Using Omics to Understand Seasonal Weight Loss in Dairy Goats: An overview of Project GOATOMICS major achievements

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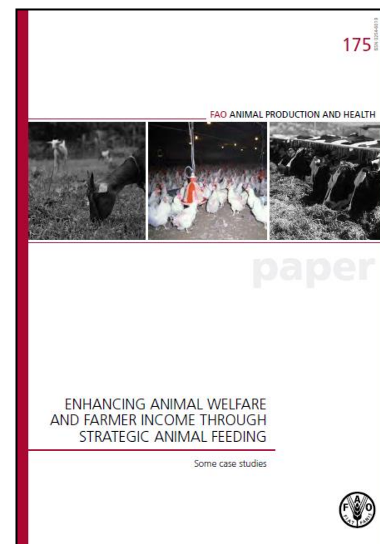
Introduction

- Seasonal weight loss poses a serious limitation to animal production in Tropical and Mediterranean areas
- Due to poor quality of pastures in the dry season, animals may loose up to 30 % of their initial body weight – constraint to ruminant production sectors with special relevance to ruminant extensive production
- In contrast, rainy season pastures are usually considered of adequate quality and availability
- To control Seasonal Weight Loss, supplementation is often implemented during dry season – Unavailable in undeveloped countries and Expensive in developed countries



The Canary islands, Spain…

Dairy goats and the Canary Islands (Spain)

common ancestry

***Palmera* Breed**

- adapted to rainy climate
- low tolerance to pasture scarcity

***Majorera* Breed**

- adapted to arid climate
- high tolerance to pasture scarcity

Lérias *et al*..2013. Trop Anim Health Prod. 45: 1731-1736

Trop Anim Health Prod (2013) 45:1731–1736
DOI 10.1007/s11250-013-0423-2

REGULAR ARTICLES

Body live weight and milk production parameters in the *Majorera* and *Palmera* goat breeds from the Canary Islands: influence of weight loss

Joana R. Lérias · Lorenzo E. Hernández-Castellano · Antonio Morales-delaNuez · Susana S. Araújo · Noemí Castro · Anastasio Argüello · Juan Capote · André M. Almeida

Journal of Dairy Research (2015) **82** 416–425.
doi:10.1017/S0022029915000412

Establishment of the biochemical and endocrine blood profiles in the *Majorera* and *Palmera* dairy goat breeds: the effect of feed restriction

Joana R Lérias[1,2], Raquel Peña[3], Lorenzo E Hernández-Castellano[4,5], Juan Capote[6], Noemí Castro[4], Anastasio Argüello[4], Susana S Araújo[1,7,8], Yolanda Saco[3], Anna Bassols[3] and André M Almeida[1,2,7]†*

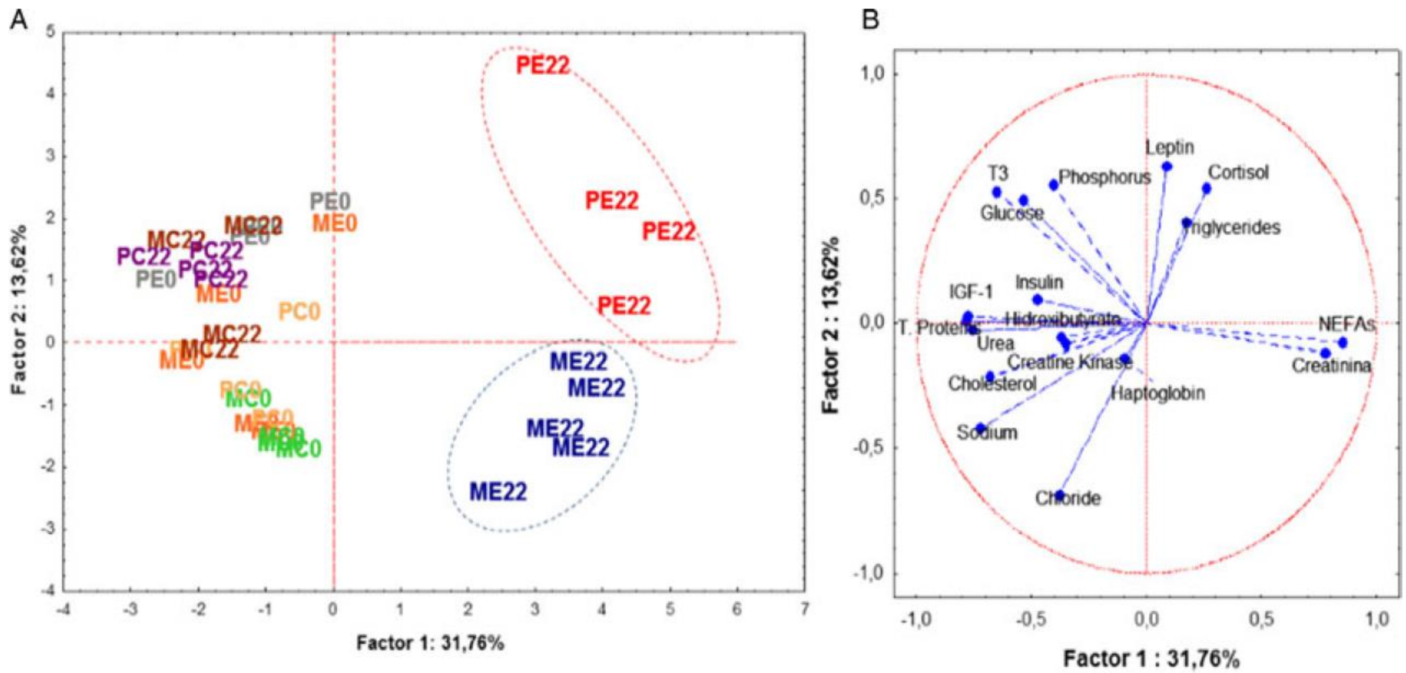
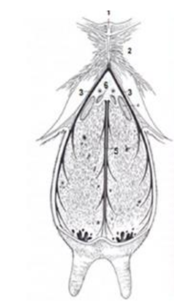


Fig. 1. PCA scatterplot of the *Majorera* and *Palmera* animals (control and underfed) at 0 and 22 d (A) and position of the variables projected in the plane as determined by the first two principal axes (B) (45·38% of the % explained variance). MC0 – *Majorera* Control, day 0; MC22 – *Majorera* control at day 22, ME0 – *Majorera* Underfed at day 0, ME22 – *Majorera* Underfed at day 22; PC0 – *Palmera* Control, day 0; PC22 – *Palmera* control at day 22, PE0 – *Palmera* Underfed at day 0 and PE22 – *Palmera* Underfed at day 22.

