Utilization of orange peels as a high value secondary feedstuff for dairy sheep

M. A. Karatzia[1], V. Kotsampasi[1], Z. Basdagianni[2], S. Mai[3], E. M. Barampouti[3], E. Kasapidou[4]

[1] ELGO-Dimitra, Research Institute of Animal Science, Paralimni, 58100 Giannitsa, Greece, [2] AUTH, Laboratory of Animal Production, School of Agriculture, 54124 Thessaloniki, Greece, [3] NTUA, School of Chemical Engineering, Unit of Environmental Science & Technology, 15780 Athens, Greece, [4] UOWM, School of Agriculture, Terma Kontopoulou, 53100 Florina, Greece

karatzia@elgo.gr

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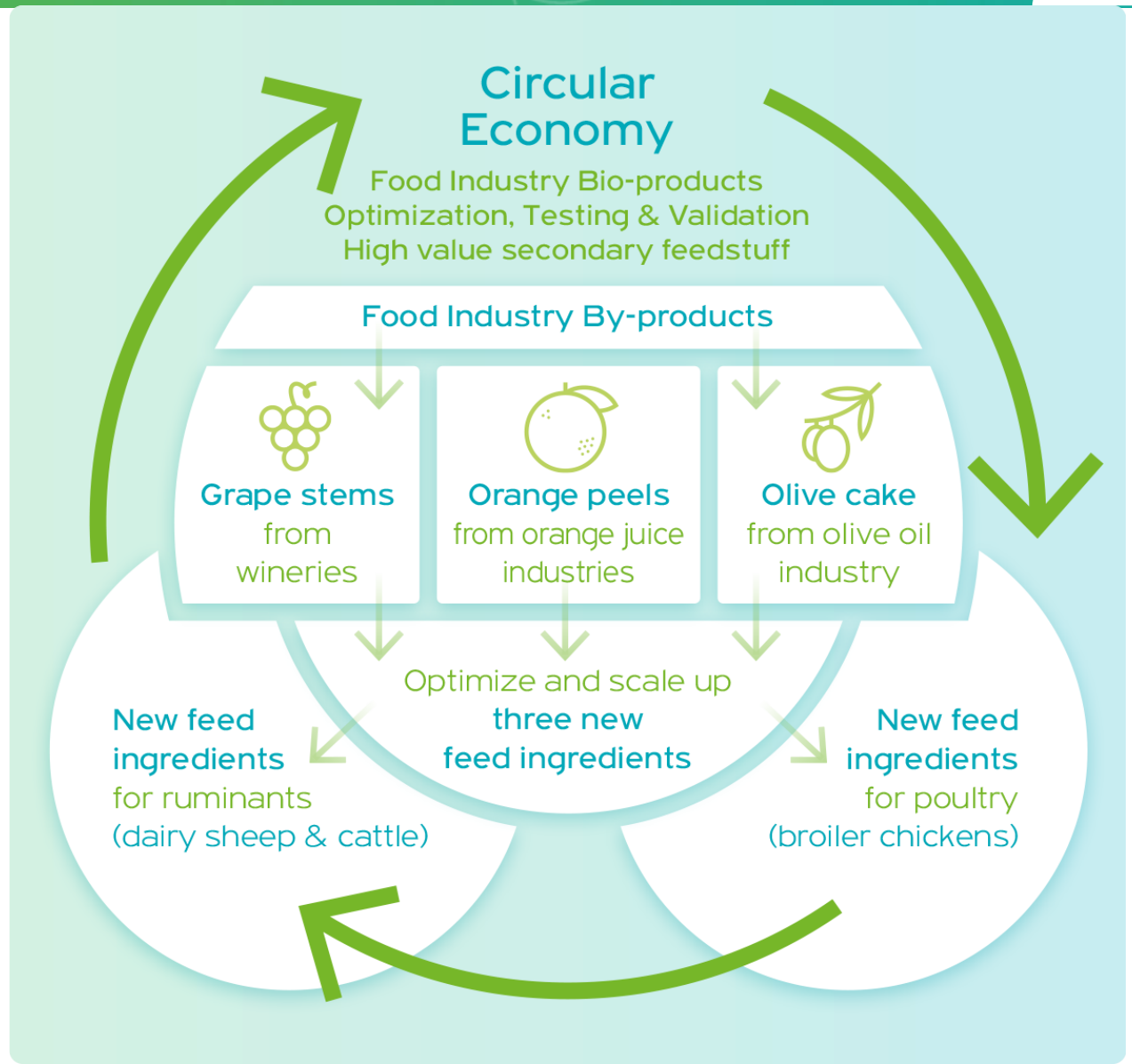
FEED FROM FOOD INDUSTRY BY-PRODUCTS

