



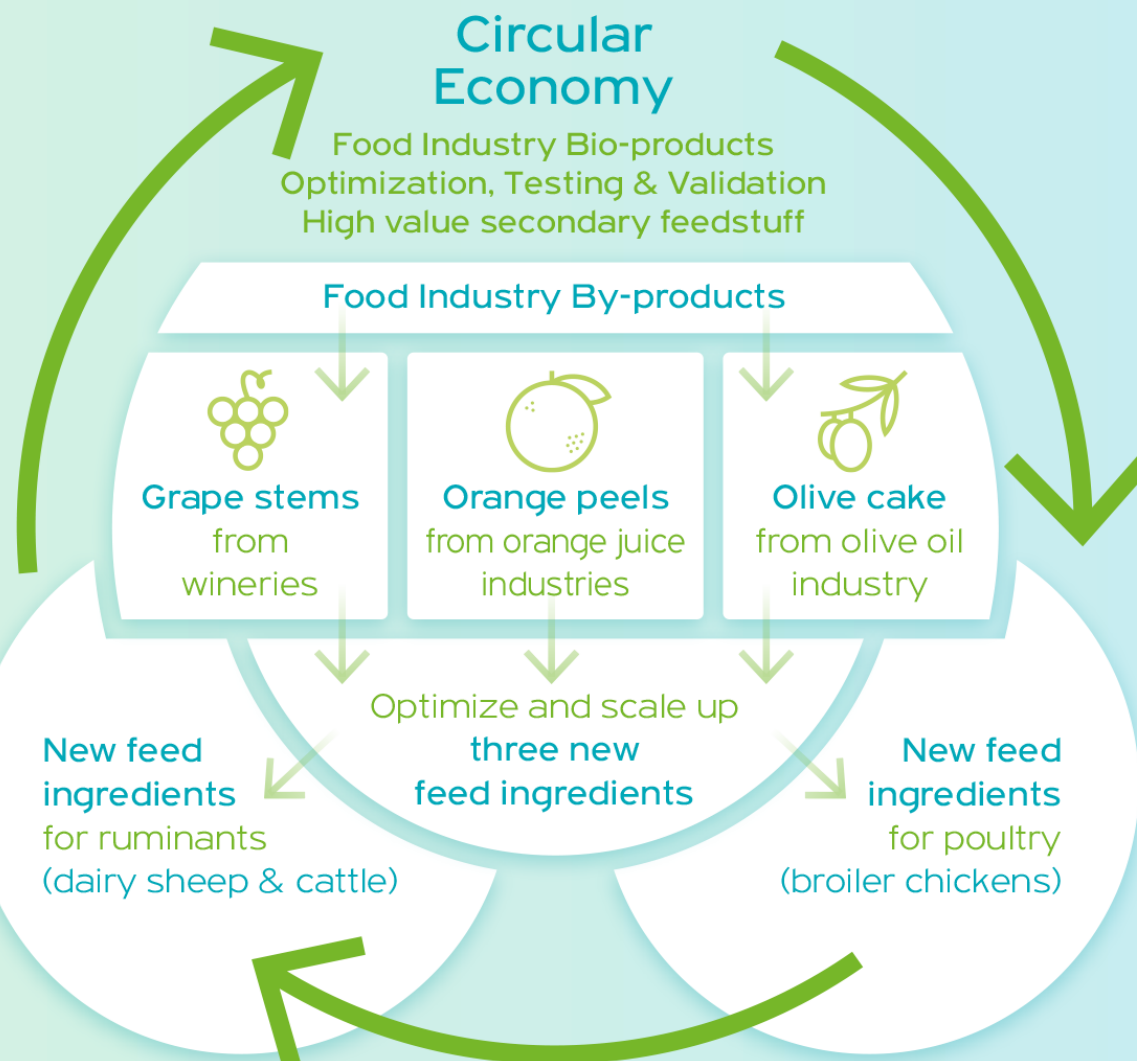
Utilization of orange peels as a high value secondary feedstuff for dairy sheep

