

INTAQT Final conference
11th September 2026
Hamburg, Germany

INTAQT One Quality

Sensory features

intaqt
one quality

Massimiliano Petracci, UNIBO



INTAQT | Sensory and technological quality traits



Technological traits

- MSA indicators: rib fat depth, ossification, marbling, meat and fat colour, ultimate pH and age (carcass)
- Spoilage microbiota, texture, lipid oxidation and colour (aged meat)

Sensory traits

- Consumer testing (aged meat)



*Individual-
animal
samples*

Technological traits

- Composition, colour and microbiological quality (raw milk)
- Freezing point, lipolysis, protein fractions and variants (raw milk)
- Microbial diversity (raw milk)

Sensory traits

- Trained sensory profiling and volatile organic compounds (UHT milk)
- Consumer testing (UHT milk and cheese)



*Farm-representative
samples*

Technological traits

- Breast muscle myopathies
- pH, colour, water-holding capacity, marinade uptake and tenderness (breast and thigh meat)
- Spoilage microbiota, lipid oxidation and discolouration during simulated retail display (processed product)

Sensory traits

- Trained sensory profiling (breast meat)
- Consumer testing (ready-to-eat breast)



Sensory &
Technological
traits

Beef meat | Carcass and quality descriptors for animals collected for sensory testing

n. = 200

MSA ¹ parameter	Suckler beef farms		Fattening cattle		Fattening cattle	
	Pasture-based		Pasture-based		Indoor	
	No fattening of culled cows	Fattening of culled cows	Low feed inputs	Medium feed inputs	Medium feed inputs	High feed inputs
n. of carcass	18	36	19	36	27	64
Age (months)	11 (1)	70 (28)	24 (3)	32 (8)	15 (3)	15 (3)
Carcass weight (kg)	206 (23)	477 (47)	294 (23)	319 (35)	296 (28)	356 (88)
Ossification	122 (16)	458 (132)	152 (23)	209 (58)	152 (32)	168 (33)
Marbling (MBC)	194 (67)	335 (84)	331 (73)	359 (122)	232 (105)	357 (86)
Rib fat (mm)	3.8 (1.7)	4.5 (2.5)	5.3 (3.3)	7.8 (3.9)	7.1 (5.8)	6.4 (4.1)
Ultimate pH	5.51 (0.18)	5.66 (0.23)	5.50 (0.14)	5.53 (0.10)	5.39 (0.20)	5.51 (0.08)

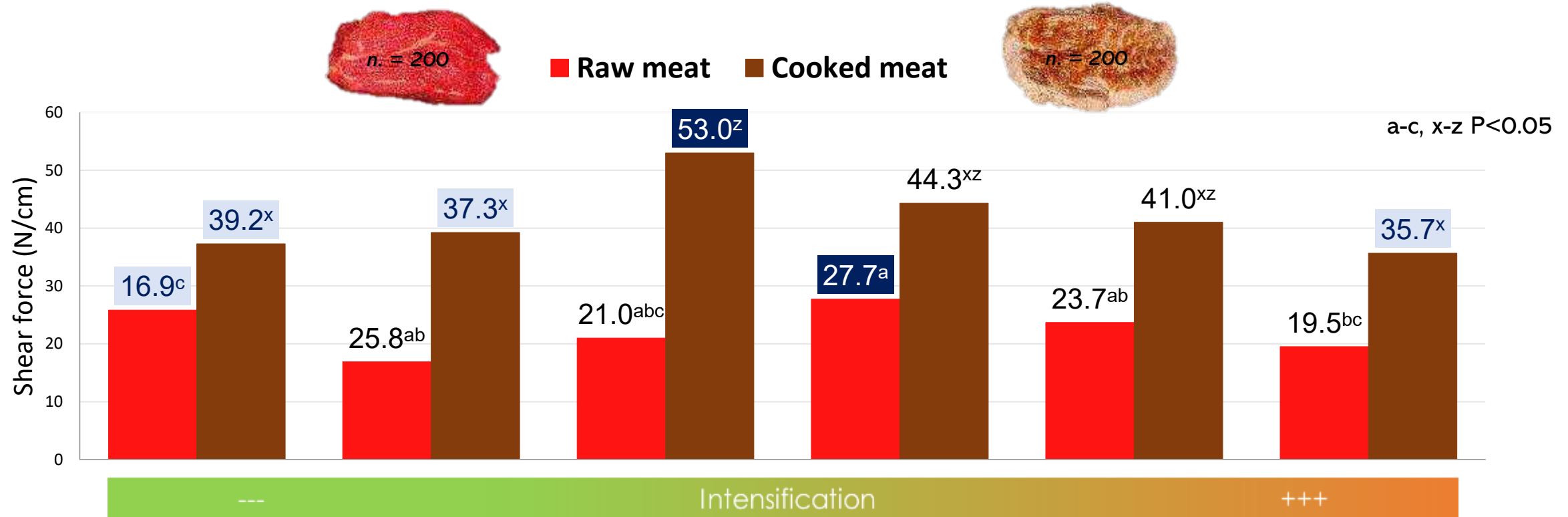
¹MSA stands for Meat Standards Australia , a comprehensive, science-based eating quality grading program developed by Meat & Livestock Australia

Values are means (standard deviations)



➡ Systems primarily separated animal category and carcass maturity; marbling, fatness and pH overlapped and showed no consistent intensification gradient

Beef meat | Instrumental tenderness

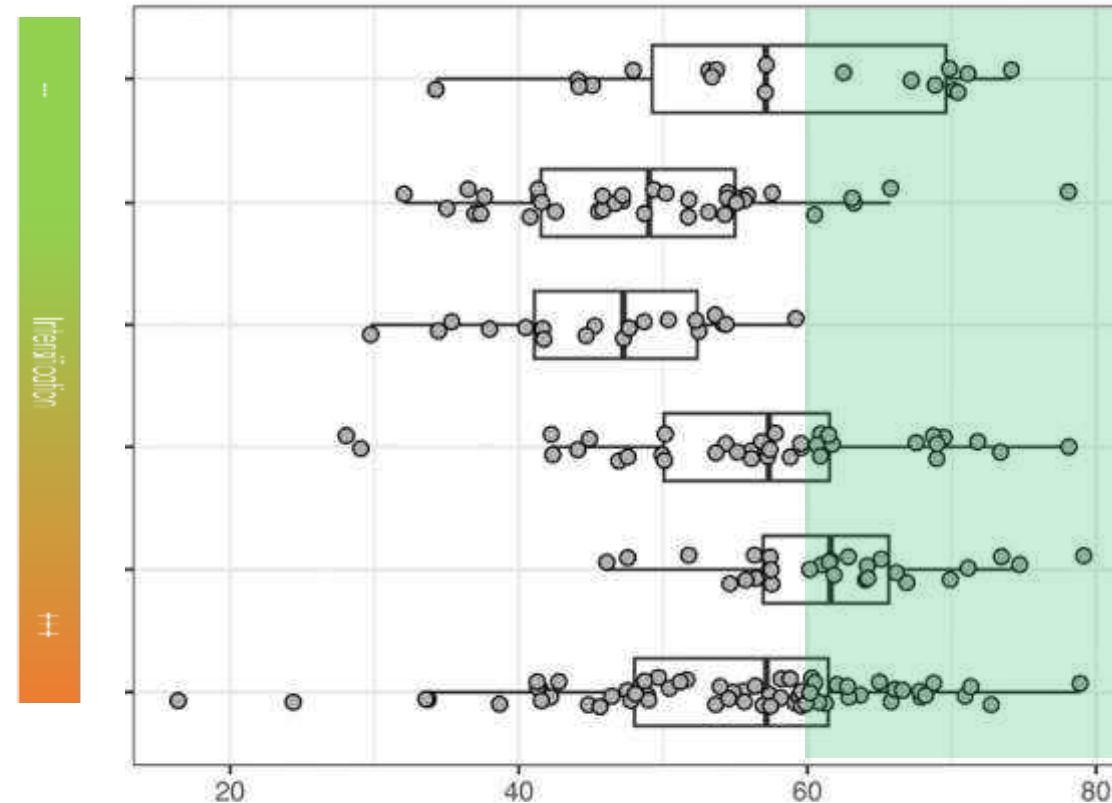


Shear force differed among production systems, with no consistent relationship with intensification

Beef meat | Consumer eating quality

MQ4 is an internationally recognised score that describes the complete eating experience of a consumer ($0.3 \times \text{tenderness} + 0.1 \times \text{juiciness} + 0.3 \times \text{flavour liking} + 0.3 \times \text{overall liking}$)

Consumer tests in
Italy, France and
Poland –Blind tests



Each point represents one animal
(n = 200); boxes show the median
and interquartile range, and
whiskers show the full range.

