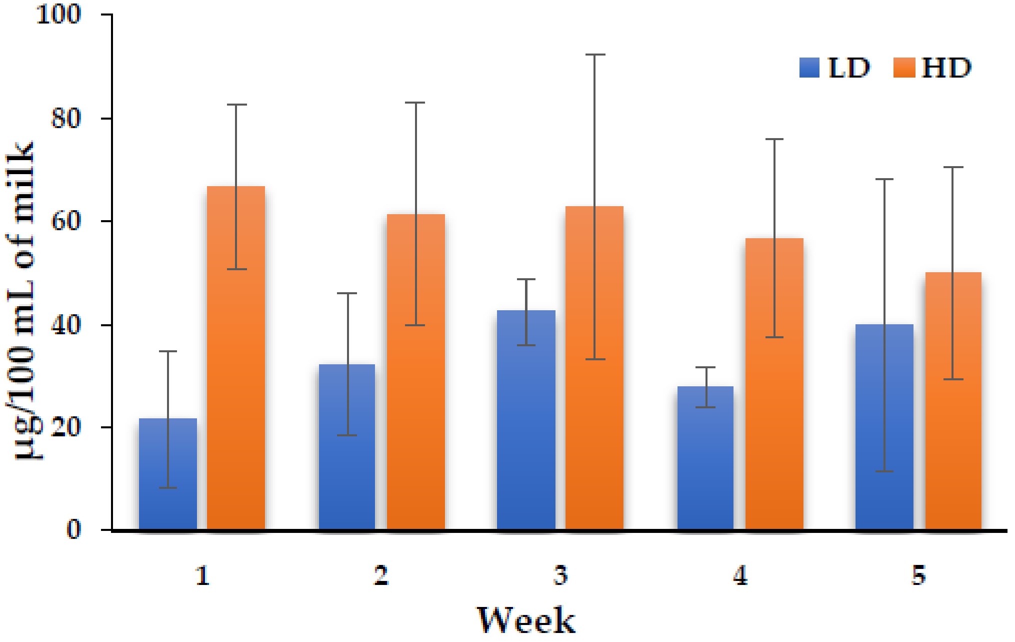
Effects of spent coffee grounds on production traits, haematological parameters, and antioxidant activity of blood and milk in dairy goats

S. Carta[a], E. Tsiplakou[b], P. Nicolussi[c], G. Pulina[a], A. Nudda[a,*]

Item	Diet			SEM	P-value	
	D0	D50	D100		L	Q
FRAP, µmol ascorbic acid	0.72	0.71	0.82	0.02	0.02	0.06
ABTS, % inhibition	34.2	32.0	31.9	0.51	0.10	0.39
MDA, µM	0.78	0.68	0.66	0.02	0.01	0.40
PC, nmol/ml	8.89	8.81	8.72	0.21	0.61	0.98

SGC intake transfer caffeine and caffeine metabolites into the milk.



Milk caffeine in low dose (LD) and high dose (HD) groups supplemented with spent ground coffee across the five weeks of experimentation.

Caffeine levels were not detectable in the control samples.

The carry-over of <u>caffeine</u> from diet to goat milk was about 3%

applied sciences

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Article

UHPLC-QTOF/MS Untargeted Lipidomics and Caffeine Carry-Over in Milk of Goats under Spent Coffee Ground Enriched Diet

Mattia Casula [1], Paola Scano [1,*], Cristina Manis [1], Giulia Tolle [1], Anna Nudda [2], Silvia Carta [2], Giuseppe Pulina [2] and Pierluigi Caboni [1]

Non-conventional byproducts: CITRUS

Chemical composition of Grape, Pomegranate, Olive, Tomato, Cocoa, Coffee, Citrus byproducts