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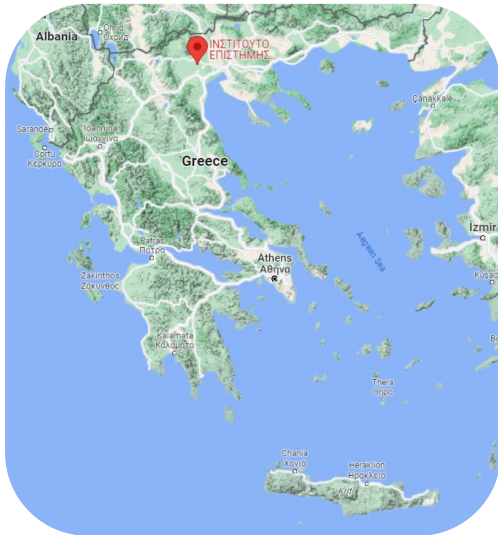
Adoption of three circular economy approaches in livestock systems by valorizing food by-products (winery, orange juice & olive oil) as **alternative feed for livestock** (dairy cattle and sheep & broiler chicken) to produce new products (dairy & meat) for human consumption.

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



National
Technical
University
of Athens



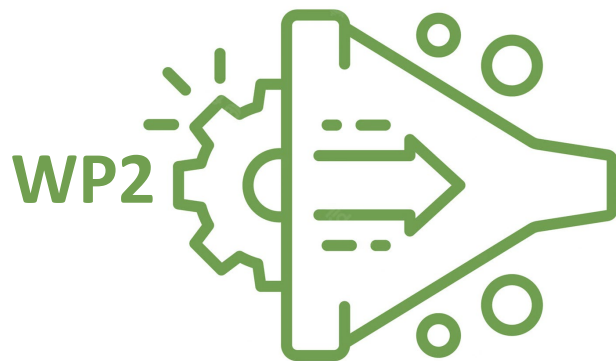
Provision of
orange peels

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

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

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

New ingredient production



✓

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

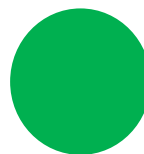
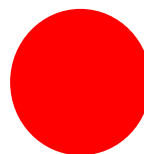
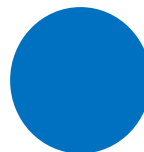
Formulation of isonitrogenous and isoenergetic diets will be formulated by substituting conventional feed ingredients and by meeting nutrient requirements (done in pre-trial, re-evaluated for fine-tuning)

	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:

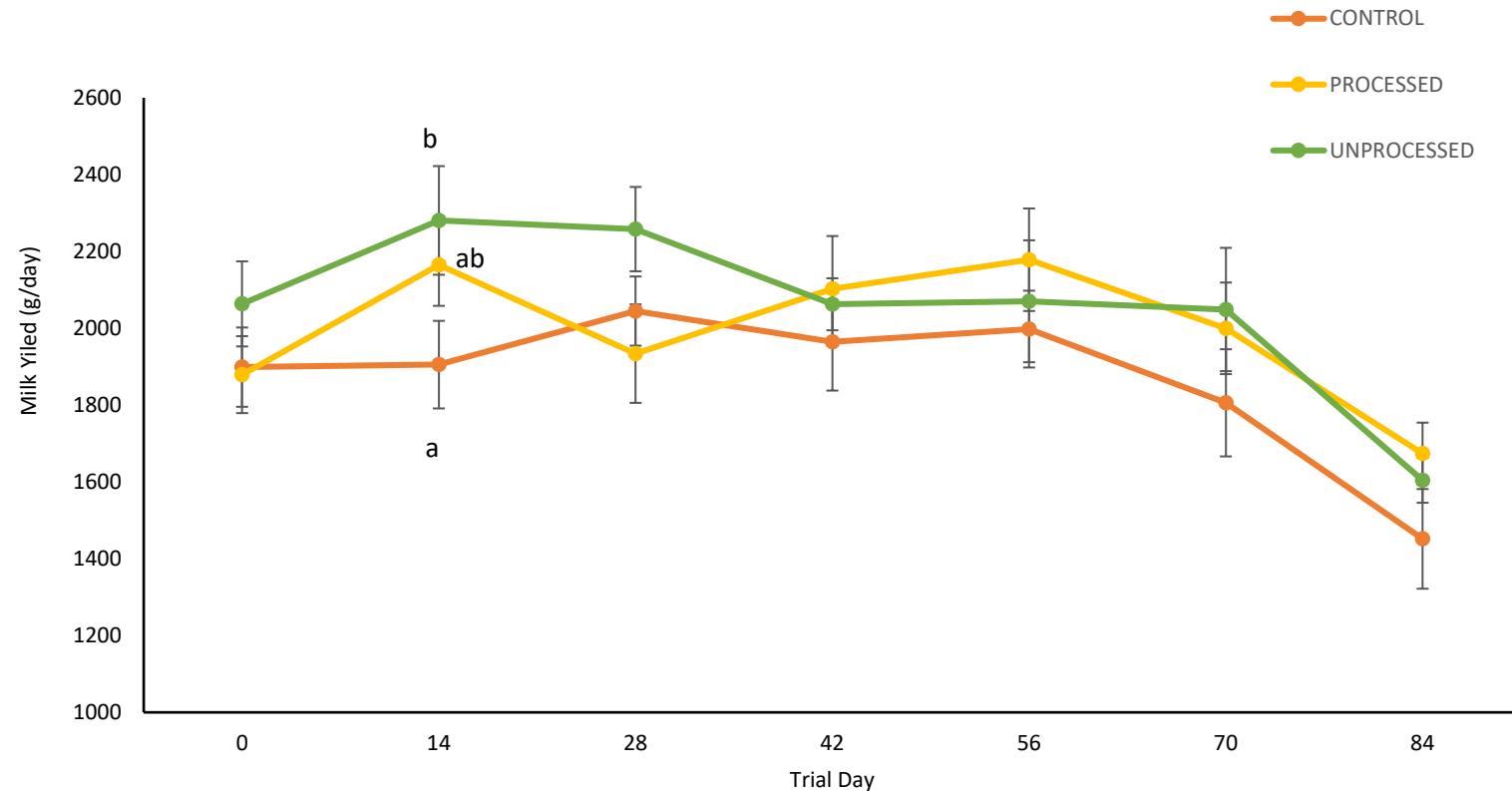
- Daily milk yield
- Chemical composition and total bacterial count of individual milk samples
- Daily feed intake and refusals
- Environmental indices
- Health and welfare
- Επίπεδο ευζωίας
- Life cycle analysis data



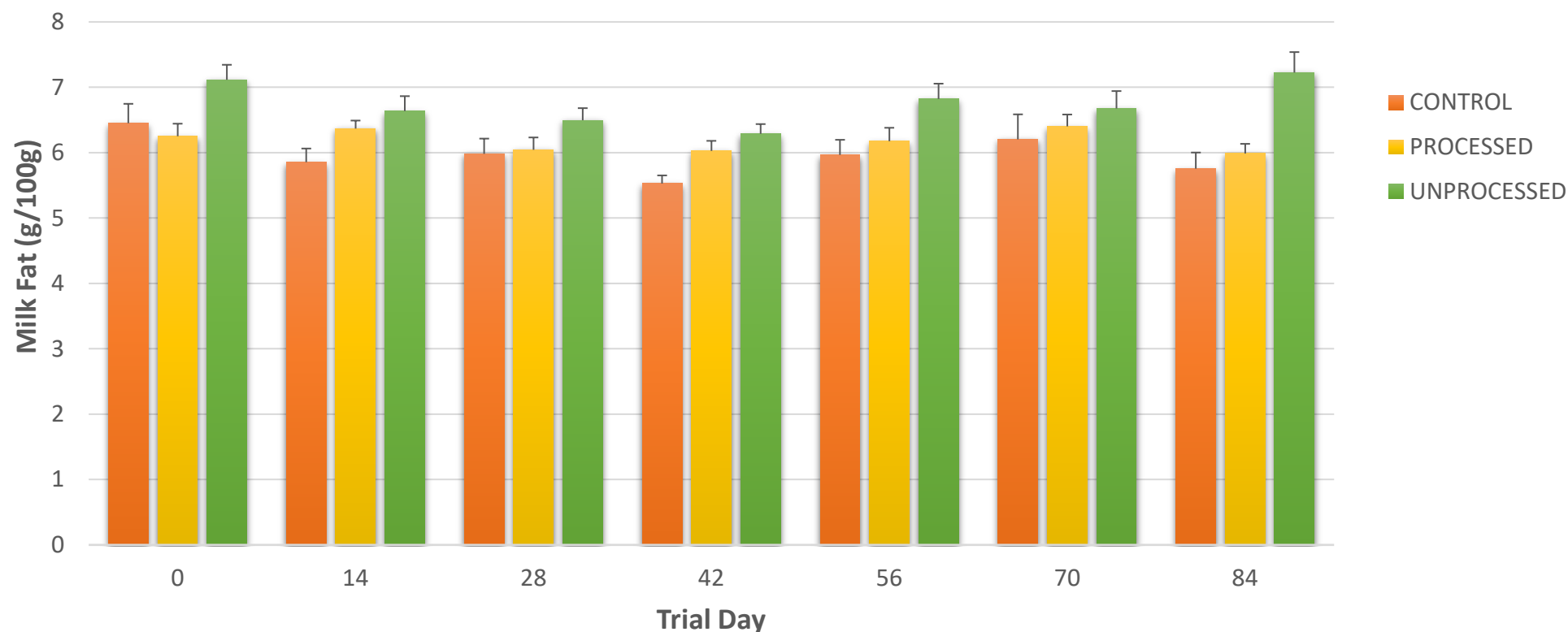
873P									
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Lab Date	09/03/23								
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Lab 2									
Ext 1									
Ext 2									
Ext 3									
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Program	Default BactoScan FC								
#inWS	#inJob	#Sub	IBC	Signal mean	CFU	ID	Time	ResultType	BottleType
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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
							10:38:38	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 ± 114.781 gr)