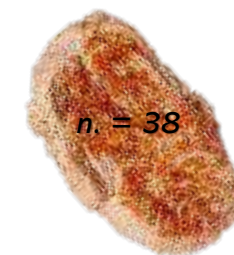
Overall liking of striploins - Mean composite score (MQ4) per animal

➔ System means differed without following the intensification gradient; within-system ranges were four to five times wider than the range between system means

Beef meat | Cross-country consumer comparison

Parameter	France	Italy	Poland
Tenderness	52.2 (15.7)	49.7 (16.7)	54.9 (14.7)
Juiciness	43.0^b (14.1)	48.9_y (15.1)	61.6^a_x (9.7)
Flavour liking	55.3^b (10.7)	54.9 (11.4)	61.7^a (9.5)
Overall liking	52.3^b (12.6)	52.9 (13.2)	60.3^a (10.4)
MQ4 score	52.1^b (11.8)	51.9_y (12.6)	58.9^a_x (10.1)

Each of 38 striploins was evaluated in two countries



Values are descriptive means (SD) for the paired cross-country subset.

^a, ^b = significant difference ($p < 0.05$) from the mean of the sensory parameter between FR and PL

_x, _y = significant difference ($p < 0.05$) from the mean of the sensory parameter between IT and PL

➡ Polish consumers used higher scores, whereas French and Italian consumers responded similarly; nevertheless, shared samples were ranked broadly consistently across countries ($r = 0.67$)

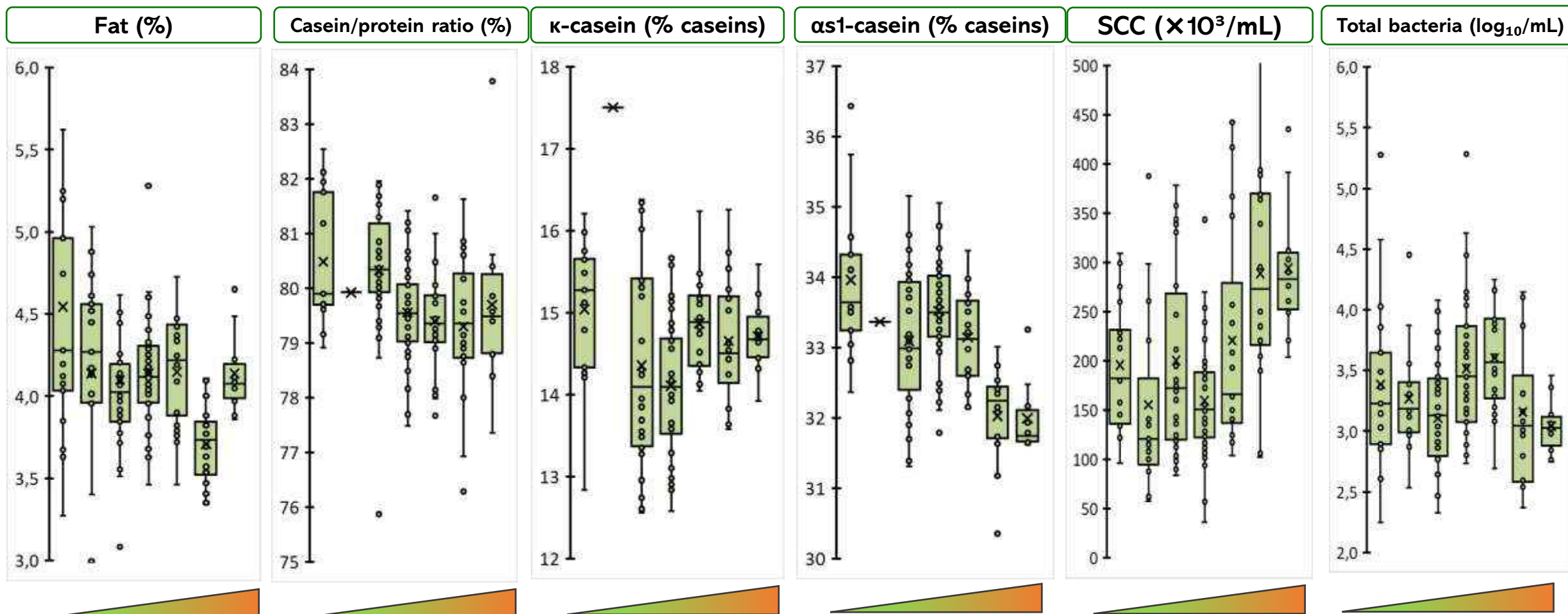


- **Production systems characterised animals more strongly than eating quality**
Age, carcass weight and ossification clearly separated systems, whereas marbling, pH, shear force and consumer scores overlapped substantially
- **Intensification did not create a consistent eating-quality hierarchy**
Farming-system labels can convey origin and management context, but they should not be used as proxies for the eating quality of an individual cut
- **Eating quality is shaped along the entire chain**
Dominant within-system variation highlights additional control points in animal selection, pre-slaughter handling, ageing and *post-mortem* management
- **A shared cross-country eating-quality framework appears feasible**
Consumers broadly agreed on sample ranking and sensory weightings; country-specific grade thresholds can accommodate differences in scale use

Dairy | Technological traits of raw milk



(n. = 373)



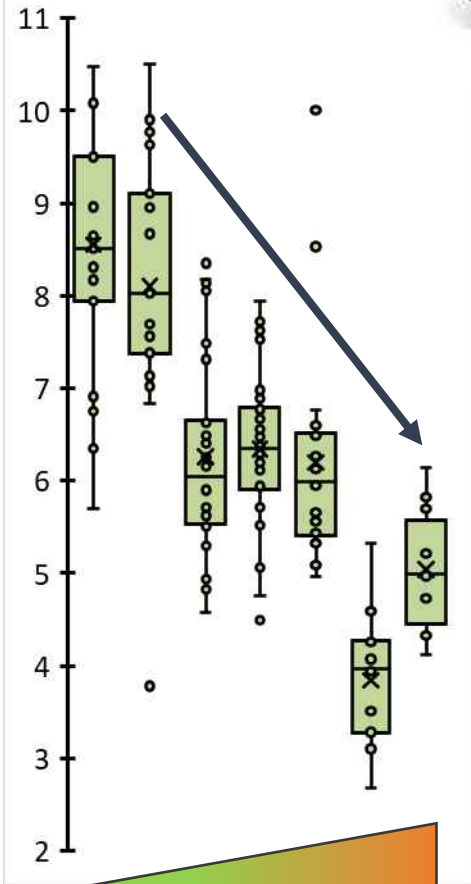
➔ Most technological traits differed among farm typologies, but showed weak and non-linear relationships with intensification

Dairy | Colour of raw and UHT milk

Raw milk (n. = 373)