Experimental Design


Goats in lactation
Two breeds: Palmera(P) and Majorera(M)
Palmera: susceptible to weight loss
Majorera: tolerant to weight loss
Two groups per breed: Control(C) vs Underfed(E)

Underfed: 15% weight loss in 22 days; 80% decrease milk production
Control: slight increase in BW and same level of milk production



Univ. Debrecen (Hu)

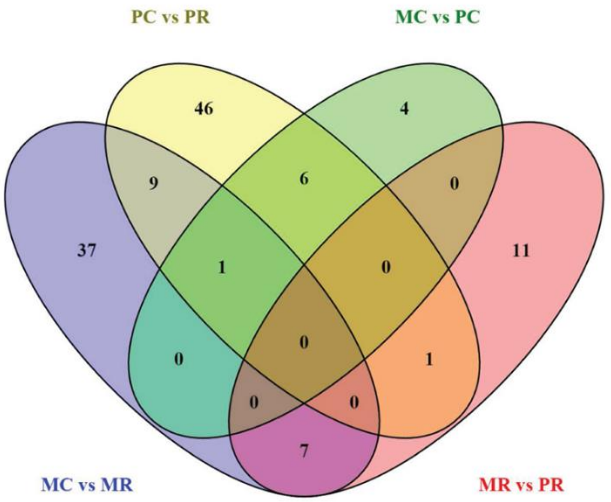
Mammary Gland Biopsy


Metabolomics – NMR

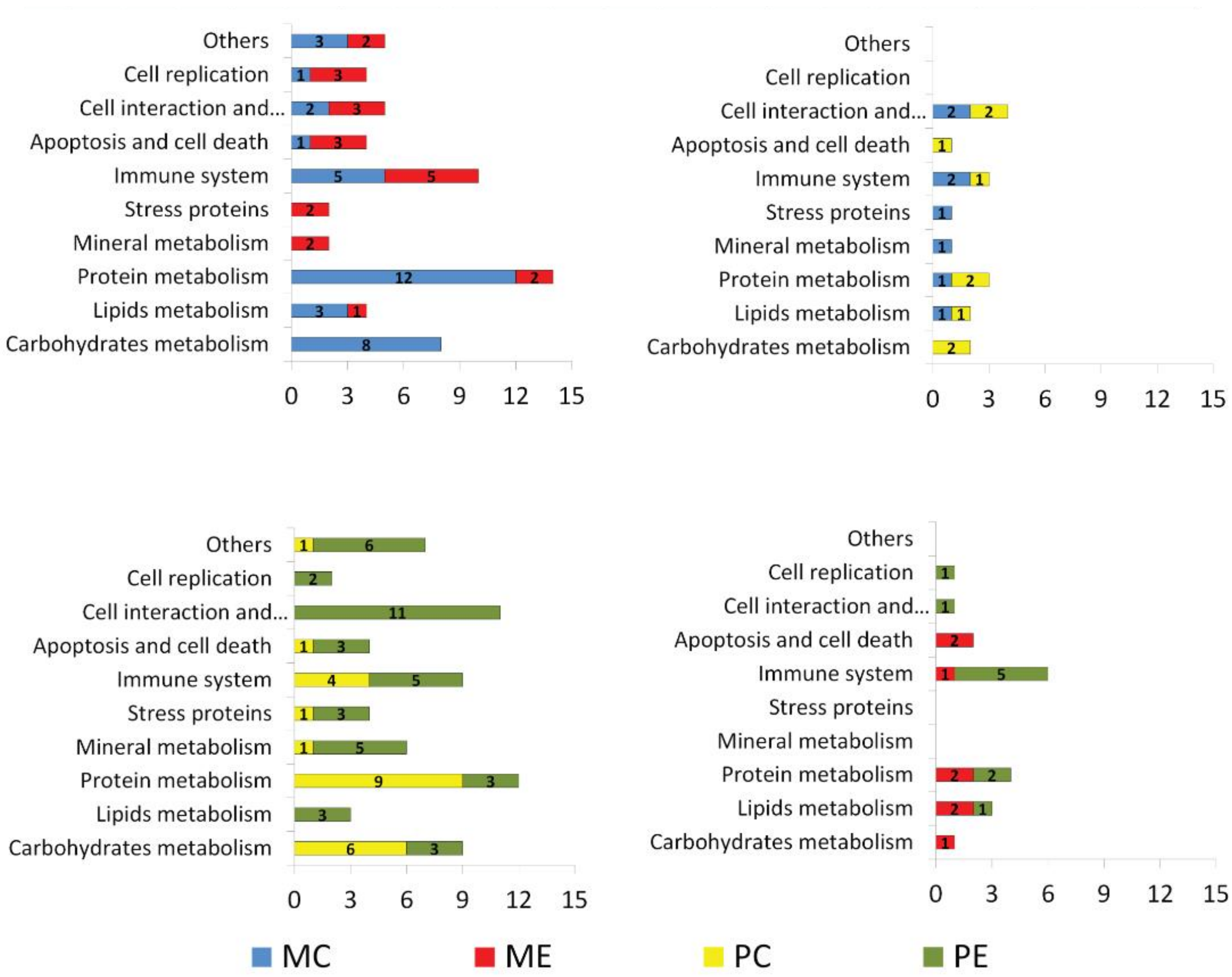
Label free Proteomics, NGS Transcriptomics & NMR Metabolomics Analysis

Proteomics - Major Findings

- First Characterization of the goat mammary gland proteome → over 1000 proteins identified
- Goat entries and sheep and cattle homologues
- 96 proteins had differential expression (fold change > 1.98 and P<0.05)
    - PC vs PE: 63 proteins
    - MC vs ME: 54 proteins
    - MC vs PC: 11 proteins
    - ME vs PE: 19 proteins
- Breed and Nutritional treatment affect significantly the mammary gland secretory tissue proteome



