August 28th, Lyon

Sweetened and salted former foodstuff products in the diet of growing and finishing pigs improve the sensory characteristics of loins without compromising growth performance

S Mazzoleni , M Tretola, C E M Bernardi, P Lin, P Silacci, G Bee, L Pinotti

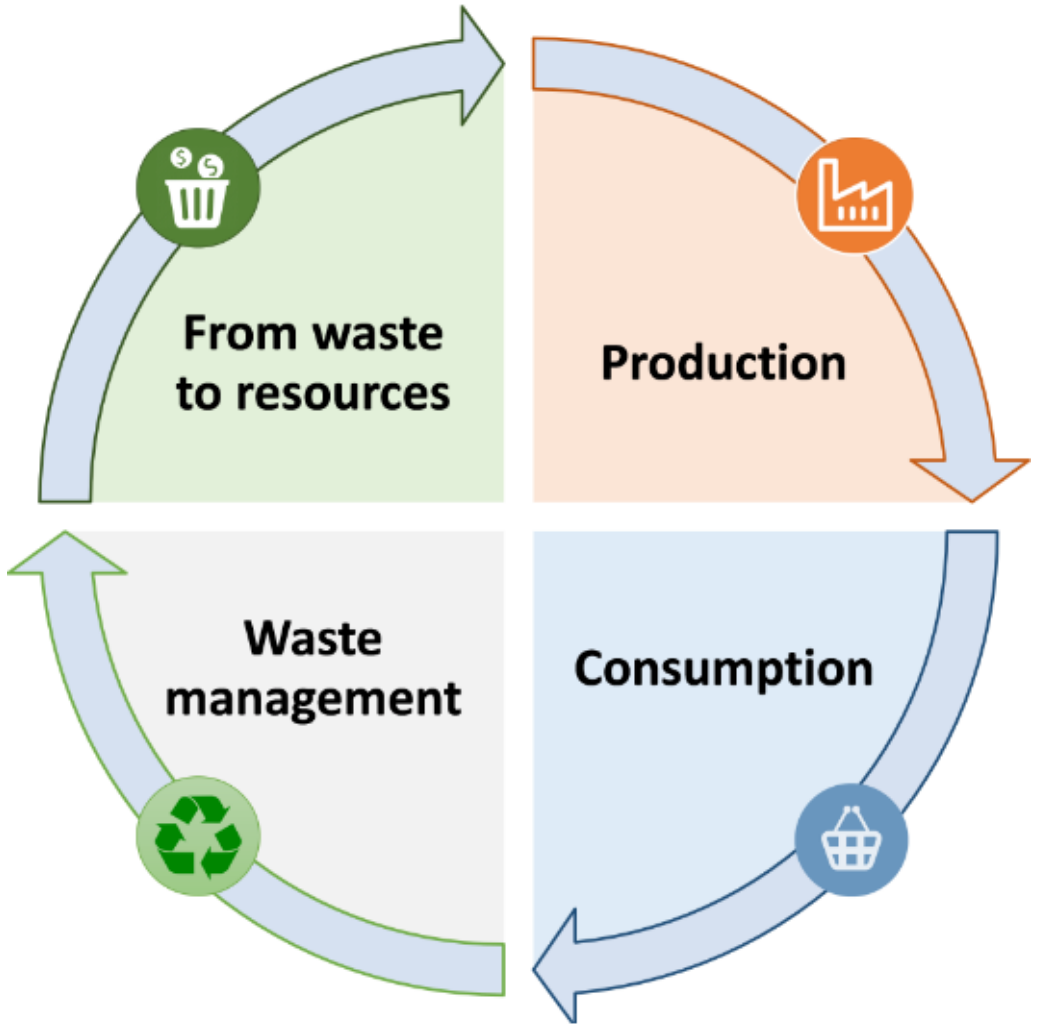
UNIVERSITÀ DEGLI STUDI DI MILANO

divas
DIPARTIMENTO DI MEDICINA VETERINARIA E SCIENZE ANIMALI

Agroscope

Background

Natural resources → Production → Consumption → Waste

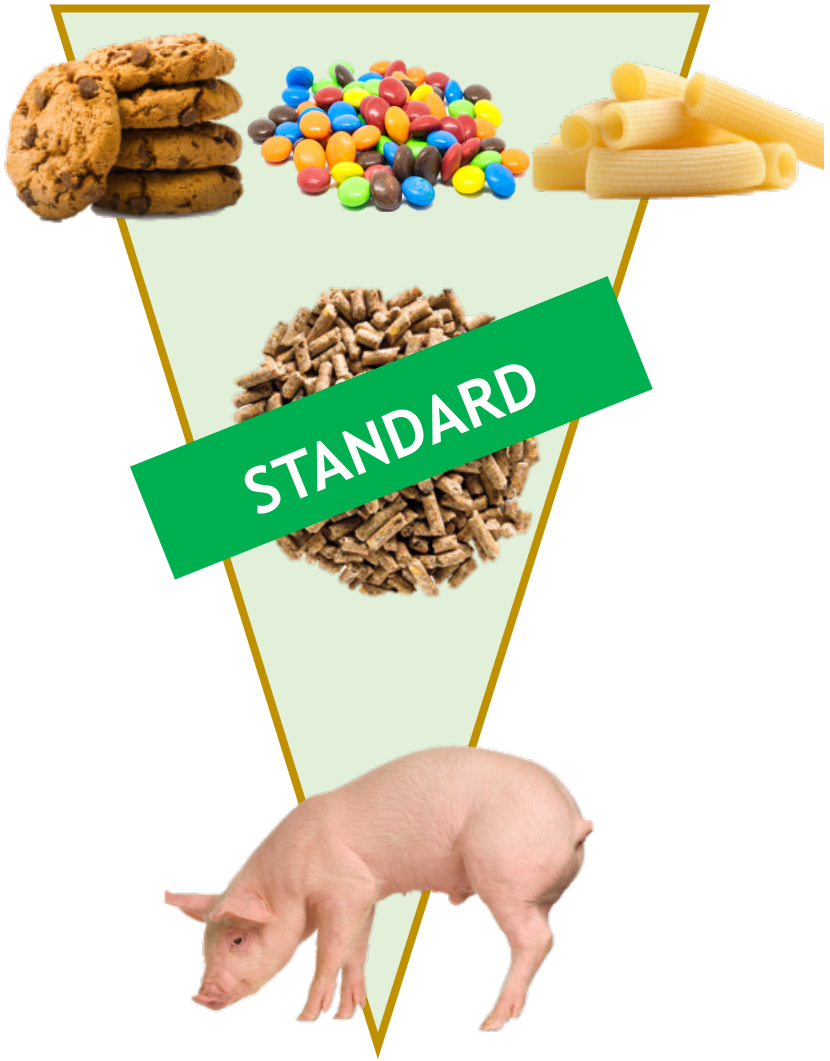


Waste prevention

Valorisation of food losses into animal feed

Background

Former Food Products: alternative ingredients for animal feed used in circular economy



- Full compliance with EU food law **(Regulation (EU) No 2017/1017)**
- No longer intended for human consumption, but **different** from household waste and catering reflux
- Rich in starch, fats and sugars: **suitable for pig nutrition**

(*Pinotti et al., 2019*)

Background - What do we know about FFPs?

ITALIAN JOURNAL OF ANIMAL SCIENCE
2019, VOL. 18, NO. 1, 987–996
https://doi.org/10.1080/1828051X.2019.1607784

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PAPER

OPEN ACCESS Check for updates

Former food products have no detrimental effects on diet digestibility, growth performance and selected plasma variables in post-weaning piglets

Marco Tretola, Matteo Ottoboni, Alice Luciano, Luciana Rossi, Antonella Baldi and Luciano Pinotti

Dipartimento di Scienze veterinarie per la salute, la produzione animale e la sicurezza alimentare, University of Milan, Milan, Italy

ELSEVIER

Contents lists available at ScienceDirect

Animal
The international journal of animal biosciences

Sugary vs salty food industry leftovers in postweaning piglets: effects on gut microbiota and intestinal volatile fatty acid production

Check for updates

M. Tretola [a,b,*], L. Ferrari [a], A. Luciano [a], S. Mazzoleni [a], N. Rovere [a], F. Fumagalli [a], M. Ottoboni [a], L. Pinotti [a]

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[b] Agroscope, Institute for Livestock Sciences, La Tioleyre 4, 1725 Posieux, Switzerland

(*Tretola* et al., 2019a, 2022; *Pinotti* et al., 2023; *Mazzoleni* et al., 2023)

ELSEVIER

animal

Available online 24 July 2023, 100918

In Press, Corrected Proof What's this?