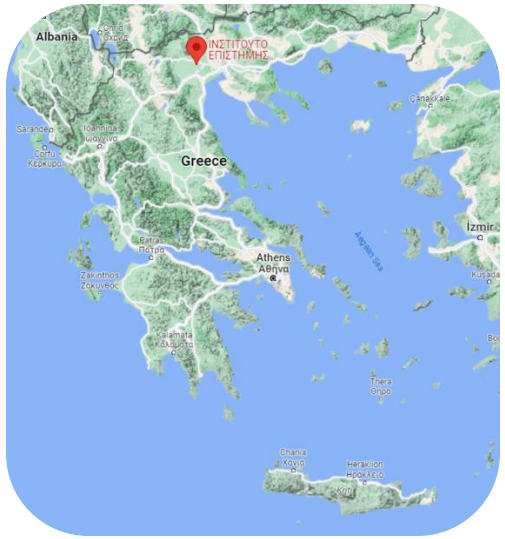
*Adoption of three circular economy approaches in livestock systems by valorizing food by-products (winery, orange juice & olive oil) as **alternative feed for livestock** (dairy cattle and sheep & broiler chicken) to produce new products (dairy & meat) for human consumption.*



*Valorization of three local crops by-products (**grape stem, orange peel and olive cake**) for animal feed by adapting three strategies to the local industry and livestock, but **replicable to Mediterranean areas**.*

Case study 2: Orange peel-based ingredients for dairy sheep

Sheep farm of the Research Institute of Animal Science of HAO-Dimitra



Two sheep flocks of indigenous breeds

Chios

Florina

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FEED FROM FOOD INDUSTRY BY-PRODUCTS

PRIMA
PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

ΣΕΒΤ

Provision of orange peels

National Technical University of Athens

Scaling up the entire process to produce improved ingredients and examining the performance of the system

HELLENIC AGRICULTURAL ORGANIZATION - DEMETER

Definition and production of experimental diets and performing the feed efficiency trials

UNIVERSITY OF WESTERN MACEDONIA

Production and characterization of the yoghurt and development of the sensory evaluation

New ingredient production

WP2

✓ **Validation** of the **production** of the new ingredient

✓ Obtaining of **new feedstuff**

✓ **Composition** of dried unprocessed orange peels ad feedstuff prepared under the implemented strategy

Composition of the new ingredient

Parameter	Dried unprocessed orange peels	Feedstuff prepared under the optimum conditions
TS (%)	91.27	94.78
Moisture (%)	8.73	5.22
ASH (%)	4.81	5.03
VS (%)	95.19	94.97
Oil (%)	2.71	2.25
TN(%)	1.15	2.36
Crude Protein (%)	7.18	14.75
Cellulose (%)	20.58	6.80
Hemicellulose (%)	24.62	17.94
Acid Insoluble Residue (%)	12.98	18.92
Ether extract (%)	3.57	2.96
Neutral detergent fibre (NDF) (%)	38.32	28.54
Acid detergent fibre (ADF) (%)	29.66	17.81
Lignin Acid Detergent (ADL) (%)	5.24	6.43
In vitro organic matter digestibility (IVOMD) (%)	72.7	89.5

Composition of the experimental diets

Ingredient composition	Diet		
	Control	EMA	EMB
Corn grain (ground)	300	300	300
Barley grain (ground)	200	200	200
Wheat bran	200	120	120
Soyabean meal	110	110	110
Sunflower meal	150	120	120
Experimental feedstuff	0	110	110
Limestone	5	5	5
Monocalcium phosphate	5	5	5
Salt	5	5	5
Vitamin & mineral premix	25	25	25
Total	1000	1000	1000

Chemical composition of the experimental diets

Chemical composition	Diet		
	Control	EMA	EMB
Dry matter (as fed)	836.75	841.70	845.56
Crude protein	148.43	140.57	148.90
Crude fat	19.12	21.56	20.89
Crude fibre	61.67	73.35	58.19
Neutral detergent fibre	153.21	171.44	160.68
Acid detergent lignin	74.59	94.34	81.30
Acid detergent fibre	3.61	8.68	9.99
Ash	25.70	27.52	27.76