Major Findings



Proteomics: Conclusions

The two goat breeds have a distinct metabolism reaction to SWL

SWL sensitive breed: Immune system

SWL tolerant breed: apoptotic pathway

Proteins suggested as markers of tolerance to SWL

Mammary Gland: metabolite profiling (mmol/g tissue)

Amino Acids Metabolism

	Majorera	*Palmera*
alanine	1.0 x10^{-3} (±1.9x10^{-4})	9.2 x10^{-4} (±4.9x10^{-4})
aspartate	8.2 x10^{-4} (± 4.1x10^{-4})	8.8 x10^{-4} (± 3.7x10^{-4})
creatine	2.2 x10^{-3} (± 5.3x10^{-4})	1.9 x10^{-3} (± 5.9x10^{-4})
glutamate	7.2 x10^{-3} (± 1.8x10^{-3})	6.3 x10^{-} (± 2.9x10^{-3})
glutathione	8.0 x10^{-4} (± 3.2x10^{-4})	8.6 x10^{-4} (± 3.7x10^{-4})
glycine	3.2 x10^{-3} (± 1.2x10^{-3})	5.0 x10^{-3} (± 3.0x10^{-3})
inosine	6.8 x10^{-4} (± 2.0x10^{-4})	5.3 x10^{-4} (± 1.5x10^{-4})
taurine	3.2 x10^{-3} (± 1.4x10^{-3})	1.8 x10^{-3} (± 1.0x10^{-3})
3-methylhistidine	1.6 x10^{-4} (± 4.3x10^{-5})	1.7 x10^{-4} (± 6.7x10^{-5})
adenosylhomocysteine	7.4 x10^{-5} (± 3.2x10^{-5})	1.1 x10^{-4} (± 8.6x10^{-5})
anserine	1.6 x10^{-4} (± 3.7x10^{-5})	1.9 x10^{-4} (± 7.1x10^{-5})
benzoate	7.7 x10^{-5} (± 4.7x10^{-5})	6.7 x10^{-5} (± 5.5x10^{-5})
carnosine	1.6 x10^{-4} (± 4.7x10^{-5})	1.1 x10^{-4} (± 4.4x10^{-5})
creatine phospphate	2.0 x10^{-4}(± 1.9x10^{-4})	1.0 x10^{-4} (± 3.6x10^{-5})
creatinine	6.4 x10^{-5} (± 1.1x10^{-5})	3.0 x10^{-5} (± 1.8x10^{-5})
isoleucine	1.7 x10^{-4} (± 3.2x10^{-5})	1.3 x10^{-4} (± 4.3x10^{-5})
leucine	3.1 x10^{-4} (± 5.1x10^{-5})	2.6 x10^{-4} (± 8.8x10^{-5})
phenylalanine	1.1 x10^{-4} (± 3.9x10^{-5})	9.0 x10^{-5} (± 2.6x10^{-5})
tyrosine	1.4 x10^{-4} (± 2.2x10^{-5})	1.1 x10^{-4} (± 4.2x10^{-5})
valine	2.8 x10^{-4} (± 3.9x10^{-5})	2.5 x10^{-4} (± 6.7x10^{-5})

Carbohydrates Metabolism

	Majorera	*Palmera*
glucose	3.8 x10^{-3} (± 1.5x10^{-3})	3.4 x10^{-3} (± 1.2x10^{-3})
lactase	3.9 x10^{-3} (± 8.6x10^{-4})	4.2 x10^{-3} (± 2.2x10^{-3})
lactose	2.5 x10^{-2} (± 1.0x10^{-2})	2.3 x10^{-2} (± 1.5x10^{-2})
UDP-glucose	2.8 x10^{-4} (± 8.5x10^{-5})	2.5 x10^{-4} (± 9.0x10^{-5})

Energy Metabolism

	Majorera	*Palmera*
AMP	1.1 x10^{-3} (± 6.1x10^{-4})	9.5 x10^{-4} (± 4.5x10^{-4})
IMP	1.5 x10^{-4} (± 6.2x10^{-5})	1.7 x10^{-4} (± 1.0x10^{-4})
NAD^+	8.4 x10^{-5} (± 7.9x10^{-5})	5.9 x10^{-5} (± 3.2x10^{-5})
ATP/ADP	7.5 x10^{-5} (± 4.6x10^{-5})	1.1 x10^{-4} (± 6.1x10^{-5})
$NADP^+$	4.2 x10^{-5} (± 1.4x10^{-5})	3.2 x10^{-5} (± 1.1x10^{-5})

Cofactors and Vitamins Metabolism

	Majorera	*Palmera*
betaine	2.4 x10^{-3} (± 1.2x10^{-3})	1.3 x10^{-3} (± 9.7x10^{-4})
carnitine	6.8 x10^{-4} (± 1.2x10^{-4})	4.9 x10^{-4} (± 1.8x10^{-4})
choline	9.9 x10^{-4} (± 1.2x10^{-4})	7.4 x10^{-4} (± 2.6x10^{-4})
glycerophosphocholine	1.6 x10^{-3} (± 5.5x10^{-4})	2.5 x10^{-3} (± 1.3x10^{-3})
myo-inositol	1.5 x10^{-3} (± 5.5x10^{-4})	1.6 x10^{-3} (± 6.2x10^{-4})
phosphocholine	1.2 x10^{-3} (± 5.7x10^{-4})	1.1 x10^{-3} (± 3.7x10^{-4})
acetyl-L-cartinite	1.1 x10^{-4} (± 5.3x10^{-5})	1.1 x10^{-4} (± 3.7x10^{-5})
methylmalonate	5.9 x10^{-5} (± 7.3x10^{-5})	5.7 x10^{-5} (± 6.8x10^{-5})
nicotinurate	2.5 x10^{-4} (± 1.6x10^{-4})	1.8 x10^{-4} (± 5.3x10^{-5})