Review: Pig-based bioconversion: the use of former food products to keep nutrients in the food chain

L. Pinotti [a], L. Ferrari [a], F. Fumagalli [a], A. Luciano [a], M. Manoni [a], S. Mazzoleni [a], C. Govoni [b], M.C. Rulli [b], P. Lin [a c], G. Bee [c], M. Tretola [a c]

ELSEVIER

Journal of Hazardous Materials

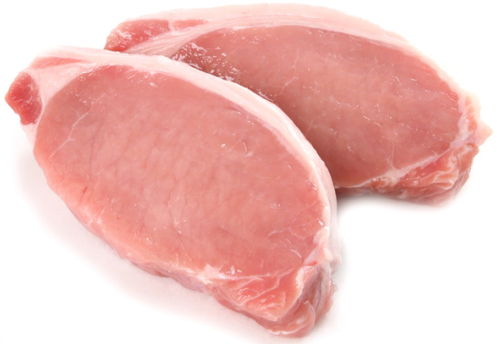
Volume 448, 15 April 2023, 130888

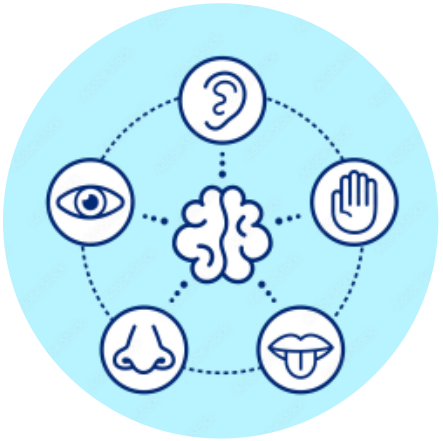
Packaging contaminants in former food products: Using Fourier Transform Infrared Spectroscopy to identify the remnants and the associated risks

Sharon Mazzoleni [a], Stefano Magni [b], Marco Tretola [a c], Alice Luciano [a], Luca Ferrari [a], Cristian Edoardo Maria Bernardi [a], Peng Lin [a], Matteo Ottoboni [a], Andrea Binelli [b], Luciano Pinotti [a d]

Aim of the study

1. Replace 30% of cereal grains with salty and sugary FFPs in growing and finishing pigs monitoring:





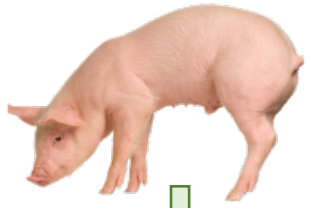
✓ **Growth performance**

✓ **Meat composition and quality traits**

✓ **Sensory characteristics of the loin**

Material & Methods - Study design

n 36



male castrated pigs
5 litters

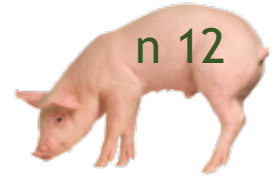
Standard diet-ST

n 12

Salty diet(30% FFPs)-SA

n 12

Sugary diet(30% FFPs)-SU



n 12

BW: weekly
FI: daily

→ ADG
ADFI
FCR

20 kg → 60 kg → 110 kg

Growing diet (G)

ST-G
SA-G
SU-G

Finishing diet (F)

ST-F
SA-F
SU-F

Slaughter

n 36 samples
longissimus thoracis

n 18 samples

- Fatty acids profile of IM fat and backfat
- pH: 45', 3h, 24h
- T (°C) : 45min, 3h, 24h
- Shear force, maturation, thawing, cooking, drip losses (%)
- L*, a*, b*, saturation (C*), hue angle (H*)

X 21

Sensory analysis:

pork aroma, pork flavor, sweet taste, salty taste, tenderness

Material & Methods

Dietary ingredients used for the experimental diets in the growing (G) and finishing (F) periods