Preliminary animal trial with unprocessed dried orange peels (March-April 2022)

Sheep farm of the Research Institute of Animal Science of HAO-Demeter

- The dried unprocessed orange peels was incorporated well in the ewes' daily ration
- After 2 days of adaptation, they consumed the new ingredient easily with no denials

New feedstuff production

250 kg (unprocessed) + 250 kg (processed) of feedstuff were produced out of 2,5 tonnes of raw material (orange peels)

Feed efficiency animal trial

Formulation of isonitrogenous and isoenergetic diets will be formulated by substituting conventional feed ingredients and by meeting the nutrient requirements (done in WP2, re-evaluated for fine-tuning)

Experimental Feedstuff Composition

Parameter	Without Process	After Process
Total Solids (% d.b)	91,85	85,62
Moisture (% d.b)	8,15	14,38
Volatile Solids (% d.b)	91,35	94,16
Ash (% d.b)	8,65	5,84
Oils (% d.b)	0,25	0,00
Water Soluble Solids (% d.b)	35,99	49,00
Free Glucose (% d.b)	0,85	0,67
Starch (% d.b)	2,39	2,51
Cellulose (% d.b)	17,47	11,28
Hemicellulose (% d.b)	30,70	18,40
Acid Soluble Lignin (% d.b)	1,06	0,83
Acid Insoluble Lignin (% d.b)	10,70	9,30
TN (% d.b)	1,38	2,89
NDF (% d.b)	34,1	34,0
ADF (% d.b)	24,8	22,8
ADL (% d.b)	9,8	6,4

Experimental Ration Composition

Formulation of isonitrogenous and isoenergetic diets will be formulated by substituting conventional feed ingredients and by meeting nutrient requirements (done in pre-trial, re-evaluated for fine-tuning)

	Diet		
Ration composition	**Control**	**EMA**	**EMB**
Corn grain	300	300	300
Barley grain	200	200	200
Wheat grain	200	120	120
Soyabean meal	110	110	110
Sunflower meal	150	120	120
Experimental feedstuff	0	110	110
Limescale	5	5	5
Monocalcium phosphate	5	5	5
Salt	5	5	5
Vitamin and mineral premix	25	25	25

Plus
1 kg of alfalfa hay and 0.3 kg of straw per ewe/day

Feed efficiency animal trial

- ✓ Allocation of ewes in 3 groups of 12 (control, experimental material A, experimental material B)
- ✓ Housed in separate floor pens and fed individually for a period of 84 days
- ✓ Starting on the day after weaning until the 16th week of lactation

- ✓ Evening and morning milk production calculation and allocation in groups according to production, lactation and days in milk

Feed efficiency animal trial

Feed efficiency trial

Recorded parameters:

- Daily milk yield
- Chemical composition and total bacterial count of individual milk samples
- Daily feed intake and refusals
- Environmental indices
- Health and welfare
- Life cycle analysis data