	Grape		Pomegranate		Olive		Tomato		Cocoa		Spent coffee ground		Citrus	
	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max
By-product from processes, %	22	20-25	55.3	49.0-67.0	42.5	35-60	5	4-7.5	72.5	70-75	65		59	49-69
Moisture, %	71.2	63.0-81.7	-		44.4	32.0-60.0	87.7	78.4-97.0	80.2	-	57.6		79.8	76.7-81.9
Chemical composition														
Dry matter, % as fed	92.0	88.6-95.0	94.0	91.2-96.1	85.7	77.5-94.7	92.7	90.3-95.2	90.6	89.5-92.9	91.3		90.7	90.2-92.1
Protein, % DM	**12.0**	8.8-16.3	**8.9**	3.6-15.4	**8.0**	7.2-9.2	**17.2**	15.7-19.1	**13.7**	6.7-17.3	**14.0**	10.1-16.9	**7.0**	5.8-8.7
Fat, % DM	**6.6**	3.9-11.4	**4.3**	0.6-13.4	**10.4**	5.4-16.5	**9.3**	6.2-11.0	**7.3**	2.0-20.4	**17**	9.3-29.20	**2.7**	1.2-4.0
NDF, % DM	42.4	37.4-53.9	40.4	20.8-68.0	61.7	58.4-64.1	58.4	55.2-61.6	49.3	33-68.6	65.1	55.5-73	20.7	12.3-33.0
ADF, % DM	36.6	30.6-49.2	29.2	15.1-49.0	51.0	45.9-54.4	48.5	46.2-50.7	35.1	13.7-64.6	40.6	33.1-48	14.8	9.6-23.1
Ash, % DM	7.7	2.1-12.1	3.8	2.4-5.4	9.6	3.7-13.6	4.1	43.1-4.8	7.4	4.6-9.2	3.5	0.27-5.6	4.7	2.8-5.9
Total polyphenol, g/kg DM	35.9	3-90	52.8	27.2-95.3	10.9	4.1-17.7	4.9	2.3-6.4	28.9	9.1-43.9	12.5	10-15	10.6	2.1-57.7
Main fatty acids (% on total FA)														
Palmitic acid	9.6	5.5-12.5	3.8	3.5-4.2	13.1	9.1-17.5	13.9	11.5-15.6	24.5	22.4-26.8	33.0	31.8-33.8	24.5	17.7-29.4
Stearic acid	4.3	2.8-4.9	2.4	1.9-2.8	5.5	2.1-13.1	4.2	3.1-4.9	25.7	23.9-27.3	7.5	7.2-8.0	4.9	3.6-7.8
Oleic acid	15.2	9.6- 19.2	7.2	5.4-9.2	65.5	54.3-75.8	19.7	17.6-20.7	34.5	30.2-39.0	10.9	9.1-12.7	21	17.1-26.7
Linoleic acid	66.9	61.1-74.0	7.1	5.9-8.1	9.9	6.6-13.8	54.8	52.2-57.1	8.4	8.4-8.5	43.3	43-43.8	31.8	29.8-33.9
Alpha linolenic acid	1.4	0.2-3.7	0.2	0.1-0.4	0.9	0.3-1.46	2.9	2.6-3.2	0.6	0.5-0.7	1.1	0.8-1.5	5.7	2.6-8.2
Punicic acid	-		73.8	71.2-75.1	-		-		-		-			

Citrus by-products in dairy sheep

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Effect of the inclusion of fresh lemon pulp in the diet of lactating ewes on the properties of milk and cheese

M. Todaro[a,*], M. Alabiso[a], M.L. Scatassa[b], A. Di Grigoli[a], F. Mazza[a], G. Maniaci[a], A. Bonanno[a]

The fresh lemon pulp decrease milk yield with the highest dose (= 2 kg/day).

M. Todaro et al. *Animal Feed Science and Technology 225 (2017) 213–223*

Table 3
Effects of diet on milk yield and composition (least square means).

	FLP0	FLP1	FLP2	SEM[1]	*P*-value
Daily milk yield (g/day)	369^{A}	355^{A}	323^{B}	34	0.001
Fat (g/kg)	81.4	79.0	82.3	2.5	0.191
Protein (g/kg)	66.8^{ab}	66.4^{a}	68.6^{b}	2.3	0.046
Casein (g/kg)	51.9^{ab}	51.3^{a}	53.3^{b}	2.0	0.033
Urea (mg/dl)	27.9^{Aa}	31.5^{Bb}	30.5^{ABb}	1.30	0.011
Lactose (g/kg)	41.1	40.5	40.5	0.8	0.353
Somatic cell count ($\log_{10}$ n. cells/ml)	5.41	5.62	5.46	0.21	0.538
pH	6.82	6.81	6.83	0.04	0.681
Titratable acidity (°SH/50 ml)	5.82	5.75	5.95	0.26	0.412

..but increased in cheese the total phenolic content and their antioxidant activity, proportional to the level of by-product intake.