Nucleotide Metabolism

	Majorera	*Palmera*
adenine	3.1 x10^{-4} (± 4.2x10^{-4})	1.9 x10^{-4} (± 1.2x10^{-4})
uridine	1.5 x10^{-4} (± 1.0x10^{-4})	1.2 x10^{-4} (± 2.7x10^{-5})
xanthine	1.5 x10^{-4} (± 6.0x10^{-5})	1.3 x10^{-4} (± 6.2x10^{-5})

TCA Cycle

	Majorera	*Palmera*
acetate	1.4 x10^{-4} (± 3.9x10^{-5})	2.3 x10^{-4} (± 1.1x10^{-4})
formate	7.6 x10^{-4} (± 8.9x10^{-4})	8.2 x10^{-4} (± 7.2x10^{-4})
fumarate	1.3 x10^{-4} (± 3.5x10^{-5})	1.1 x10^{-4} (± 5.4x10^{-5})
citrate	1.1 x10^{-4} (± 7.2x10^{-5})	2.0 x10^{-4} (± 2.6x10^{-4})
pyruvate	2.0 x10^{-4} (± 8.1x10^{-5})	1.6 x10^{-4} (± 1.3x10^{-4})
succinate	1.5 x10^{-4} (± 7.5x10^{-5})	2.0 x10^{-4} (± 1.0x10^{-4})

47 metabolites:

all common constituents of mammary gland and meat

Mammary Gland: metabolite profiling (mmol/g tissue)

Amino Acids Metabolism

	Majorera	*Palmera*
alanine	1.0×10^{-3} ($\pm 1.9 \times 10^{-4}$)	9.2×10^{-4} ($\pm 4.9 \times 10^{-4}$)
aspartate	8.2×10^{-4} ($\pm$ 4.1×10^{-4})	8.8×10^{-4} ($\pm$ 3.7×10^{-4})
creatine	2.2×10^{-3} ($\pm$ 5.3×10^{-4})	1.9×10^{-3} ($\pm$ 5.9×10^{-4})
glutamate	7.2×10^{-3} ($\pm$ 1.8×10^{-3})	$6.3 \times 10^{-}$ ($\pm$ 2.9×10^{-3})
glutathione	8.0×10^{-4} ($\pm$ 3.2×10^{-4})	8.6×10^{-4} ($\pm$ 3.7×10^{-4})
glycine	3.2×10^{-3} ($\pm$ 1.2×10^{-3})	5.0×10^{-3} ($\pm$ 3.0×10^{-3})
inosine	6.8×10^{-4} ($\pm$ 2.0×10^{-4})	5.3×10^{-4} ($\pm$ 1.5×10^{-4})
taurine	3.2×10^{-3} ($\pm$ 1.4×10^{-3})	1.8×10^{-3} ($\pm$ 1.0×10^{-3})
3-methylhistidine	1.6×10^{-4} ($\pm$ 4.3×10^{-5})	1.7×10^{-4} ($\pm$ 6.7×10^{-5})
adenosylhomocysteine	7.4×10^{-5} ($\pm$ 3.2×10^{-5})	1.1×10^{-4} ($\pm$ 8.6×10^{-5})
anserine	1.6×10^{-4} ($\pm$ 3.7×10^{-5})	1.9×10^{-4} ($\pm$ 7.1×10^{-5})
benzoate	7.7×10^{-5} ($\pm$ 4.7×10^{-5})	6.7×10^{-5} ($\pm$ 5.5×10^{-5})
carnosine	1.6×10^{-4} ($\pm$ 4.7×10^{-5})	1.1×10^{-4} ($\pm$ 4.4×10^{-5})
creatine phospphate	2.0×10^{-4}($\pm$ 1.9×10^{-4})	1.0×10^{-4} ($\pm$ 3.6×10^{-5})
creatinine	6.4×10^{-5} ($\pm$ 1.1×10^{-5})	3.0×10^{-5} ($\pm$ 1.8×10^{-5})
isoleucine	1.7×10^{-4} ($\pm$ 3.2×10^{-5})	1.3×10^{-4} ($\pm$ 4.3×10^{-5})
leucine	3.1×10^{-4} ($\pm$ 5.1×10^{-5})	2.6×10^{-4} ($\pm$ 8.8×10^{-5})
phenylalanine	1.1×10^{-4} ($\pm$ 3.9×10^{-5})	9.0×10^{-5} ($\pm$ 2.6×10^{-5})
tyrosine	1.4×10^{-4} ($\pm$ 2.2×10^{-5})	1.1×10^{-4} ($\pm$ 4.2×10^{-5})
valine	2.8×10^{-4} ($\pm$ 3.9×10^{-5})	2.5×10^{-4} ($\pm$ 6.7×10^{-5})

Carbohydrates Metabolism

	Majorera	*Palmera*
glucose	3.8×10^{-3} ($\pm$ 1.5×10^{-3})	3.4×10^{-3} ($\pm$ 1.2×10^{-3})
lactase	3.9×10^{-3} ($\pm$ 8.6×10^{-4})	4.2×10^{-3} ($\pm$ 2.2×10^{-3})
lactose	2.5×10^{-2} ($\pm$ 1.0×10^{-2})	2.3×10^{-2} ($\pm$ 1.5×10^{-2})
UDP-glucose	2.8×10^{-4} ($\pm$ 8.5×10^{-5})	2.5×10^{-4} ($\pm$ 9.0×10^{-5})

Energy Metabolism

	Majorera	*Palmera*
AMP	1.1×10^{-3} ($\pm$ 6.1×10^{-4})	9.5×10^{-4} ($\pm$ 4.5×10^{-4})
IMP	1.5×10^{-4} ($\pm$ 6.2×10^{-5})	1.7×10^{-4} ($\pm$ 1.0×10^{-4})
NAD^+	8.4×10^{-5} ($\pm$ 7.9×10^{-5})	5.9×10^{-5} ($\pm$ 3.2×10^{-5})
ATP/ADP	7.5×10^{-5} ($\pm$ 4.6×10^{-5})	1.1×10^{-4} ($\pm$ 6.1×10^{-5})
$NADP^+$	4.2×10^{-5} ($\pm$ 1.4×10^{-5})	3.2×10^{-5} ($\pm$ 1.1×10^{-5})