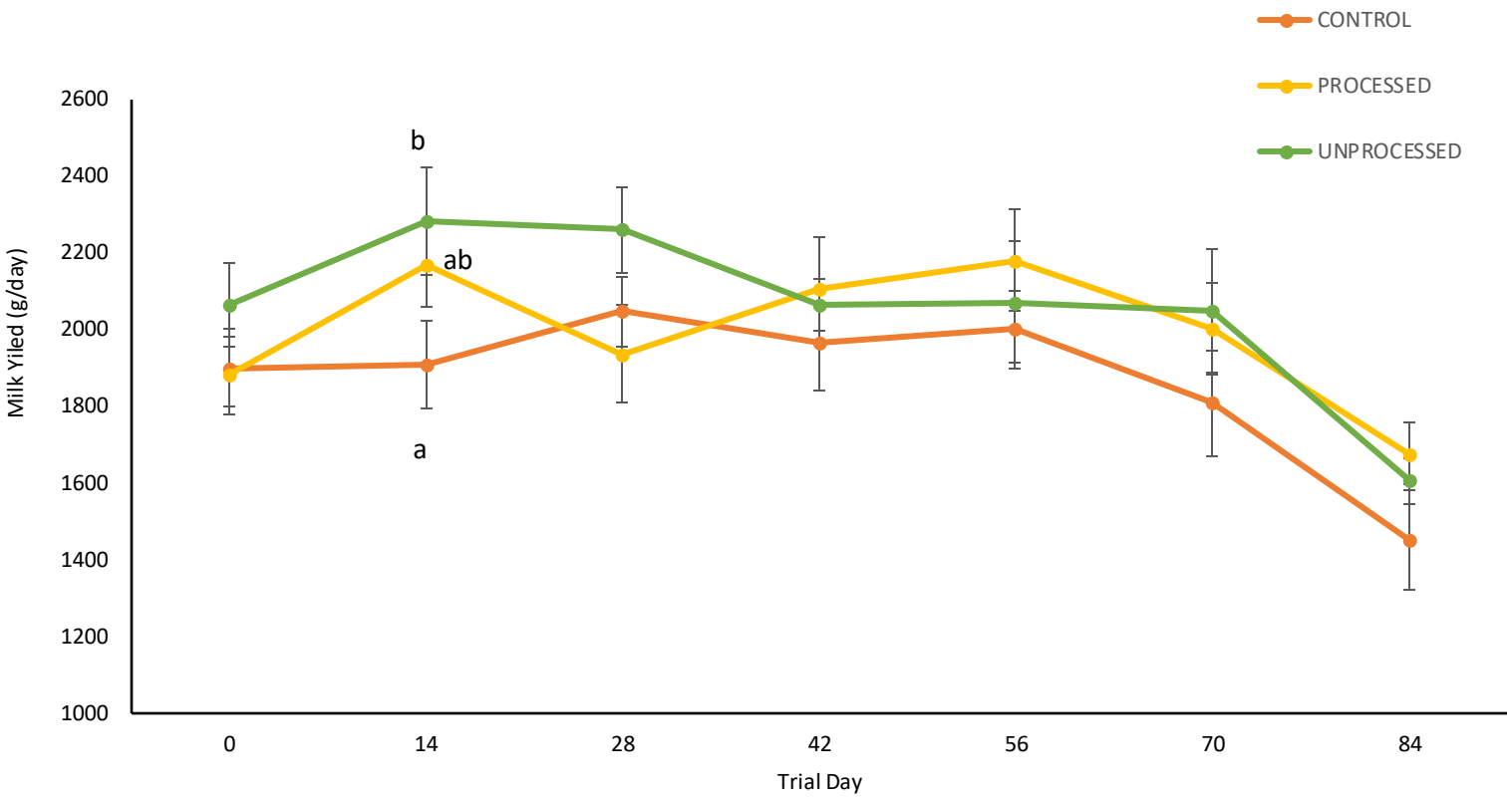
873P

Batch	873P
Batch Date	08/03/23
Total	39
Lab Date	09/03/23
Lab 1	
Lab 2	
Ext 1	
Ext 2	
Ext 3	
Batch Type	Normal
Program	Default BactoScan FC

#inWS	#inJob	#Sub	IBC	Signal mean	CFU	ID	Time	ResultType	BottleType
5	1	1	14334		1523		10:24:16	Normal	Normal
6	2	1	26170		3134		10:24:52	Normal	Normal
7	3	1	9441		1003		10:25:28	Normal	Normal
8	4	1	3586		491		10:26:04	Normal	Normal
9	5	1	14607		1552		10:26:40	Normal	Normal
10	6	1	6327		724		10:27:15	Normal	Normal
11	7	1	4037		533		10:27:51	Normal	Normal
12	8	1	18545		2194		10:28:27	Normal	Normal
13	9	1	1947		293		10:29:03	Normal	Normal
14	10	1	25233		3039		10:29:39	Normal	Normal
15	11	1	1458		223		10:30:15	Normal	Normal
					335		10:30:51	Normal	Normal
					57		10:31:27	Normal	Normal
							10:32:03	Normal	Normal
							10:32:39	Normal	Normal
							10:33:15	Normal	Normal
							10:33:51	Normal	Normal
							10:34:26	Normal	Normal
							10:35:02	Normal	Normal
							10:35:38	Normal	Normal
							10:36:14	Normal	Normal
							10:36:50	Normal	Normal
							10:37:26	Normal	Normal
							10:38:02	Normal	Normal