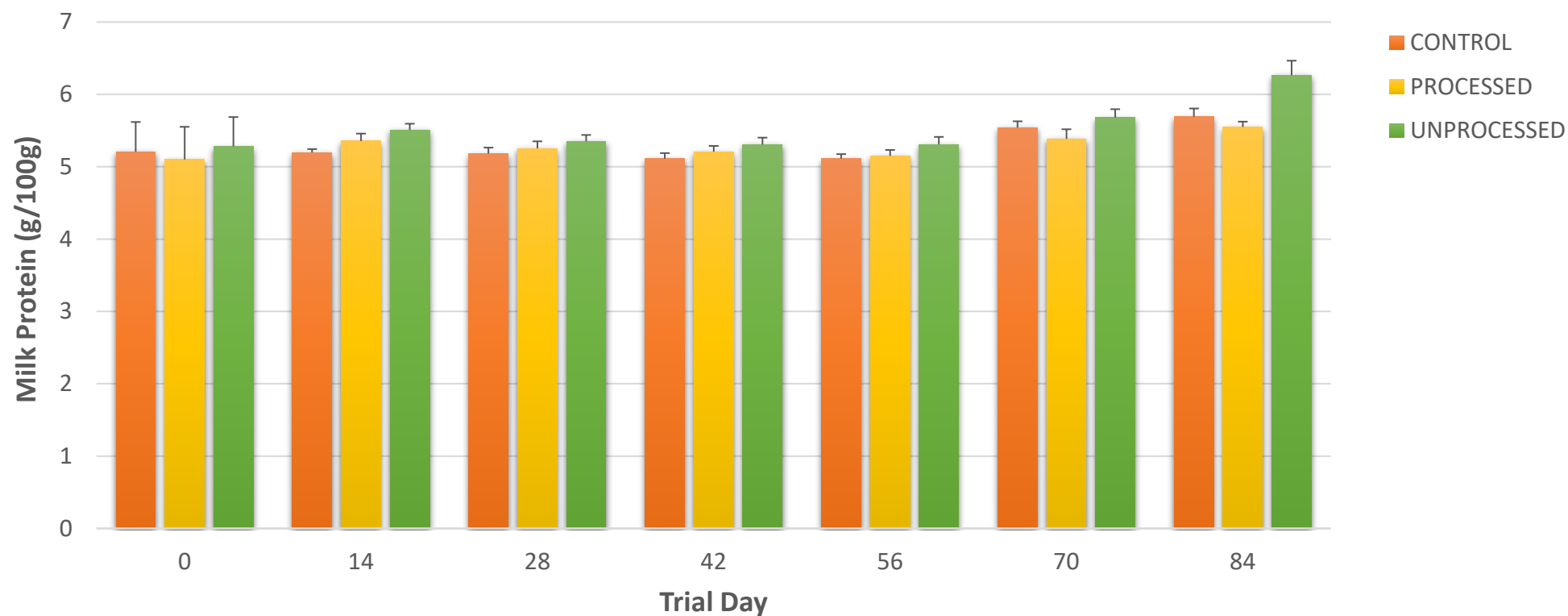
Mean milk fat content



- ✓ 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

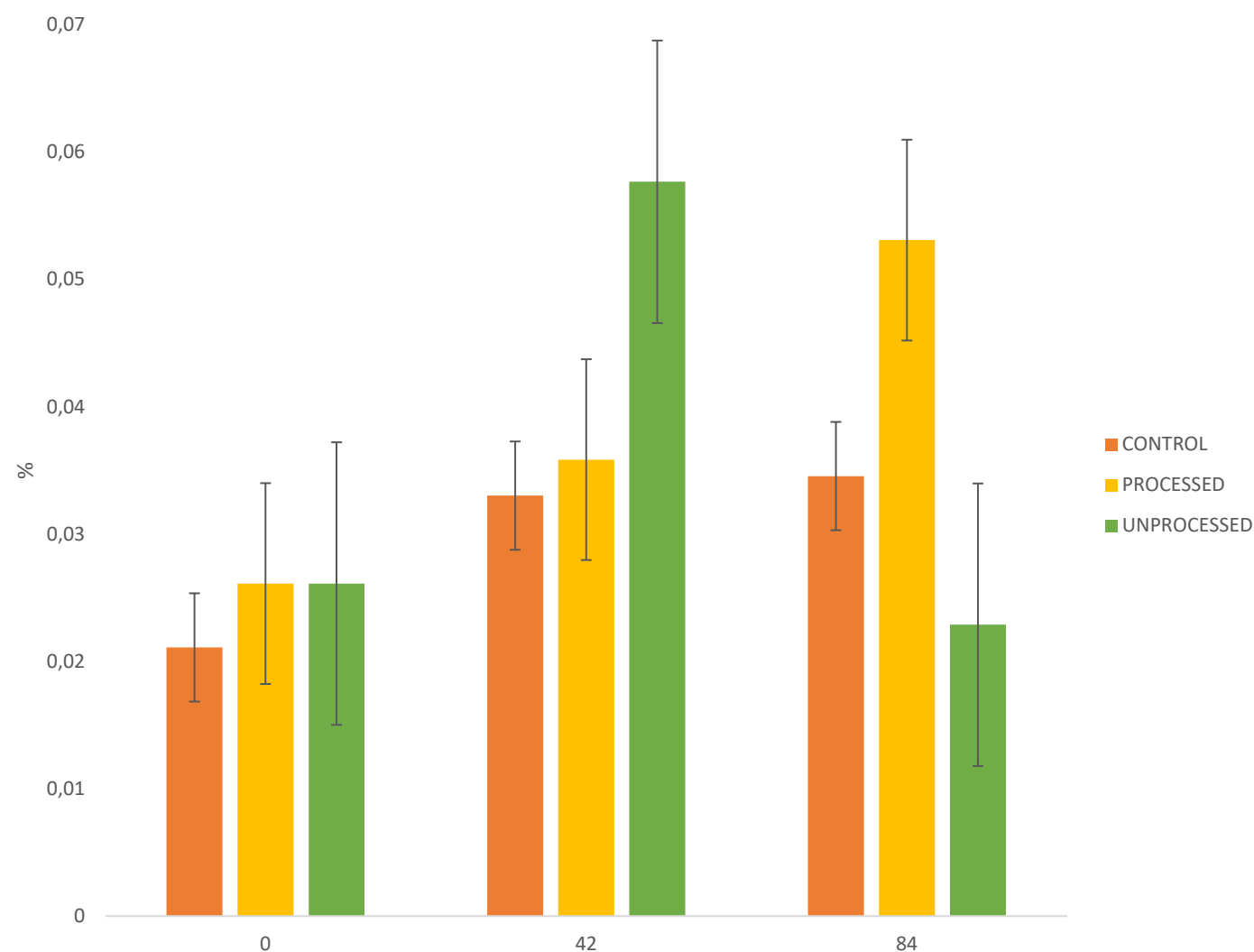
Mean milk protein content

- ✓ 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 ($p < 0.05$)



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 abundance 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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