	Dietary treatments					
	Growing diets			Finishing diets		
Ingredient, %	ST-G	SA-G	SU-G	ST-F	SA-F	SU-F
Barley	41.10	39.70	38.00	46.40	41.30	41.80
Wheat	30.00	-	-	30.00	-	-
Salty FFPs	-	30.00	-	-	30.00	-
Sugary FFPs	-	-	30.00	-	-	30.00
Fat	2.69	-	0.79	2.22	-	0.68
Potato protein	5.00	5.00	5.00	5.00	5.00	5.00
Soybean meal	6.59	6.16	7.36	3.55	2.77	4.03
Wheat bran	4.34	9.06	8.76	3.93	12.30	9.87
Dried beet pulp	5.15	5.15	5.15	4.50	4.50	4.50

	Dietary treatments					
	Growing diets			Finishing diets		
	ST-G	SA-G	SU-G	ST-F	SA-F	SU-F
Analyzed nutrient composition (g/kg DM)						
Total ash	68	74	72	62	65	64
Crude fat	52	53	61	45	53	59
CP	173	174	176	152	151	153
Crude fiber	42	40	39	42	39	40
Sodium	1.3	3.7	1.5	1.7	3.2	1.7
SFA	18	12	18	16	12	20
MUFA	19	26	20	14	29	25
PUFA	17	16	14	16	18	18
Calculated						
Digestible phosphorus (g/kg DM)	2.9	2.9	2.9	2.2	2.2	2.2
Digestible lysine (g/kg DM)	8.3	8.3	8.3	6.2	6.2	6.2
DE (MJ/kg DM)	13.7	13.7	13.7	13.7	13.7	13.7

*All diets were formulated based on the Swiss feeding recommendations for pigs (isoenergetic and isonitrogenous)

(Agroscope, 2022)

Material & Methods – Evaluation methods

Meat quality traits

pH and T (°C)	10th-rib level inside of the left carcass side
Drip losses	Measured as the proportions of purge generated during storage for 24h at 2°C
Shear force	Texture Analyzer (2.5-mm thick Warner Blatzer shear blade)
Cooking loss	LT chops: weighed and cooked on a Indu-griddle SH/GR 3500 grill plate (inner T of 69°C)
L*, a*, b*	1.5-cm-thick chops formula chroma = √a* 2 + b* 2

Meat chemical composition

Fatty acids ➢ Gas chromatography (Kragten-Ampuero et al., 2014)

Sensory analysis

- Pork loins: cooked in a heating plate for 10 min (to a core temperature of 69°C ± 2°C) and cut into 1 cm cubes
- Samples were rated on a linear scale in which the difference from the control sample was expressed in the range *"much less intense than the control"* to *"much more intense than the control"*

Material & Methods - Statistical analysis

Meat quality traits and meat chemical composition

- R software (Version 4.2.1)
  - Lme4 package (diet and time as fixed and animal as random effects)

Sensory data

- XLSTAT (Version 2019.2.2), T-test (SU vs ST and SA vs ST)

Significant differences when p-value < 0.05

Results – Growth performance

Body weight	ST	SA	SU	SEM	P-value
At start of the growing period	22.0	22.5	22.6	0.647	**0.72**
At the start of finishing period	64.4	64.3	64.2	0.835	**0.94**
At slaughter	107.4	109.1	108.9	1.294	**0.48**

Average daily gain	ST	SA	SU	SEM	P-value
Growing period	0.91	0.88	0.86	0.020	**0.26**
Finishing period	0.95	0.95	0.96	0.034	**0.98**
Growing-finishing period	0.93	0.92	0.91	0.021	**0.78**

Average feed intake	ST	SA	SU	SEM	P-value
Growing period	1.81	1.83	1.78	0.052	**0.68**
Finishing period	2.71	2.70	2.75	0.061	**0.79**
Growing-finishing period	2.25	2.26	2.25	0.051	**0.97**

Body weight, average daily gain, average feed intake did not significantly differ ($P>0.05$) among the three groups

Results – Growth performance

Feed conversion ratio (kg/kg)

	ST	SA	SU	SEM	P-value
Growing period	1.99b	2.08a	2.07a	0.021	**<0.01**
Finishing period	2.85	2.84	2.90	0.055	**0.61**
Growing-finishing period	2.43	2.48	2.50	0.030	**0.21**

Growing period → ST-G diet had a lower FCR compared to SA-G (+ 4.5%) and SU-G (+ 4.0%) diets

Growing-finishing period → FCR did not significantly differ (P>0.05) among the three groups

Results – Fatty acids profile of intramuscular fat (IM)