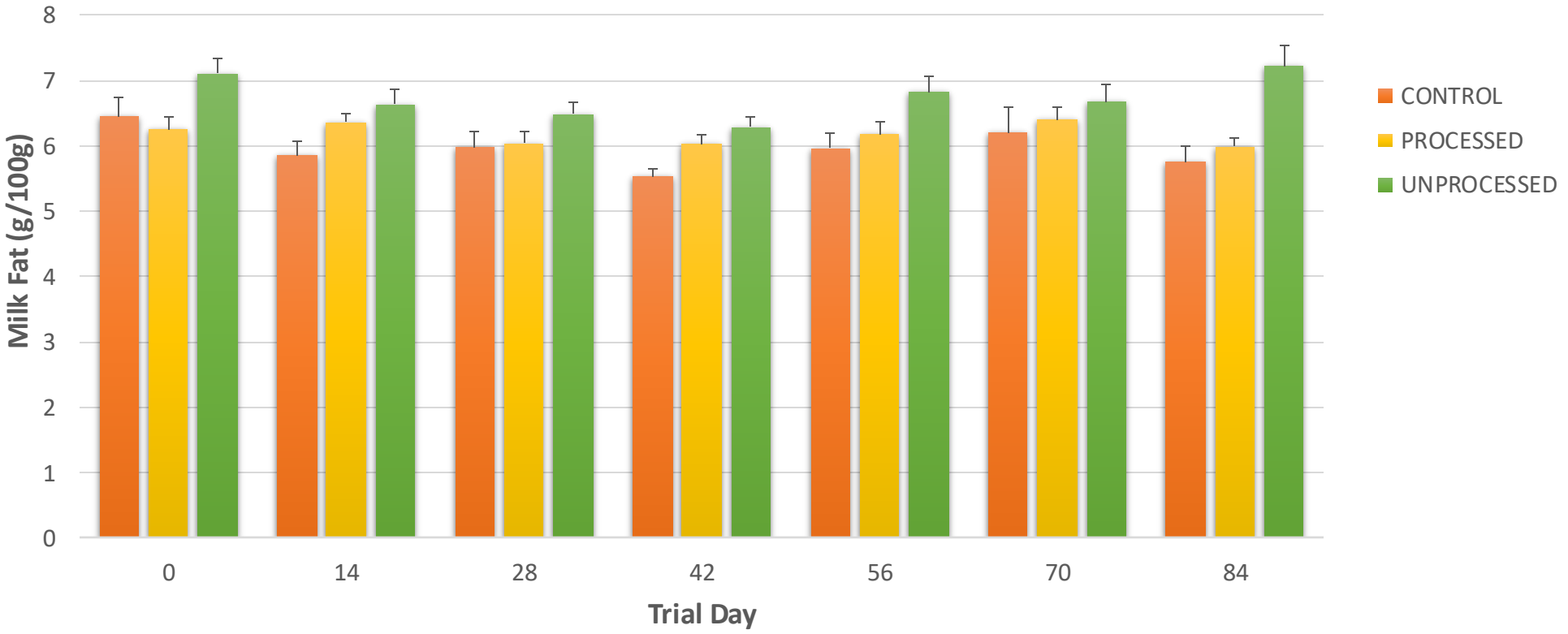
Fat corrected average milk yield

- ✓Significant difference ($p<0.05$) between Control and Unprocessed at the 2nd sampling (day 14 of the trial)
- ✓The Unprocessed group had higher milk yield on average (2055.45 ± 115.327 gr), until the middle of the trial, when the Processed group reached, and occasionally surpassed its' milk yield (1990.46 ± 115.110 gr)
- ✓The Control group remained steadily throughout the trial at lower levels (1866.96 ± 114.781gr)