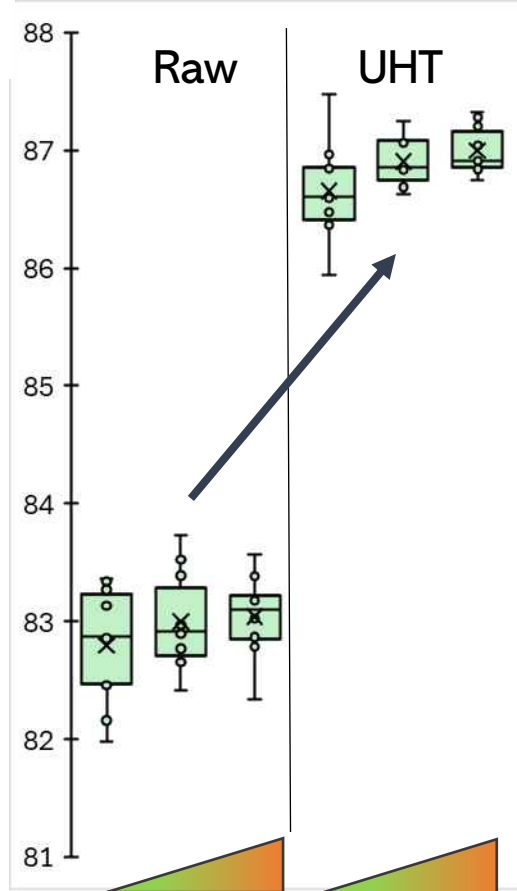


Yellowness b^*

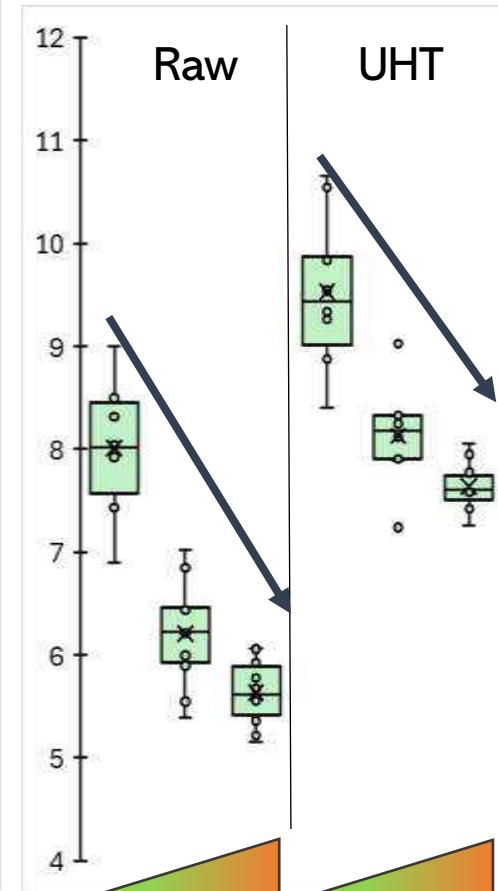


UHT milk (n. = 30)

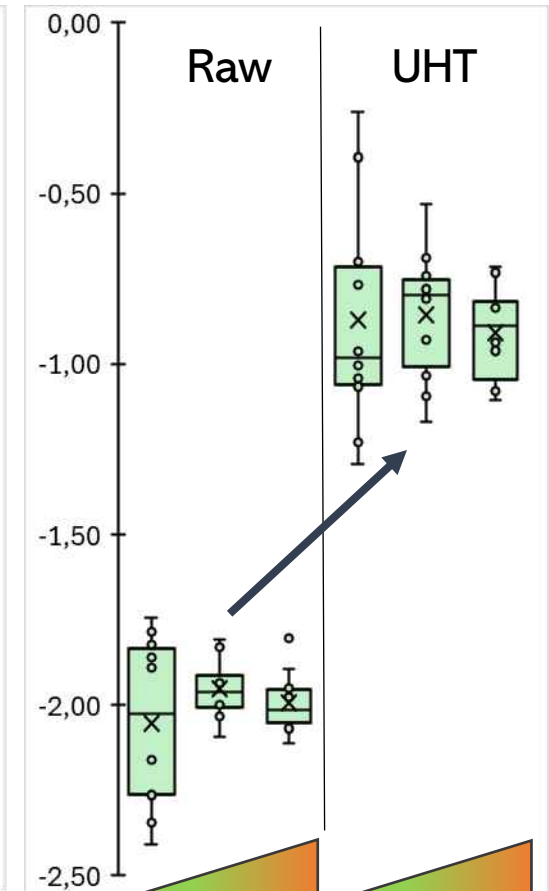
Lightness L^*



Yellowness b^*

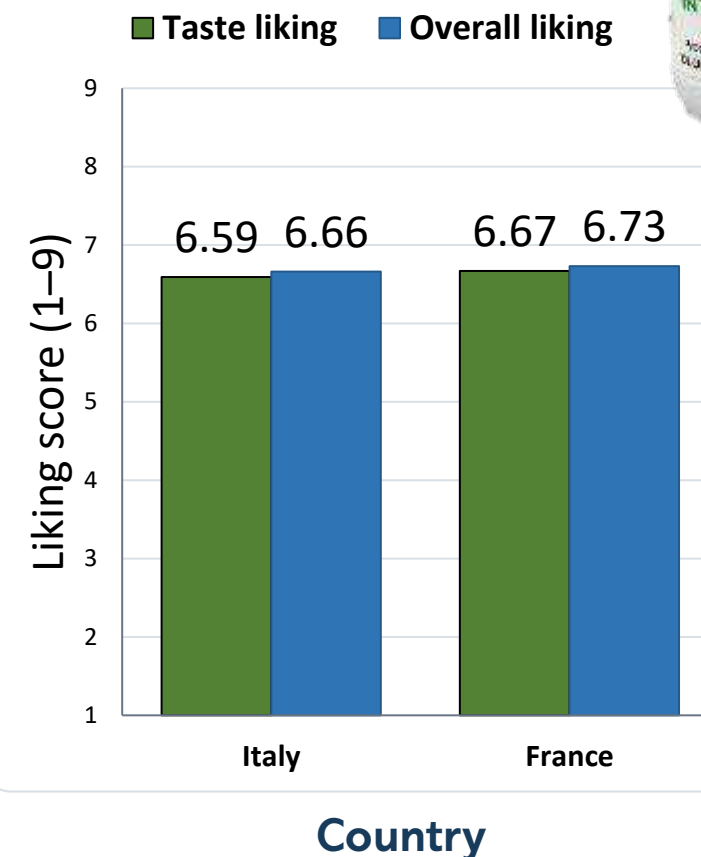
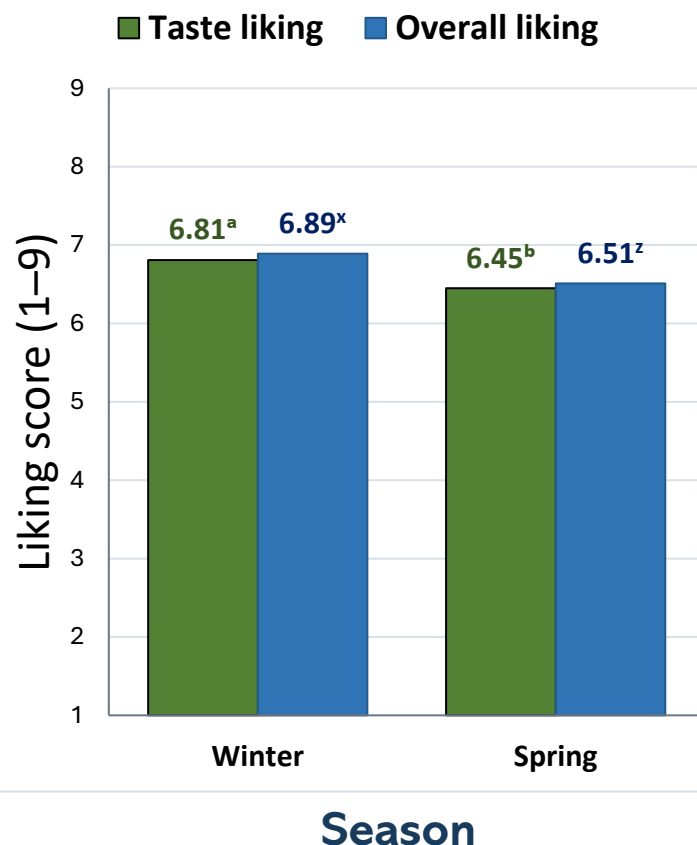
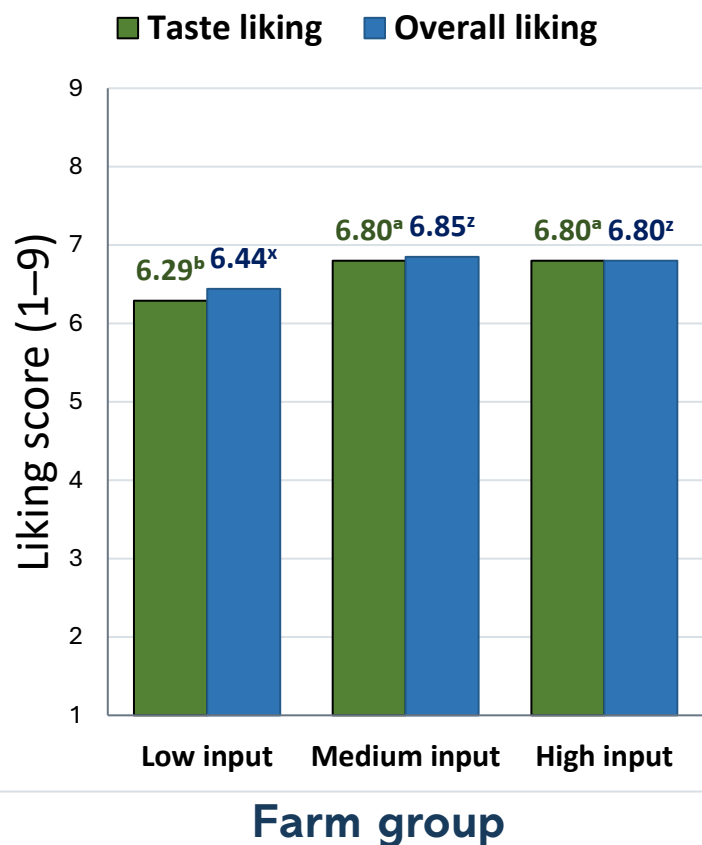