		ST	SA	SU	SEM	P-value
Intramuscular fat (g kg -1 muscle)		40.1	47.9	44.1	6.61	0.351
Fatty acid profile (g 100g-1 total fatty acids)						
12:0		0.04	0.04	0.05	0.002	0.252
14:0	Myristic	0.51	0.60	0.57	0.029	0.467
16:0	Palmitic	9.70	10.80	11.60	0.536	0.337
16:1	Palmitoleic	1.34	1.49	1.41	0.071	0.716
17:0		0.07	0.07	0.07	0.003	0.936
18:0	Stearic	4.81	5.61	5.32	0.253	0.437
18:1 n-9	Oleic	17.3	22.4	19.7	1.05	0.141
18:2 n-6	Linoleic	2.31	2.52	2.43	0.077	0.554
18:3 n-3	Alpha-linolenic	0.15	0.14	0.14	0.006	0.873
20:2 n-6		0.07	0.09	0.08	0.004	0.265
20:3 n-3		0.02	0.02	0.00	0.001	0.599
20:3 n-6		0.06	0.06	0.06	0.001	0.847
20:4 n-6	Arachidonic	0.42	0.43	0.42	0.005	0.523
20:5 n-3	**EPA**	**0.03b**	**0.02a**	**0.02ab**	**0.001**	**<0.001**
22:4 n-6		0.06	0.06	0.05	0.001	0.076
22:5 n-3	**DPA**	**0.07b**	**0.05a**	**0.06ab**	**0.001**	**0.002**

	ST	SA	SU	SEM	P-value
MUFA	20.9	26.5	23.5	1.22	0.181
PUFA	3.36	3.57	3.45	0.090	0.701
SFA	15.3	18.1	16.9	0.82	0.382
PUFA/SFA ratio	0.23	0.20	0.21	0.005	0.196
MUFA/SFA ratio	**1.39a**	**1.46b**	**1.39a**	**0.012**	**0.022**
Sum of n-3 FA	0.27	0.27	0.26	0.009	0.551
Sum of n-6 FA	2.94	3.01	3.07	0.087	0.515
n-6/n-3 FA ratio	**10.8a**	**13.1c**	**12.0b**	**0.20**	**<0.001**

SA:

↓ 20:5 n-3 and 22:5 n-3 compared to ST

↑MUFA/SFA ratio compared to ST and SU

↑ n-6:n-3 ratio compared to ST and SU

SU:

↑ n-6:n-3 ratio compared to ST

Results – Fatty acids profile of backfat

	ST	SA	SU	SEM	P-value
10:0	0.49	0.43	0.47	0.014	0.179
12:0	**0.70a**	**0.65a**	**1.28b**	**0.049**	**<0.001**
14:0	**11.6b**	**10.1a**	**12.4c**	**0.20**	**<0.001**
c9 14:1	**0.22b**	**0.12a**	**0.19b**	**0.010**	**<0.001**
15:0	**0.57b**	**0.44a**	**0.56b**	**0.017**	**<0.001**
16:0	**231c**	**213a**	**221b**	**1.1**	**<0.001**
16:1 n-7	**17.7b**	**12.9a**	**14.4a**	**0.50**	**<0.001**
17:0	**3.34b**	**2.46a**	**2.98b**	**0.103**	**0.001**
c10 17:1	**3.39b**	**2.16a**	**2.63a**	**0.126**	**<0.001**
18:0	**144b**	**126a**	**137ab**	**2.3**	**0.002**
Trans 18:1 n-7	**26.3c**	**18.8a**	**21.2b**	**0.60**	**<0.001**
18:1 cis-9	**391a**	**427c**	**408b**	**3.6**	**<0.001**
18:2 n-6	82.1	82.6	82.4	0.81	0.971
18:3 n-6	0.19	0.18	0.17	0.008	0.640
18:3 n-3	**7.25c**	**5.86a**	**6.53b**	**0.135**	**<0.001**
c10 19:1	**0.76b**	**0.51a**	**0.63ab**	**0.039**	**0.027**
20:0	2.21	2.08	2.17	0.044	0.469