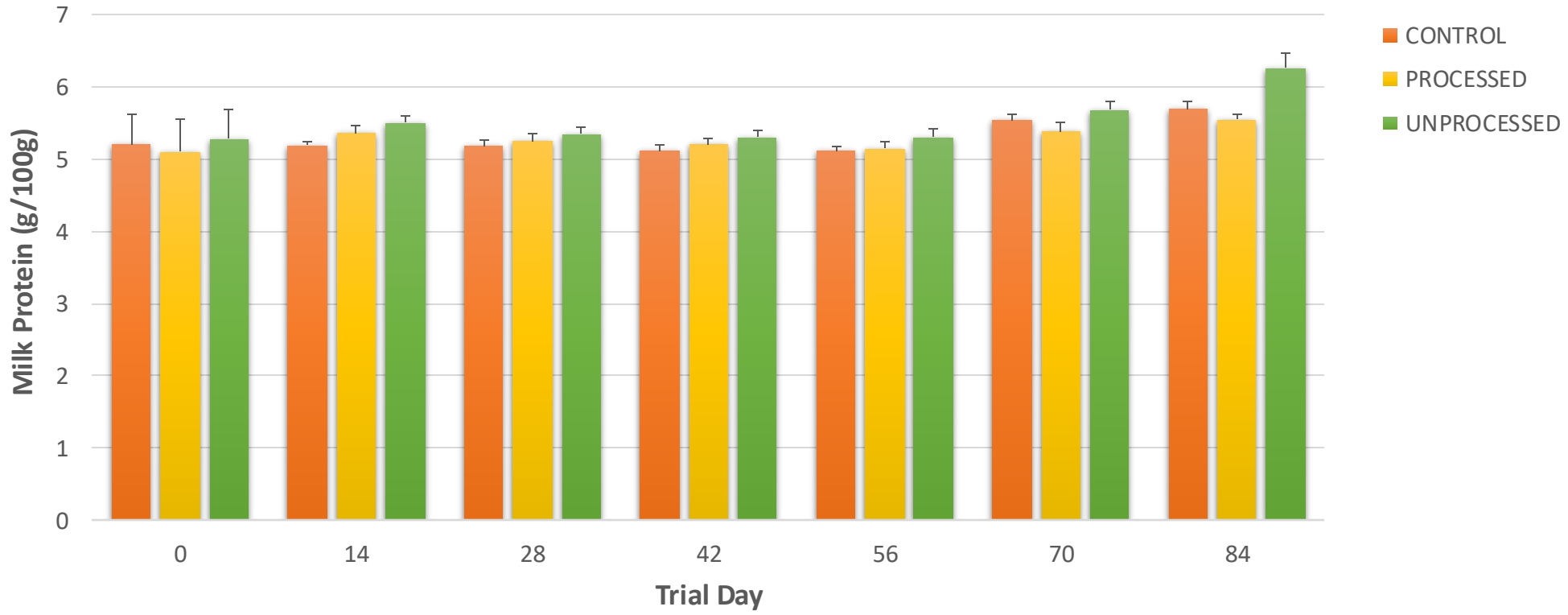
Mean milk fat content

- ✓ At the majority of the samplings milk fat concentration in the Unprocessed treatment was significantly higher than in the Control group (6.75 ± 0.229 vs 5.96 ± 0.246 g/100g, $p<0.05$)
- ✓ Milk fat concentration in the Processed treatment (6.17 ± 0 .170 vs 5.96 ± 0.246 g/100g) was higher compared to the Control group, although not statistically significant