Cofactors and Vitamins Metabolism

	Majorera	*Palmera*
betaine	2.4×10^{-3} ($\pm$ 1.2×10^{-3})	1.3×10^{-3} ($\pm$ 9.7×10^{-4})
carnitine	6.8×10^{-4} ($\pm$ 1.2×10^{-4})	4.9×10^{-4} ($\pm$ 1.8×10^{-4})
choline	9.9×10^{-4} ($\pm$ 1.2×10^{-4})	7.4×10^{-4} ($\pm$ 2.6×10^{-4})
glycerophosphocholine	1.6×10^{-3} ($\pm$ 5.5×10^{-4})	2.5×10^{-3} ($\pm$ 1.3×10^{-3})
myo-inositol	1.5×10^{-3} ($\pm$ 5.5×10^{-4})	1.6×10^{-3} ($\pm$ 6.2×10^{-4})
phosphocholine	1.2×10^{-3} ($\pm$ 5.7×10^{-4})	1.1×10^{-3} ($\pm$ 3.7×10^{-4})
acetyl-L-cartinite	1.1×10^{-4} ($\pm$ 5.3×10^{-5})	1.1×10^{-4} ($\pm$ 3.7×10^{-5})
methylmalonate	5.9×10^{-5} ($\pm$ 7.3×10^{-5})	5.7×10^{-5} ($\pm$ 6.8×10^{-5})
nicotinurate	2.5×10^{-4} ($\pm$ 1.6×10^{-4})	1.8×10^{-4} ($\pm$ 5.3×10^{-5})

Nucleotide Metabolism

	Majorera	*Palmera*
adenine	3.1×10^{-4} ($\pm$ 4.2×10^{-4})	1.9×10^{-4} ($\pm$ 1.2×10^{-4})
uridine	1.5×10^{-4} ($\pm$ 1.0×10^{-4})	1.2×10^{-4} ($\pm$ 2.7×10^{-5})
xanthine	1.5×10^{-4} ($\pm$ 6.0×10^{-5})	1.3×10^{-4} ($\pm$ 6.2×10^{-5})

TCA Cycle

	Majorera	*Palmera*
acetate	1.4×10^{-4} ($\pm$ 3.9×10^{-5})	2.3×10^{-4} ($\pm$ 1.1×10^{-4})
formate	7.6×10^{-4} ($\pm$ 8.9×10^{-4})	8.2×10^{-4} ($\pm$ 7.2×10^{-4})
fumarate	1.3×10^{-4} ($\pm$ 3.5×10^{-5})	1.1×10^{-4} ($\pm$ 5.4×10^{-5})
citrate	1.1×10^{-4} ($\pm$ 7.2×10^{-5})	2.0×10^{-4} ($\pm$ 2.6×10^{-4})
pyruvate	2.0×10^{-4} ($\pm$ 8.1×10^{-5})	1.6×10^{-4} ($\pm$ 1.3×10^{-4})
succinate	1.5×10^{-4} ($\pm$ 7.5×10^{-5})	2.0×10^{-4} ($\pm$ 1.0×10^{-4})

Lactose

~2×10^{-2} mmol/g tissue

Mammary Gland: metabolite profiling (mmol/g tissue)

Amino Acids Metabolism

	Majorera	*Palmera*
alanine	1.0 x10^{-3} (±1.9x10^{-4})	9.2 x10^{-4} (±4.9x10^{-4})
aspartate	8.2 x10^{-4} (± 4.1x10^{-4})	8.8 x10^{-4} (± 3.7x10^{-4})
creatine	2.2 x10^{-3} (± 5.3x10^{-4})	1.9 x10^{-3} (± 5.9x10^{-4})
glutamate	7.2 x10^{-3} (± 1.8x10^{-3})	6.3 x10^{-} (± 2.9x10^{-3})
glutathione	8.0 x10^{-4} (± 3.2x10^{-4})	8.6 x10^{-4} (± 3.7x10^{-4})
glycine	3.2 x10^{-3} (± 1.2x10^{-3})	5.0 x10^{-3} (± 3.0x10^{-3})
inosine	6.8 x10^{-4} (± 2.0x10^{-4})	5.3 x10^{-4} (± 1.5x10^{-4})
taurine	3.2 x10^{-3} (± 1.4x10^{-3})	1.8 x10^{-3} (± 1.0x10^{-3})
3-methylhistidine	1.6 x10^{-4} (± 4.3x10^{-5})	1.7 x10^{-4} (± 6.7x10^{-5})
adenosylhomocysteine	7.4 x10^{-5} (± 3.2x10^{-5})	1.1 x10^{-4} (± 8.6x10^{-5})
anserine	1.6 x10^{-4} (± 3.7x10^{-5})	1.9 x10^{-4} (± 7.1x10^{-5})
benzoate	7.7 x10^{-5} (± 4.7x10^{-5})	6.7 x10^{-5} (± 5.5x10^{-5})
carnosine	1.6 x10^{-4} (± 4.7x10^{-5})	1.1 x10^{-4} (± 4.4x10^{-5})
creatine phospphate	2.0 x10^{-4}(± 1.9x10^{-4})	1.0 x10^{-4} (± 3.6x10^{-5})
creatinine	6.4 x10^{-5} (± 1.1x10^{-5})	3.0 x10^{-5} (± 1.8x10^{-5})
isoleucine	1.7 x10^{-4} (± 3.2x10^{-5})	1.3 x10^{-4} (± 4.3x10^{-5})
leucine	3.1 x10^{-4} (± 5.1x10^{-5})	2.6 x10^{-4} (± 8.8x10^{-5})
phenylalanine	1.1 x10^{-4} (± 3.9x10^{-5})	9.0 x10^{-5} (± 2.6x10^{-5})
tyrosine	1.4 x10^{-4} (± 2.2x10^{-5})	1.1 x10^{-4} (± 4.2x10^{-5})
valine	2.8 x10^{-4} (± 3.9x10^{-5})	2.5 x10^{-4} (± 6.7x10^{-5})

Carbohydrates Metabolism

	Majorera	*Palmera*
glucose	3.8 x10^{-3} (± 1.5x10^{-3})	3.4 x10^{-3} (± 1.2x10^{-3})
lactase	3.9 x10^{-3} (± 8.6x10^{-4})	4.2 x10^{-3} (± 2.2x10^{-3})
lactose	2.5 x10^{-2} (± 1.0x10^{-2})	2.3 x10^{-2} (± 1.5x10^{-2})
UDP-glucose	2.8 x10^{-4} (± 8.5x10^{-5})	2.5 x10^{-4} (± 9.0x10^{-5})