Redness a^*



➡ The milk from grass-based systems remained yellower after UHT treatment

Dairy | Consumer liking of UHT milk



a-b, x-z $P < 0.05$

➡ Taste liking was lower for the low-input farm group and for spring milk, whereas overall liking did not differ among farm groups, seasons or countries



Distinct cheese sensory features according to animal diets

- Yellower colour, a more melting texture and more pronounced flavours were associated with fresh-herbage feeding

Cabiddu et al., 2022

Results confirmed when 1/3 of the ingested hay was replaced with fresh



- Italian consumers: no preference in average

Gagliano et al., 2025

- Appreciations depend on consumers' expectations for colour and texture

Tura et al., 2024

➡ Diet-related sensory distinctiveness did not translate into consistent consumer preference

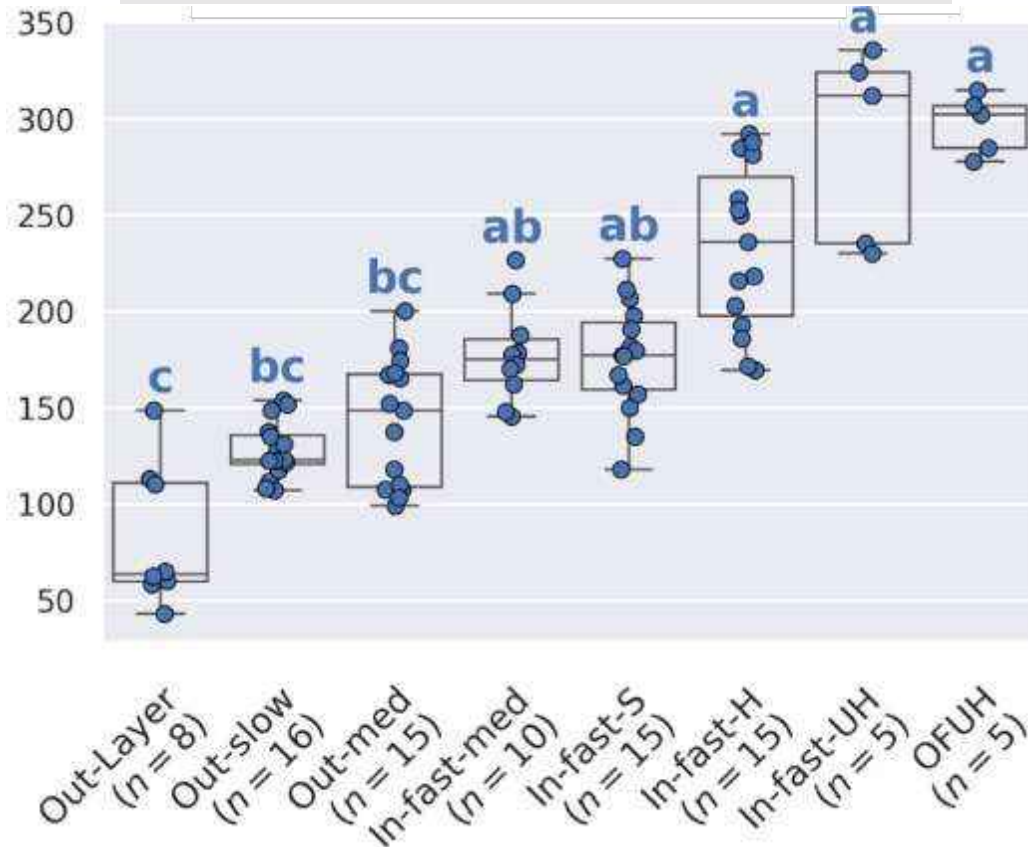
- **Technological quality was only weakly associated with intensification**
Fat content, the casein-to-protein ratio and somatic cell count showed modest trends, while most physicochemical and microbiological traits showed no consistent intensification-related pattern
- **Diet and season shaped dairy product identity**
Greater grass use was associated with yellower milk and distinct sensory profiles in UHT milk and cheese
- **Distinctiveness did not guarantee preference**
Spring UHT milk from low-input, pasture-based farms received the lowest liking scores, whereas Parmigiano Reggiano liking did not differ between feeding treatments
- **Farming-system intensity alone is an incomplete descriptor**
Genetic, physiological, geographical and processing factors should also be considered, supporting trait-specific interventions rather than a single ranking of systems

Chicken meat | Breast meat yields

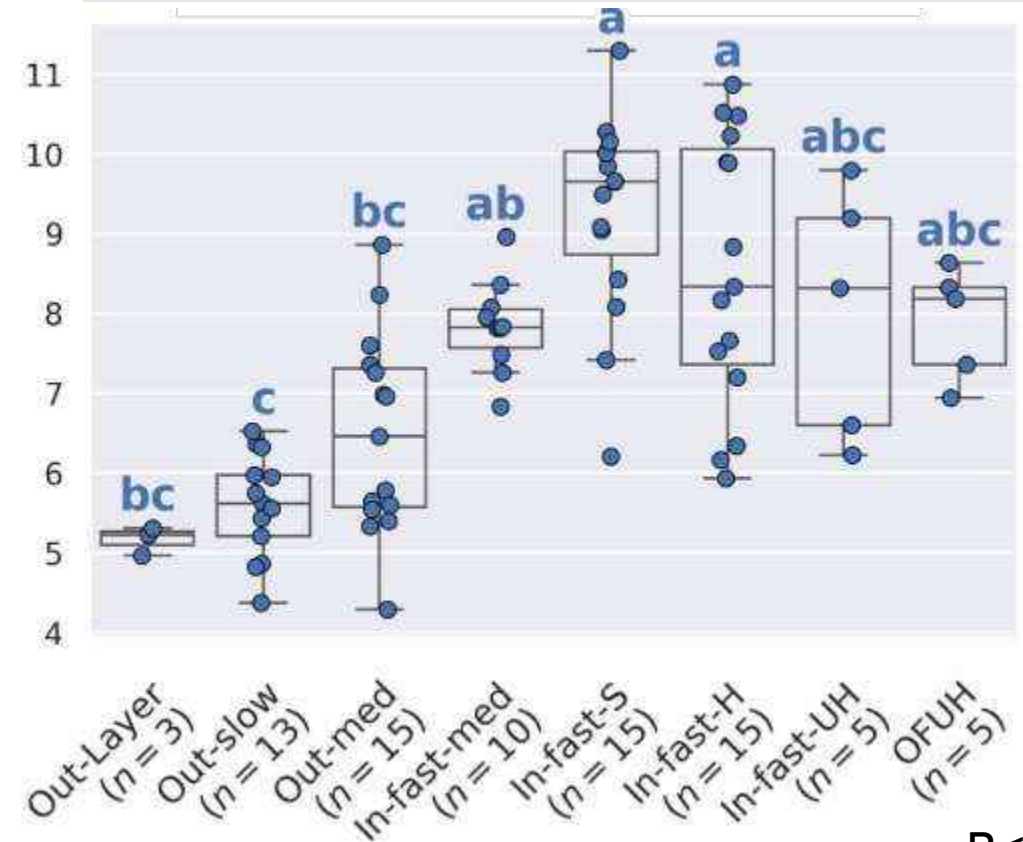
Farm n. = 90



Pectoralis major weight (g)