	ST	SA	SU	SEM	P-value
20:2 n-6	4.35	4.25	4.31	0.074	0.872
20:3 n-3	**1.32b**	**0.98a**	**1.21b**	**0.033**	**<0.001**
20:3 n-6	**0.61b**	**0.51a**	**0.55ab**	**0.011**	**0.002**
20:4 n-6	1.57	1.52	1.42	0.029	0.109
22:4 n-6	0.57	0.51	0.49	0.016	0.129
22:5 n-3	**0.60b**	**0.41a**	**0.48a**	**0.021**	**<0.001**
MUFA	**458a**	**479b**	**466a**	**3.3**	**0.030**
PUFA	102	98.3	99.9	0.99	0.344
SFA	**395c**	**356a**	**378b**	**3.5**	**<0.001**
PUFA/SFA	0.26	0.28	0.26	0.003	0.123
MUFA/SFA	**1.15a**	**1.34b**	**1.23a**	**0.017**	**<0.001**
Sum of n-3	**9.11c**	**7.25a**	**8.22b**	**0.170**	**<0.001**
Sum of n-6	89.4	89.5	89.3	0.85	0.994
n-6/n-3	**9.82a**	**12.4c**	**10.8b**	**0.20**	**<0.001**

- **SA and SU:** ↓ several FAs compared to the ST, especially SFA and the total of n-3
- **SA:** ↑ MUFA/SFA and n-6/n-3 ratio compared to SU and ST
- **SU:** ↑ 12:0, 14:0, 18:1 cis-9 and the n-6/n-3 ratio compared to ST

Results – Meat quality traits

	ST	SA	SU	SEM	P-value
pH 45'	6.7	6.8	6.7	0.05	**0.39**
pH 3h	6.5	6.6	6.5	0.07	**0.58**
pH 24h	5.4	5.4	5.4	0.02	**0.47**
T 45min, °C	34.3	34.7	33.6	0.78	**0.56**
T 3h, °C	20.8	21.0	20.7	0.34	**0.83**
T 24h, °C	5.0	4.9	4.7	0.17	**0.54**
Maturation loss, %	2.8	2.9	3.1	0.19	**0.63**
Thawing loss, %	6.0	5.4	5.7	0.31	**0.41**
Cooking loss, %	21.5	21.3	21.1	0.73	**0.95**
Drip loss, %	2.3	2.3	2.8	0.26	**0.27**
WBSF, N	51.1	47.7	48.9	2.35	**0.58**
SD (wbsf), N	5.9	4.7	5.9	0.79	**0.49**
CV (wbsf), %	11.9	10.0	12.3	1.78	**0.73**

All the meat quality traits analysed did not significantly differ (P>0.05) among the three groups

Results – Meat quality traits

Colour parameters measured in fresh meat over 3 days of aerobic refrigerated storage

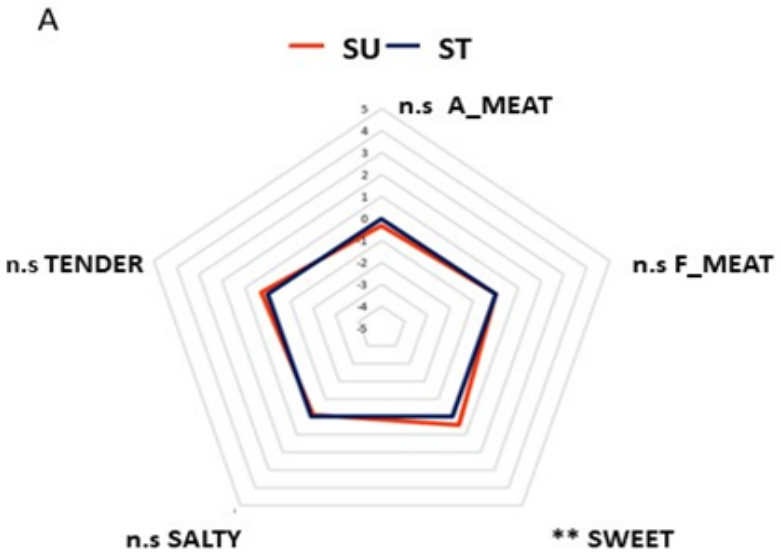
	ST		SA		SU			P-values		
Time	24h	72h	24h	72h	24h	72h	SEM	D	T	DxT
L*	56.1	58.5	56.3	59.8	56.5	59.4	0.63	**0.775**	**<0.001**	**0.297**
a*	0.88	1.17	0.93	1.17	0.84	1.12	0.088	**0.745**	**0.001**	**0.838**
b*	11.9	13.2	11.8	13.4	11.7	13.1	0.21	**0.571**	**<0.001**	**0.561**
C*	12.3	13.7	12.1	13.8	11.9	13.5	0.24	**0.611**	**<0.001**	**0.681**
H*	4.35	4.32	4.35	4.33	4.36	4.33	0.011	**0.663**	**0.021**	**0.547**