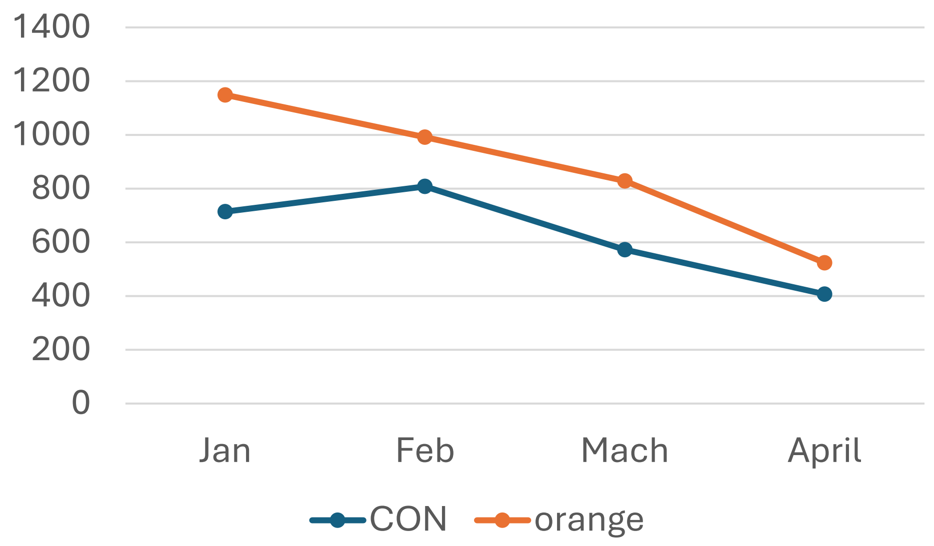
Table 5
Cheese quality characteristics (least square means).

	FLP0	FLP1	FLP2	SEM[1]	*P*-value
Bulk milk fat (g/kg)	80.9	83.3	85.3	7.7	0.921
Bulk milk protein (g/kg)	67.5	69.4	67.3	3.6	0.913
Cheese yield (kg cheese/100 l of milk)	19.1	22.5	21.3	1.88	0.484
Cheese DM[2] (kg cheese DM/100 l of milk)	62.5	60.8	63.1	1.30	0.474
Cheese protein (g/kg DM)	454	439	457	19.9	0.792
Cheese fat (g/kg DM)	410	449	414	31.2	0.653
Cheese total phenolic compounds (g GAE[3]/kg DM)	1.35^{A}	7.47^{B}	10.4^{C}	1.22	0.011
TEAC[4] (mmol Trolox/100 g DM)	1.24^{a}	2.94^{b}	2.38^{b}	0.47	0.051
Phenolic compounds recovery (%)	0.75^{A}	3.27^{B}	3.46^{B}	0.23	0.001

fresh lemon pulp 1 kg/day of FLP (FLP12 kg/day of FLP (FLP2).

Citrus by-products in dairy sheep

The dried orange pulp increase (P<0,01) MY in Comisana ewes



The dried orange pulp in dose of 10% (DM basis) in replacing the cane molasses and beet pulp present in the pelleted feed of the control group.

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Effect of Molasses and Dried Orange Pulp as Sheep Dietary Supplementation on Physico-Chemical, Microbiological and Fatty Acid Profile of Comisana Ewe's Milk and Cheese

Luigi Liotta[1], Cinzia L. Randazzo[2], Nunziatina Russo[2], Alessandro Zumbo[1], Ambra Rita Di Rosa[1], Cinzia Caggia[2] and Vincenzo Chiofalo[3]*

The AIBP in sheep diets tended to decrease milk somatic cell counts.