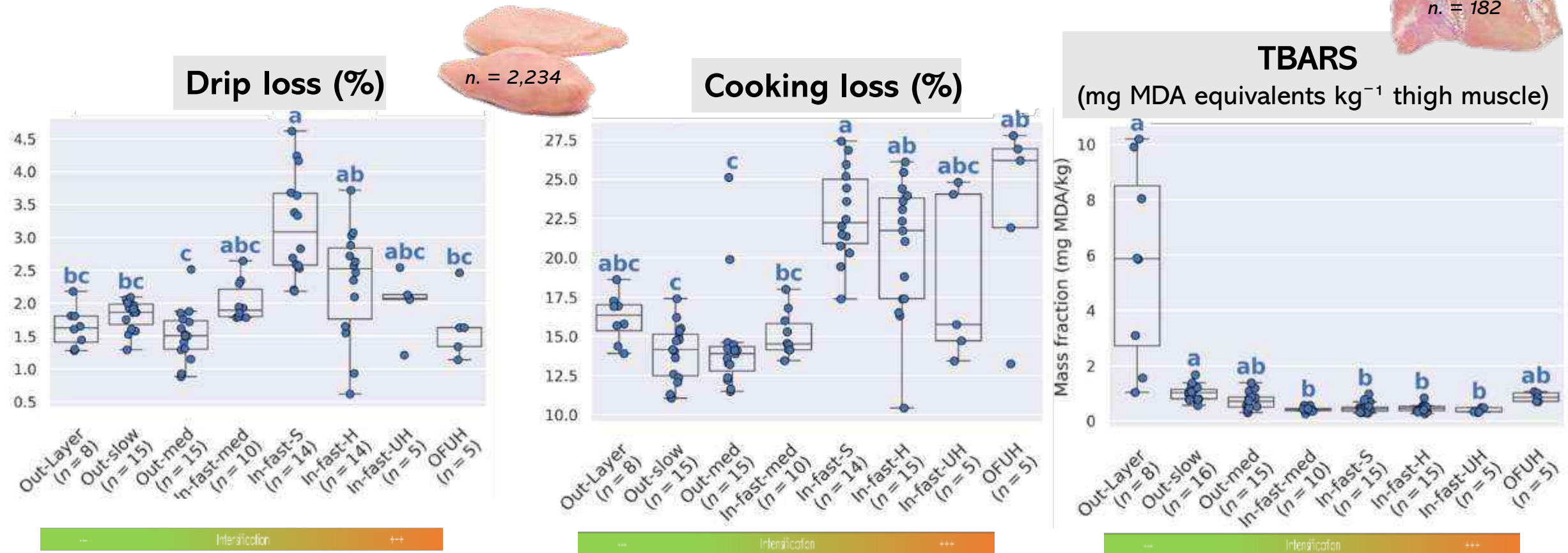
Pectoralis major yield (%)



a-c, $P < 0.05$

➡ Fast-growing, heavier birds showed higher *Pectoralis major* weight and yield

Chicken meat | Technological traits of raw meat



a-c, P<0.05



Fast-growing systems showed lower water-holding capacity, whereas lipid oxidation was highest in the outdoor layer group; responses were therefore trait-specific rather than uniformly related to intensification

Chicken meat | Trained-panel sensory profile

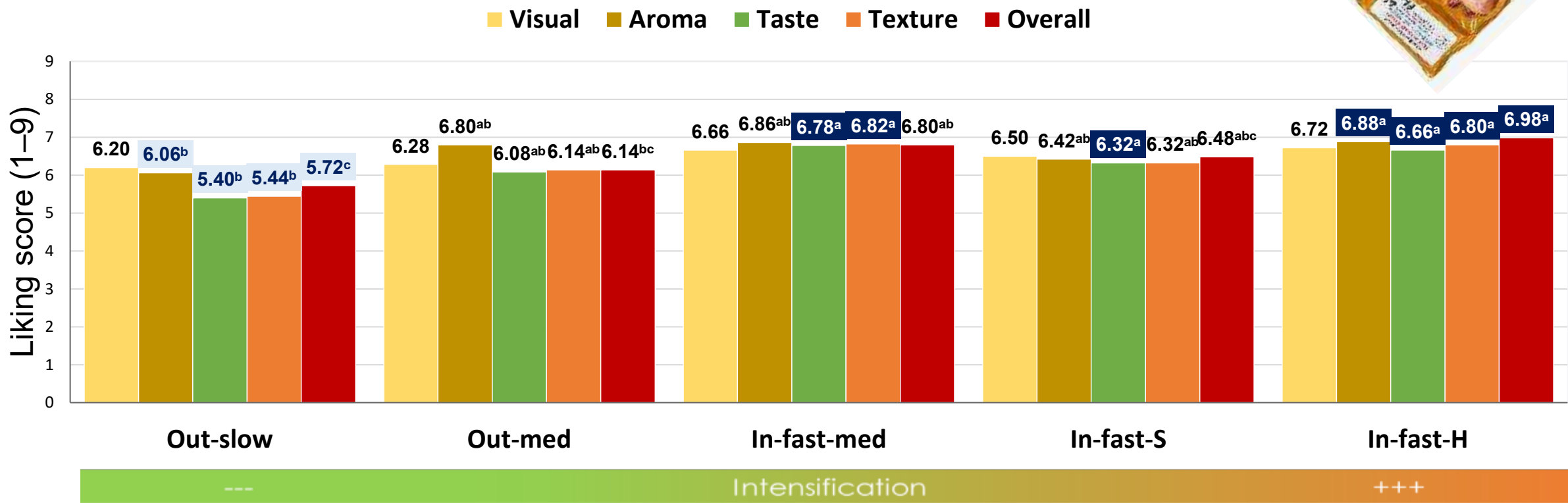
	Traits	Out-layer	Out-slow-1	Out-slow-2	In-fast-med	In-fast-H	OFUH
 Breast	Tenderness	3.77^b (1.06)	3.93^b (1.03)	3.78^b (1.05)	4.52^a (1.03)	4.13^{ab} (1.10)	3.08^c (0.91)
	Juiciness	2.23 (1.07)	2.57 (1.13)	2.40 (1.04)	2.67 (1.16)	2.69 (1.19)	2.24 (0.95)
	Fibrous	2.28^{ab} (1.04)	2.14^b (1.06)	2.37^{ab} (1.02)	1.90^b (1.02)	2.27^{ab} (1.07)	2.64^a (1.15)
	Powdery	0.92^b (0.72)	1.07^{ab} (0.74)	1.07^{ab} (0.77)	1.34^a (0.99)	0.82^b (0.76)	0.98^b (0.78)
	Sour flavour	1.01^{ab} (0.89)	1.28^a (1.06)	1.23^a (0.97)	0.93^{abc} (0.83)	0.59^c (0.44)	0.69^{bc} (0.63)
 Thigh	Tenderness	3.15^c (0.95)	2.94^c (0.82)	3.22^c (0.85)	4.10^{ab} (0.93)	4.31^a (0.92)	3.73^b (0.93)
	Juiciness	1.66^{ab} (0.90)	1.46^b (0.82)	1.69^{ab} (0.88)	1.95^a (1.04)	1.94^a (0.99)	1.74^{ab} (0.94)
	Fibrous	1.62^a (0.87)	1.90^a (0.94)	1.68^a (0.93)	1.23^b (0.77)	1.18^b (0.80)	1.53^{ab} (0.95)
	Powdery	0.53^b (0.36)	0.59^c (0.40)	0.56^c (0.38)	0.95^b (0.84)	1.29^a (1.05)	0.89^c (0.69)
	Sour flavour	0.86^{ab} (0.79)	0.94^a (1.06)	0.86^{ab} (0.82)	0.72^{ab} (0.80)	0.58^b (0.45)	0.71^{ab} (0.79)



a-c, P<0.05

➔ Sensory differences were mainly textural and reflected the combined effects of growth rate and slaughter age; the youngest fast-growing groups were generally more tender and less fibrous