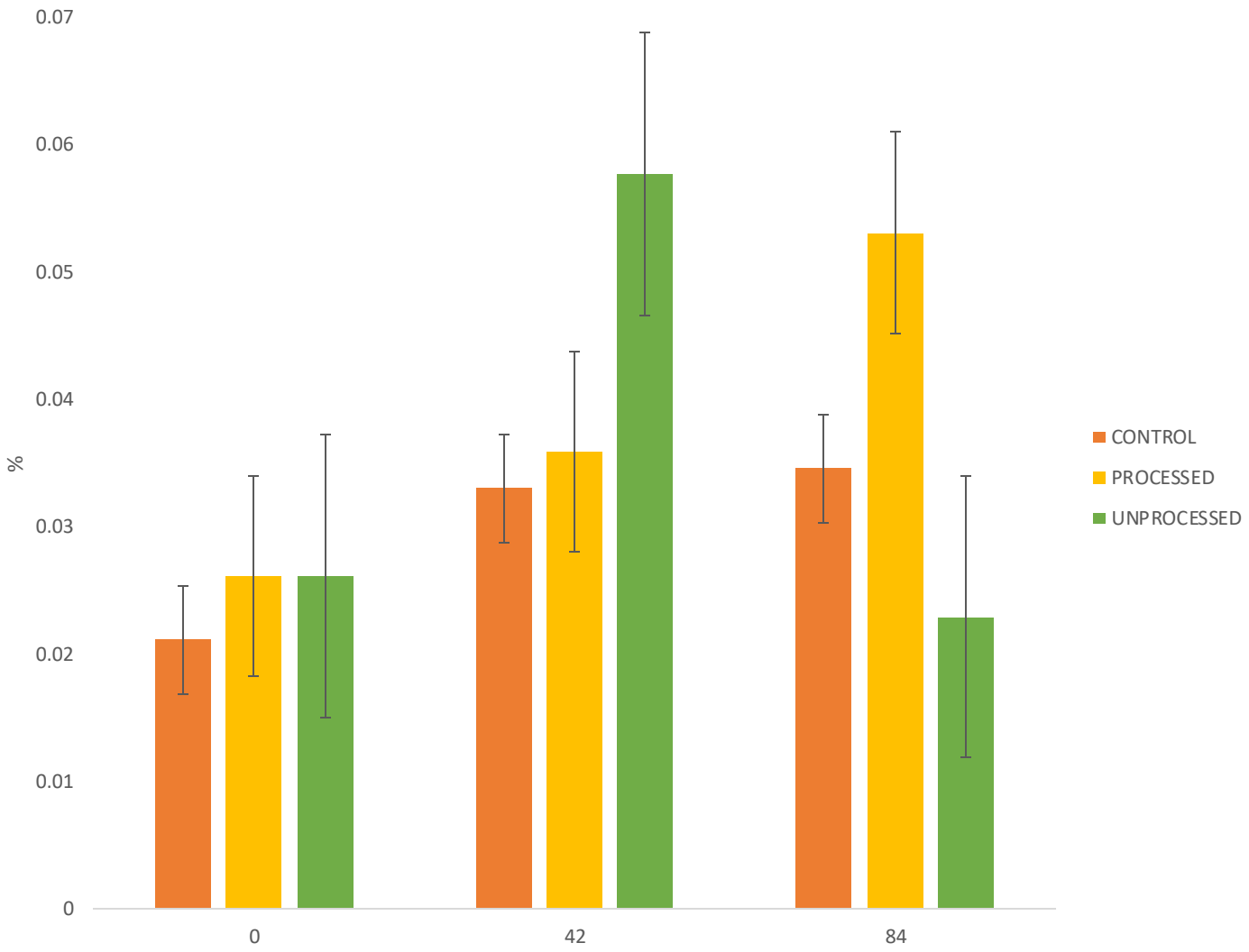
- ✓ Milk protein concentration was higher at all samplings for the Unprocessed treatment (5.52 ± 0.156 vs 5.29 ± 0.125-Control and 5.28 ± 0.145-Processed $p>0.05$)
- ✓ A significant increase was recorded on days 14 and 84 between unprocessed and control treatments ($p<0.05$)

Mean milk protein content



Relative abundance of methanogenic bacteria in the rumen

- ✓ The relative abundance of methanogens was overall higher in the experimental groups, compared to the controls, in all samplings
- ✓ Data were not evaluated statistically due to a low aboundance of archaea in the samples (0.046% of the total reads), although methanogens accounted for 76.15% of the archaea
- ✓ The steep reduction of the methanogens at the end of the trial in the unprocessed group, could be attributed to the tannin content of the feed, as well as to an undocumented property of orange as a potent inhibitor of the enzyme hydroxyl methyl glutaryl coenzyme A (HMG-CoA) reductase which catalyses the synthesis of units essential for cell membrane stability



To conclude

- ✓ *Ewes consumed with great willingness both the processed and the unprocessed orange peel-based feed*
- ✓ *On average the Unprocessed trial had higher milk yield, though without any statistical significance in comparison to the Processed one*
- ✓ *Higher milk fat and protein were also observed in the Unprocessed group*
- ✓ *Unprocessed orange peel feed could increase acetic acid production in the rumen, thus increasing fat composition in milk and finally milk fat content.*
- ✓ *Both treatments (Processed and Unprocessed) yielded better productive results, both in terms of milk quantity and composition, in comparison to the Controls, throughout the trial*
- ✓ *Both Unprocessed and Processed orange peel feeds probably contain antimicrobial factors that suppress colony forming in milk*
- ✓ *Inclusion of orange peels either processed or unprocessed affected milk fatty acid composition in relation to milk from ewes on a conventional diet*
- ✓ *Processed orange peel feed could have better digestibility, thus enhancing the consumption of roughages*
- ✓ *Unprocessed dried orange peel feed could be attributed with reducing methanogens in the rumen, possibly due to its tannin content*

Thank you!

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