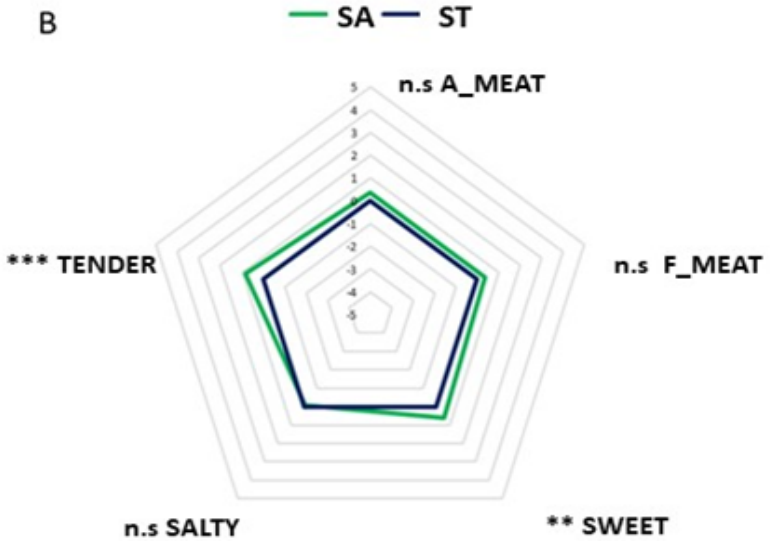
P-values for dietary treatment (D), time of storage (T) and their interaction (DxT)

- ✓ The diets did not affect (P>0.05) any of the measured parameters
- ✓ All the parameters were affected by the time of storage

Results – Meat's sensory attributes

Sensory attributes	SU vs ST	SA vs ST
Pork aroma	-0.23	0.37
Pork flavour	0	0.36
Sweet flavour	0.46	0.60
Salty flavour	-0.11	-0.07
Tenderness	0.26	0.84





SU vs **ST**→ SU samples were perceived as significantly sweeter ($p<0.01$) than the ST

SA vs **ST**→ SA samples were perceived as significantly sweeter ($p<0.001$) and more tender ($p<0.0001$) than the ST

Take home messages

- ✓ The use of salty and sugary FFPs up to 30% level of inclusion did not impair the growth performance when well-balanced and iso diets were provided
- ✓ The 30% of FFPs in pig diets affected the fatty acid profile of IM fat and backfat
- ✓ Salty and sugary FFPs improved sensory attributes of the *longissimus thoracis*

Thank you!!

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DIPARTIMENTO DI MEDICINA VETERINARIA E SCIENZE ANIMALI

Agroscope

		Growing diets			Finishing diets		
		ST-G	SA-G	SU-G	ST-F	SA-F	SU-F
Fatty acids profile (g 100g-1 total fatty acids)							
14:0	Myristic	0.61	0.18	0.75	0.50	0.16	0.94
16:0	Palmitic	11.6	8.80	10.6	10.5	9.04	12.7
16:1	Palmitoleic	0.80	0.14	0.32	0.64	0.16	0.40
18:0	Stearic	4.54	1.54	3.96	3.85	1.54	4.36
18:1 trans-11	Vaccenic	1.16	0.46	0.62	0.94	0.50	0.75
18:1 cis-9	Oleic	14.9	23.9	17.7	11.7	27.3	22.6
18:2 n-6	Linoleic	14.4	13.7	12.1	14.1	15.8	15.7
18:3 n-3	α-linolenic	1.49	1.19	1.13	1.24	1.15	1.31
20:0	Arachidic	0.11	0.15	0.16	0.10	0.15	0.18
20:1	Eicosenoic	0.26	0.19	0.16	0.22	0.21	0.21
22:0	Docosanoic	0.08	0.23	0.12	0.07	0.22	0.14
SFA		17	11	17	15	11	19
MUFA		18	25	19	14	28	24
PUFA		16	15	13	15	17	17