Chicken meat | Consumer liking of ready-to-eat breast



a-c, P<0.05

➡ In the Italian consumer test, the outdoor slow-growing product received the lowest ratings; aroma, taste, texture and overall liking differed among systems, whereas visual liking did not

- **Growth rate and slaughter age were stronger quality drivers than intensity alone**
Fast-growing, heavier birds yielded more breast meat but had lower water-holding capacity and a higher risk of myopathies; lipid oxidation was greatest in the outdoor layer group
- **Sensory differences were mainly textural**
The youngest fast-growing groups were generally more tender and less fibrous, with juicier thigh meat; older slow-growing groups showed stronger acid or metallic notes
- **Consumer preference was product- and market-dependent**
Italian consumers rated the indoor fast-heavy product higher than the outdoor slow-growing product, whereas differences in France were small; no system was consistently preferred across markets

- **Intensification did not generate a universal quality gradient**
Effects were product- and trait-specific: clearest in chicken, weaker for milk technological traits and beef eating quality
- **Biological and chain-specific drivers mattered more than system labels**
Animal category and whole-chain management influenced beef; diet and season shaped dairy; genotype, growth rate and slaughter age shaped chicken
- **Product distinctiveness and consumer liking are not interchangeable**
A production signature may support authentication and differentiation, but it does not guarantee preference or the quality of an individual portion
- **One Quality requires targeted optimisation, not a single ranking**
Within-system variability reveals scope for improvement, while the relevant levers depend on the product, farm context and target market

Thank you for your attention

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Health and safety quality

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Fenja Klevenhusen, University of Kassel



Introduction

INTAQT - *INnovative Tools for Assessment and Authentication of chicken meat, beef and dairy products' QualiTies*

- How do husbandry systems affect livestock product
 - Safety as one part of the intrinsic quality of food
 - Raw milk from tank milk on farm
 - Liver samples collected at slaughter
 - Fecal samples from chicken farms



Analyses of liver and milk samples

Target analyses	Method
Heavy metals	GC-ICP-MS
Mycotoxins	LC-MS/MS
Plant toxins in milk	LC-MS/MS
PCBs, Dioxins (PCDD), Furans (PCDF)	HRGC-HRMS
Perfluorinated alkyl substances (PFAS)	LC-MS/MS
Microbes in feces and meat	qPCR
Resistance genes in feces	DNA sequencing

Statistics

- R software version 4.5.2
- tested for normality and homoscedasticity with Shapiro-Wilk and Levene's test
- If given: ANOVA plus Tukey test
- If not: Kruskal-Wallis test plus Dunn-Holm
- Significant difference if $P < 0.05$



Heavy metals



Heavy metals in liver and milk

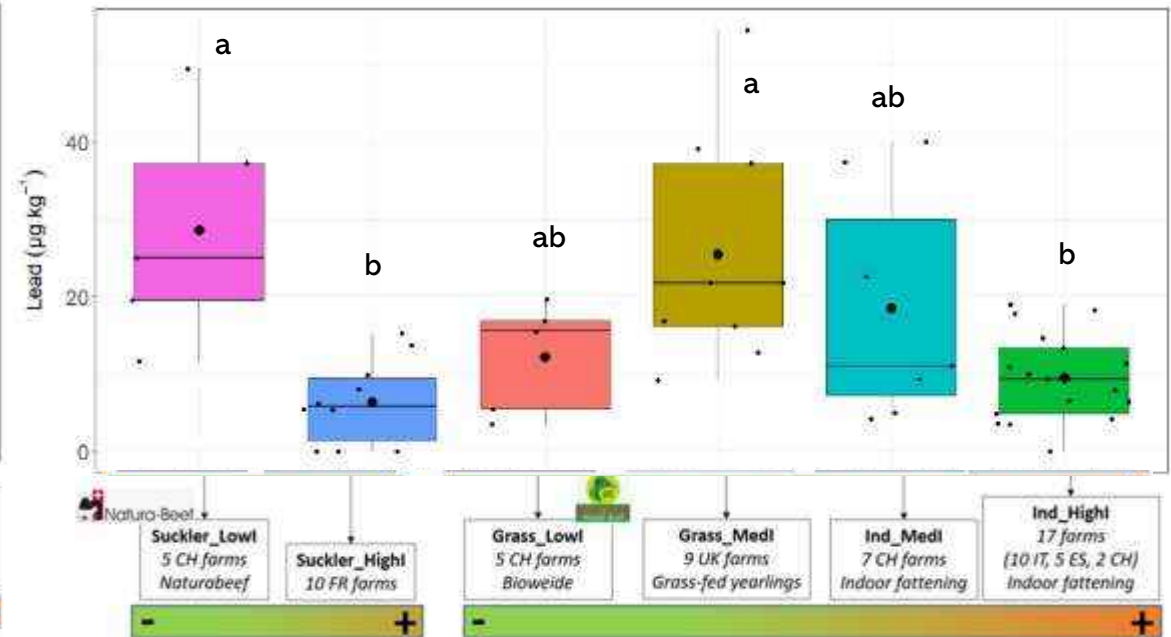
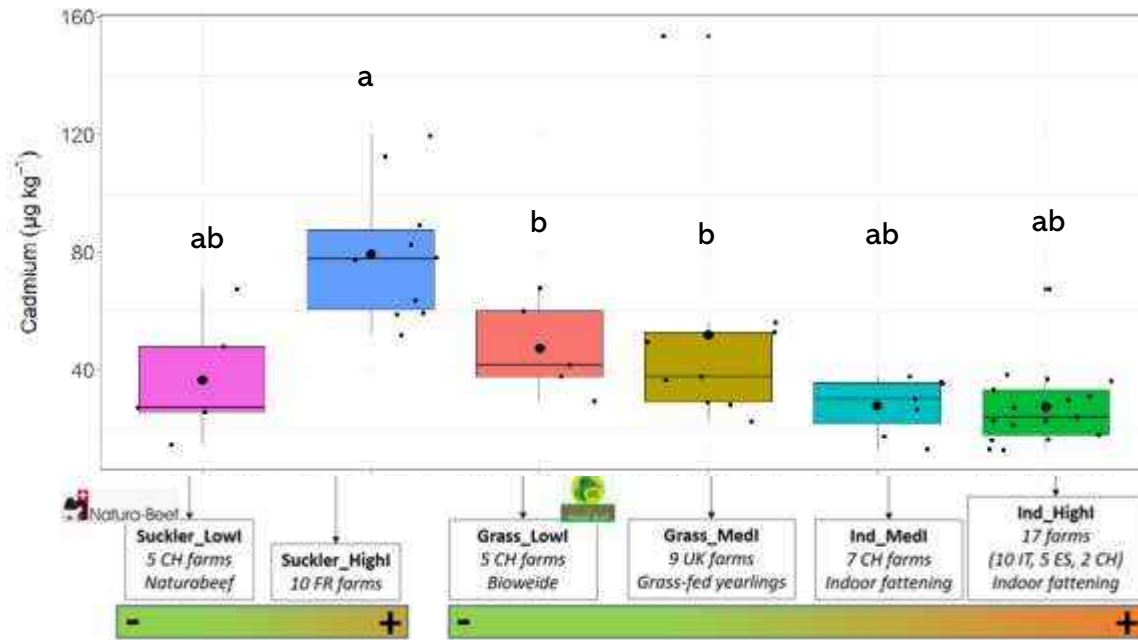
	Chicken liver	Max. level*	Beef liver	Max. level*	Milk	Max. level*
Lead	< LOQ	0.1 mg/kg offal	< max. level	500 µg/kg offal	< max. value	20 µg /kg milk
Cadmium	< max. level	500 µg/kg liver	< max. level	500 µg/kg liver	< LOQ	-
Mercury		-		-		-
Arsenic		-		-		-