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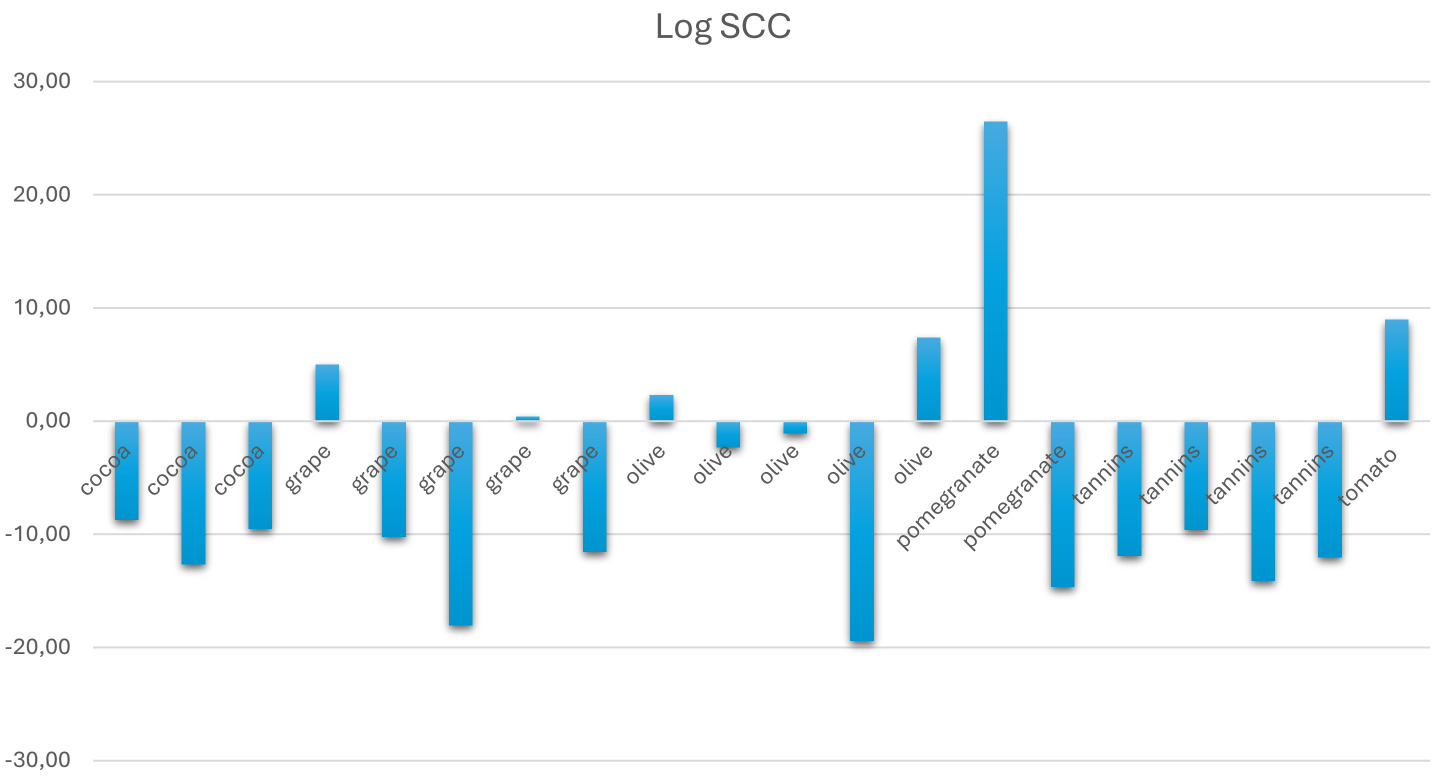
MDPI

Review

Feeding and Nutritional Factors That Affect Somatic Cell Counts in Milk of Sheep and Goats

Anna Nudda *, Silvia Carta, Gianni Battacone and Giuseppe Pulina



Data are expressed as difference (in percentage) between the treatment and the control group

Final remarks

Benefits

- Non-conventional agro-industrial BP rich in polyphenols could be included in concentrate formulation as “functional ingredients” or to replace ingredients with high digestible fiber
- Proper polyphenol amount improve the antioxidant "power" of animals and milk.
- Polyphenols could improve animal health status and contribute to reduce the use of drugs in the livestock sector.

Limitations

- High amount of water
- Technical tool for preservation and storage often has high costs and energy consumption.
- Seasonal production
- Spatial dispersion
- Molecules with potential negative effects (e.g. theobromine)

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Thanks for your attention

Anna Nudda: anudda@uniss.it

NextGenerationEU; PNRR M4C2, CN00000022 AGRITECH.