Energy Metabolism

	Majorera	*Palmera*
AMP	1.1 x10^{-3} (± 6.1x10^{-4})	9.5 x10^{-4} (± 4.5x10^{-4})
IMP	1.5 x10^{-4} (± 6.2x10^{-5})	1.7 x10^{-4} (± 1.0x10^{-4})
NAD^+	8.4 x10^{-5} (± 7.9x10^{-5})	5.9 x10^{-5} (± 3.2x10^{-5})
ATP/ADP	7.5 x10^{-5} (± 4.6x10^{-5})	1.1 x10^{-4} (± 6.1x10^{-5})
$NADP^+$	4.2 x10^{-5} (± 1.4x10^{-5})	3.2 x10^{-5} (± 1.1x10^{-5})

Cofactors and Vitamins Metabolism

	Majorera	*Palmera*
betaine	2.4 x10^{-3} (± 1.2x10^{-3})	1.3 x10^{-3} (± 9.7x10^{-4})
carnitine	6.8 x10^{-4} (± 1.2x10^{-4})	4.9 x10^{-4} (± 1.8x10^{-4})
choline	9.9 x10^{-4} (± 1.2x10^{-4})	7.4 x10^{-4} (± 2.6x10^{-4})
glycerophosphocholine	1.6 x10^{-3} (± 5.5x10^{-4})	2.5 x10^{-3} (± 1.3x10^{-3})
myo-inositol	1.5 x10^{-3} (± 5.5x10^{-4})	1.6 x10^{-3} (± 6.2x10^{-4})
phosphocholine	1.2 x10^{-3} (± 5.7x10^{-4})	1.1 x10^{-3} (± 3.7x10^{-4})
acetyl-L-cartinite	1.1 x10^{-4} (± 5.3x10^{-5})	1.1 x10^{-4} (± 3.7x10^{-5})
methylmalonate	5.9 x10^{-5} (± 7.3x10^{-5})	5.7 x10^{-5} (± 6.8x10^{-5})
nicotinurate	2.5 x10^{-4} (± 1.6x10^{-4})	1.8 x10^{-4} (± 5.3x10^{-5})

Nucleotide Metabolism

	Majorera	*Palmera*
adenine	3.1 x10^{-4} (± 4.2x10^{-4})	1.9 x10^{-4} (± 1.2x10^{-4})
uridine	1.5 x10^{-4} (± 1.0x10^{-4})	1.2 x10^{-4} (± 2.7x10^{-5})
xanthine	1.5 x10^{-4} (± 6.0x10^{-5})	1.3 x10^{-4} (± 6.2x10^{-5})

TCA Cycle

	Majorera	*Palmera*
acetate	1.4 x10^{-4} (± 3.9x10^{-5})	2.3 x10^{-4} (± 1.1x10^{-4})
formate	7.6 x10^{-4} (± 8.9x10^{-4})	8.2 x10^{-4} (± 7.2x10^{-4})
fumarate	1.3 x10^{-4} (± 3.5x10^{-5})	1.1 x10^{-4} (± 5.4x10^{-5})
citrate	1.1 x10^{-4} (± 7.2x10^{-5})	2.0 x10^{-4} (± 2.6x10^{-4})
pyruvate	2.0 x10^{-4} (± 8.1x10^{-5})	1.6 x10^{-4} (± 1.3x10^{-4})
succinate	1.5 x10^{-4} (± 7.5x10^{-5})	2.0 x10^{-4} (± 1.0x10^{-4})