* Maximum levels by COMMISSION REGULATION (EU) 2023/915

Heavy metals in beef liver ($\mu\text{g/kg}$ wet weight)

Maximum levels*

- Cadmium 500 $\mu\text{g/kg}$ liver
- Lead 500 $\mu\text{g/kg}$ liver

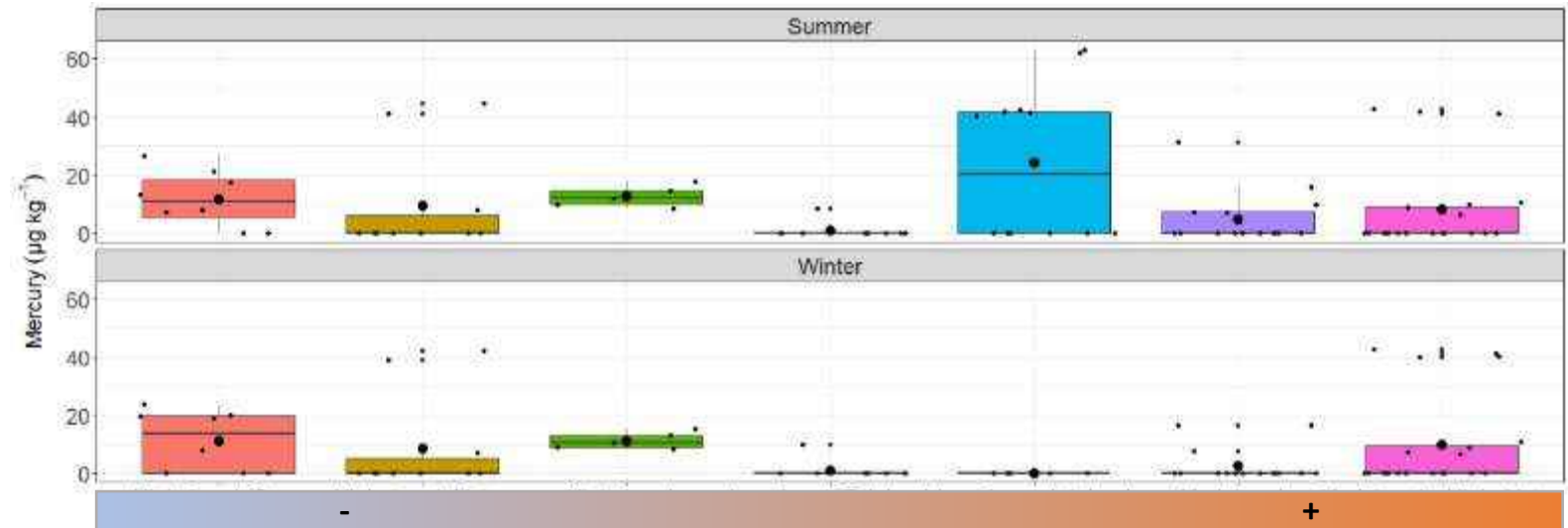


All data for Mercury were below the limit of quantification (<LOQ).

Mercury in milk

Maximum levels*

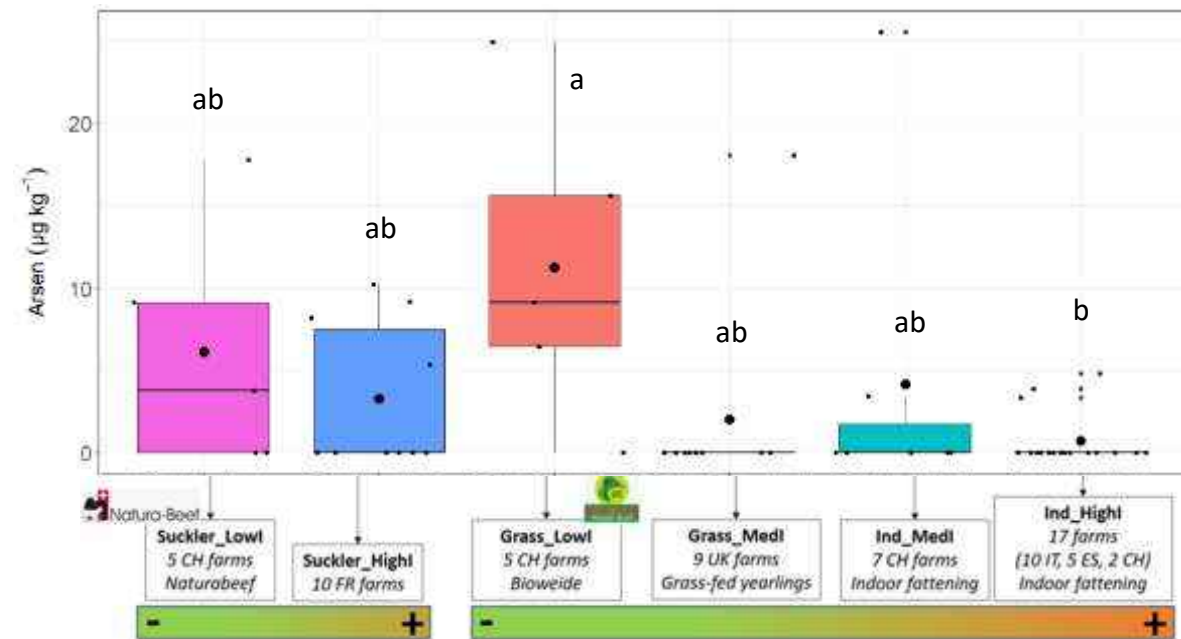
- Mercury 1000 μg /kg fish



Arsenic in beef liver

Maximum levels*

- Arsenic 20 μg /kg Infant formulae (powder)