Lactose

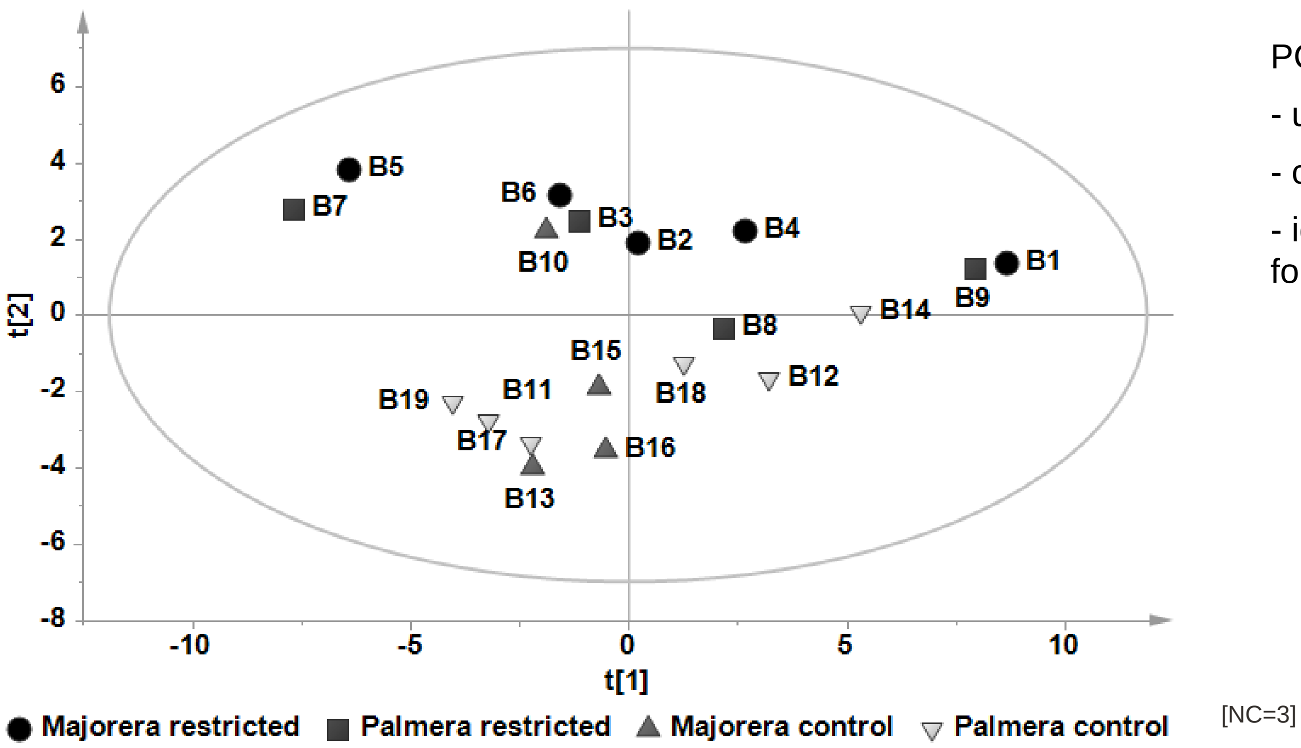
~2x10^{-2} mmol/g tissue

$NADP^+$

~4x10^{-5} mmol/g tissue

Mammary Gland: multivariate analysis

Principal Component Analysis (PCA)



PCA:

- unsupervised analysis
- cluster the samples (scores)
- identify metabolites responsible for the group clustering (loadings)

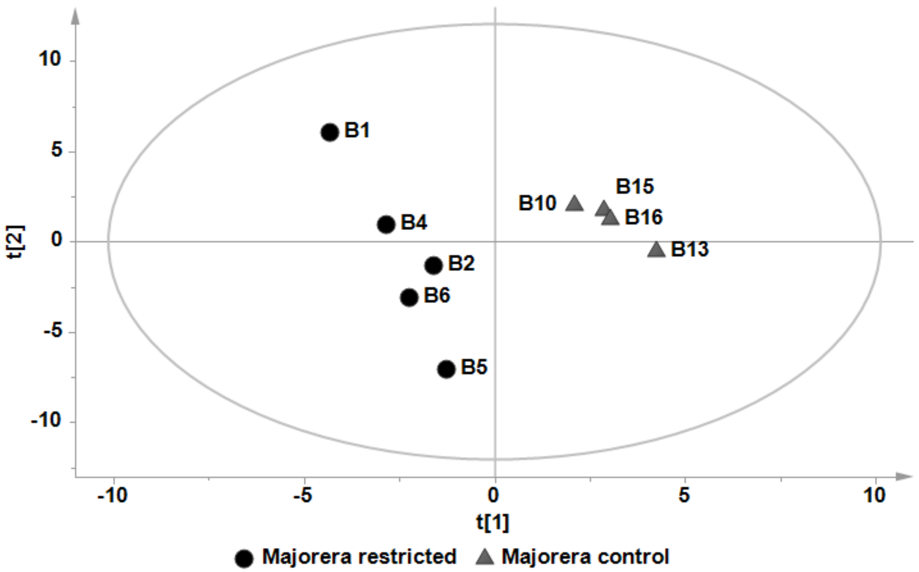
- PCA is not capable of separating the 4 groups.

Mammary Gland: multivariate analysis

Partial Least Squares Discriminant Analysis (PLS) &

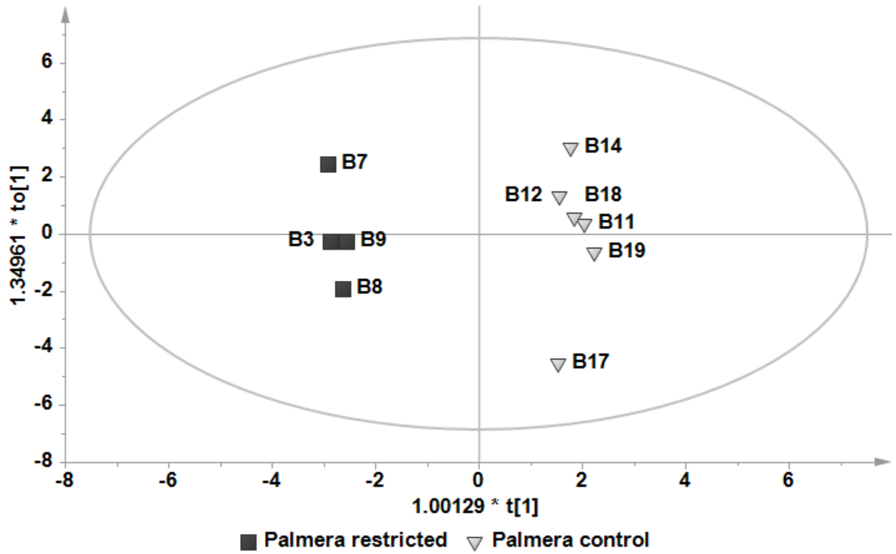
Orthogonal Partial Least Squares Discriminant Analysis (OPLS)

PLS *Majorera* breed



[NC=2; Q^2=0.81; $\rho_{CV\text{-}ANOVA}$=0.91]

OPLS *Palmera* breed



[NC=1+3+0; Q^2=0.66; $\rho_{CV\text{-}ANOVA}$=1.01]

- PLS/OPLS analysis was necessary to differentiate between control and restricted groups.

PLS / OPLS:

- supervised analysis
- evaluate repeated variables between groups
- highlight differences between groups

Metabolomics: Conclusions

Majorera breed

- Acetate *

- IMP
- Phosphocholine

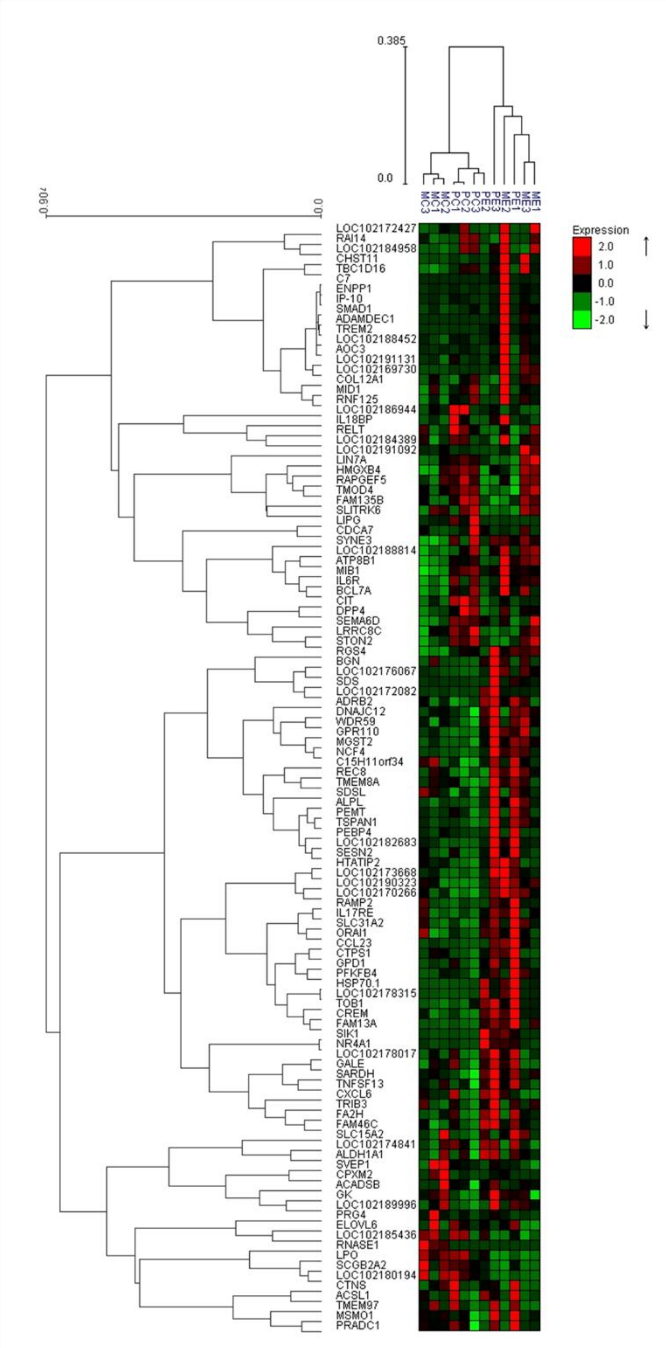
- Variations are consistent between breeds

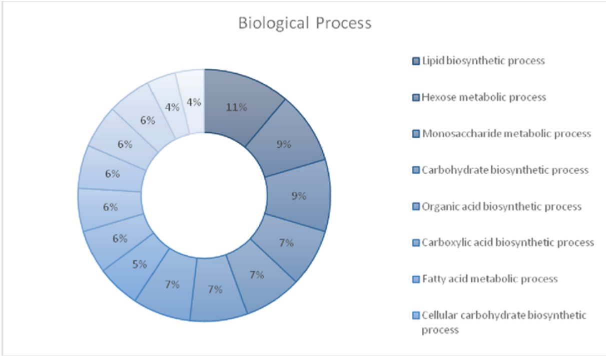
- Differences could be related to:
  - ✓ metabolism adaptation to the low-energy diet
  - ✓microflora composition *

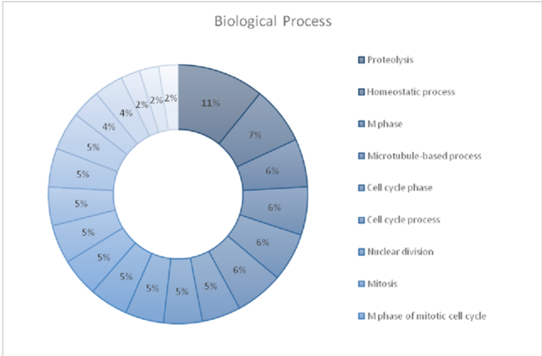
Palmera breed

- IMP
- ATP/ADP/AMP
- Phosphocholine

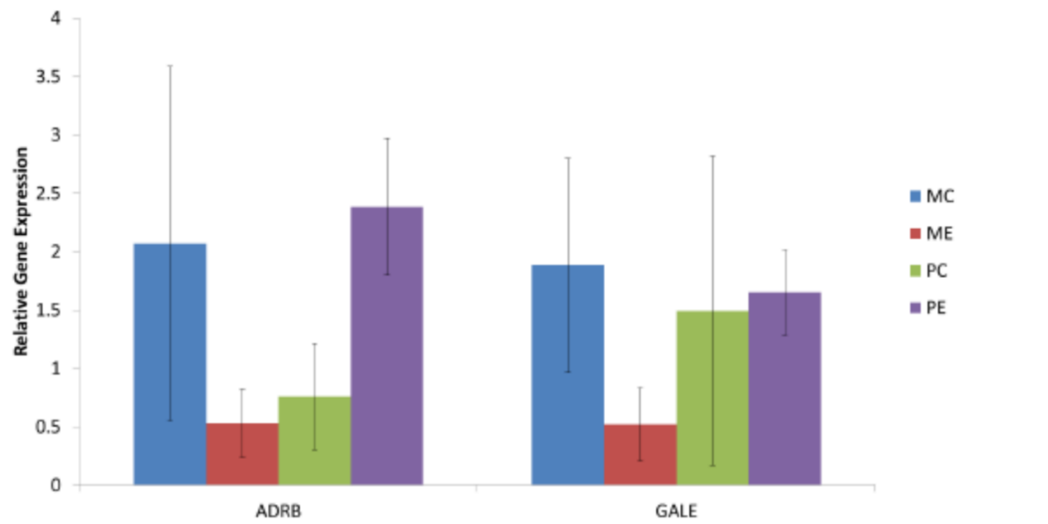
Transcriptome analysis







Reprograming of genes expression occurs as result of the stress imposed, irrespective to the breed studied



Validation of expression profiles through Real time quantitative PCR

Transcriptomics Analysis: Major Conclusions

- Reprograming of gene expression as a result of the stress imposed
- Different behavior of both breeds in response to SWL
- Numerous Biological processes affected in both breeds (Proteolysis, Fatty Acid Synthesis, etc.)
- Release of new genomic resources and shed light into the genes and regulatory networks underlying milk production under nutritional stress

Ricardo et al. (in preparation)

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The goat (*Capra hircus*) mammary gland secretory tissue proteome as influenced by weight loss: A study using label free proteomics

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NMR-metabolomics profiling of mammary gland secretory tissue and milk serum in two goat breeds with different levels of tolerance to seasonal weight loss†

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