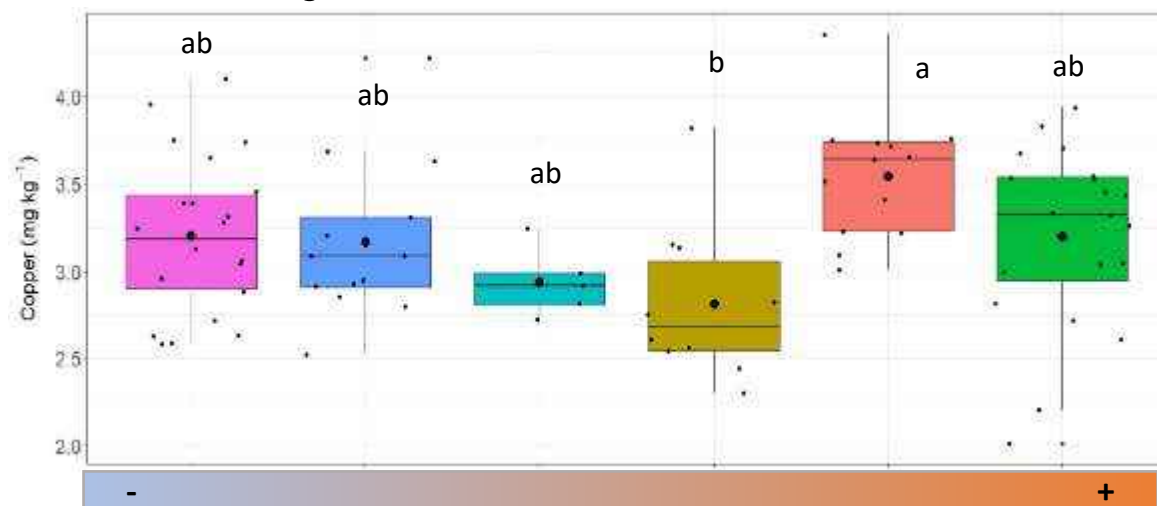


* Maximum levels by COMMISSION REGULATION (EU) 2023/915

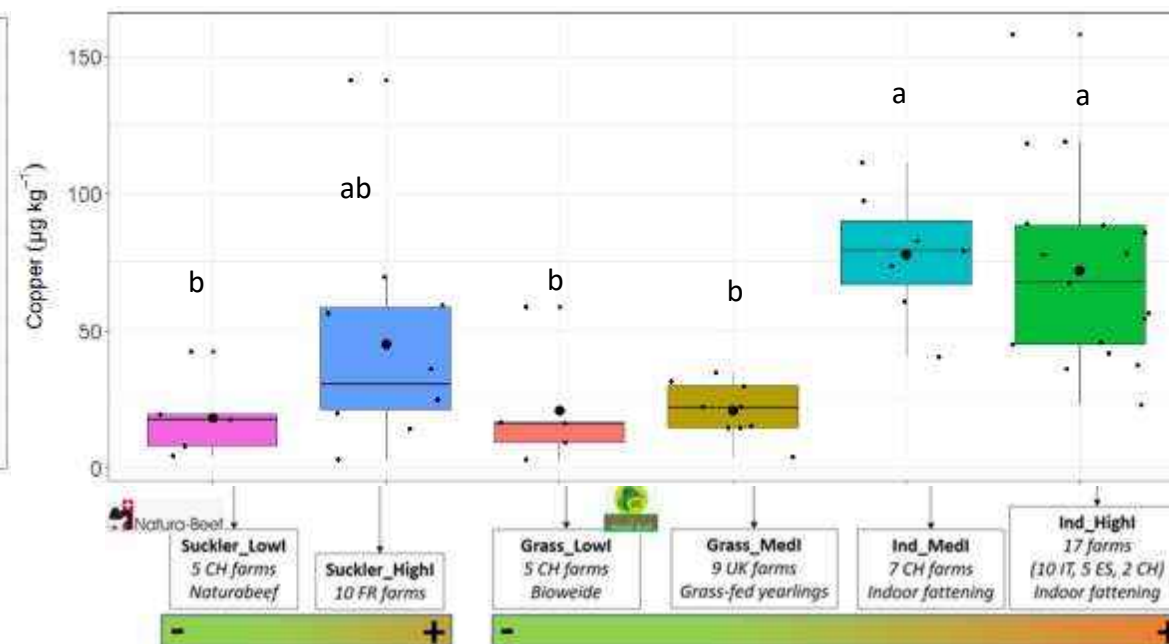


Copper

Poultry liver



Beef liver





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Mycotoxins

Plant toxins (milk)

Maximum levels for animal products
only for Aflatoxin M₁ in milk



Mycotoxins in chicken liver

(given in µg/kg)

Most analysed mycotoxins (22 compounds) were below the limit of detection (< LOD).

*standard deviation in brackets

	Outdoor Slow	Outdoor Medium	Outdoor Fast_Heavy	Indoor Fast-med	Indoor Fast	Indoor Fast_Heavy
Beauvericin	0.180 (0.007)	0.184 (0.007)	0.179 (0.009)	0.178 (0.006)	0.177 (0.005)	0.177 (0.005)
Enniatin A	0.064 (0.044)	0.078 (0.043)	0.106 (0.020)	0.082 (0.029)	0.092 (0.028)	0.086 (0.032)
Enniatin A1	0.164 (0.067)	0.182 (0.015)	0.178 (0.007)	0.161 (0.058)	0.165 (0.046)	0.176 (0.005)
Enniatin B	0.189 (0.099)	0.202 (0.007)	0.201 (0.008)	0.199 (0.010)	0.201 (0.006)	0.177 (0.063)
Enniatin B1	0.305 (0.228)	0.225 (0.103)	0.159 (0.034)	0.446 (0.310)	0.210 (0.107)	0.225 (0.104)

+

Enniatins are emerging toxic compounds made by *Fusarium*,
Beauvericin is made by *Fusarium* and *Beauveria*

Mycotoxins in beef liver (given in ng/kg)

Most analysed mycotoxins (22 compounds) were below the limit of detection (< LOD).

	Suckler_Low Input	Suckler High Input	Grass Low Input	Grass Medium Input	Indoor Medium Input	Indoor High Input
Enniatin A	0.08 (0.05)ab	0.06 (0.05)a	0.06 (0.04)ab	0.11 (0.01)b	0.06 (0.05)a	0.09 (0.03)ab
Enniatin A1	0.16 (0.06)	0.16 (0.06)	0.14 (0.07)	0.18 (0.01)	0.09 (0.09)	0.16 (0.09)
Enniatin B	0.22 (0.04)	0.18 (0.07)	0.24 (0.04)	0.25 (0.10)	0.23 (0.05)	0.20 (0.05)
Enniatin B1	0.19 (0.05)ab	0.18 (0.04)b	0.22 (0.09)ab	0.55 (0.21)a	0.22 (0.09)b	0.40 (0.42)a

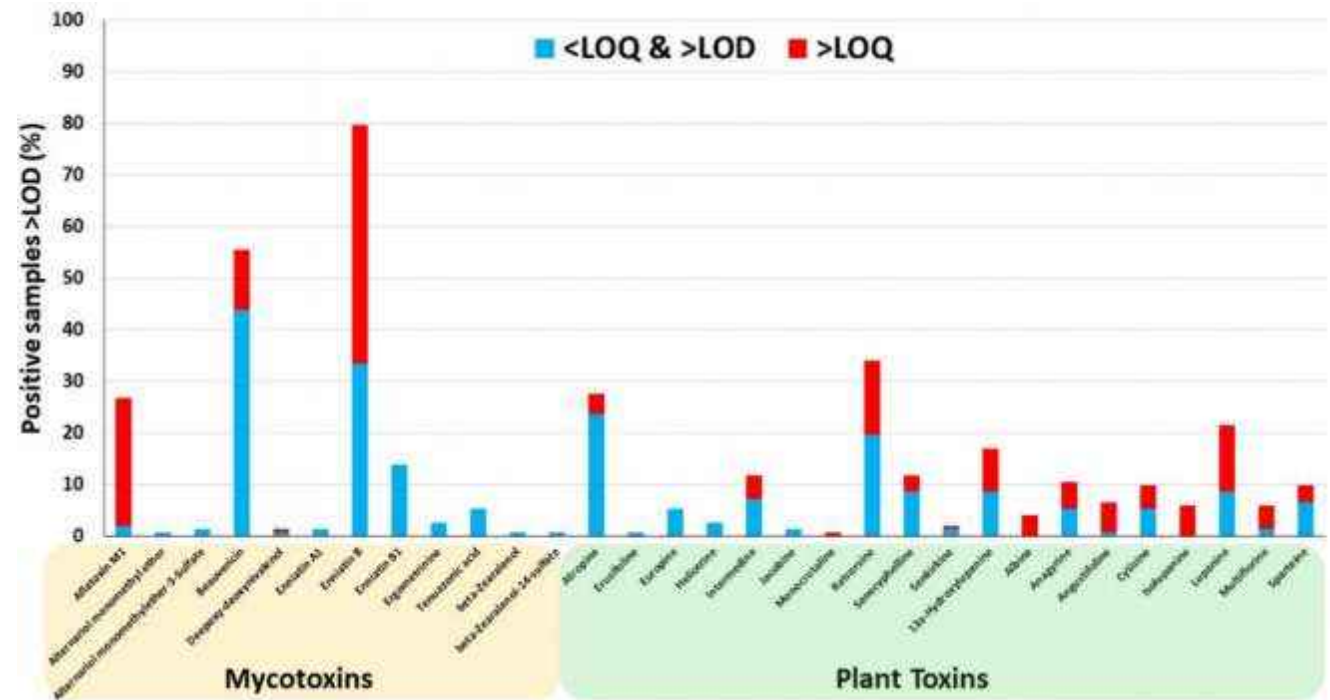
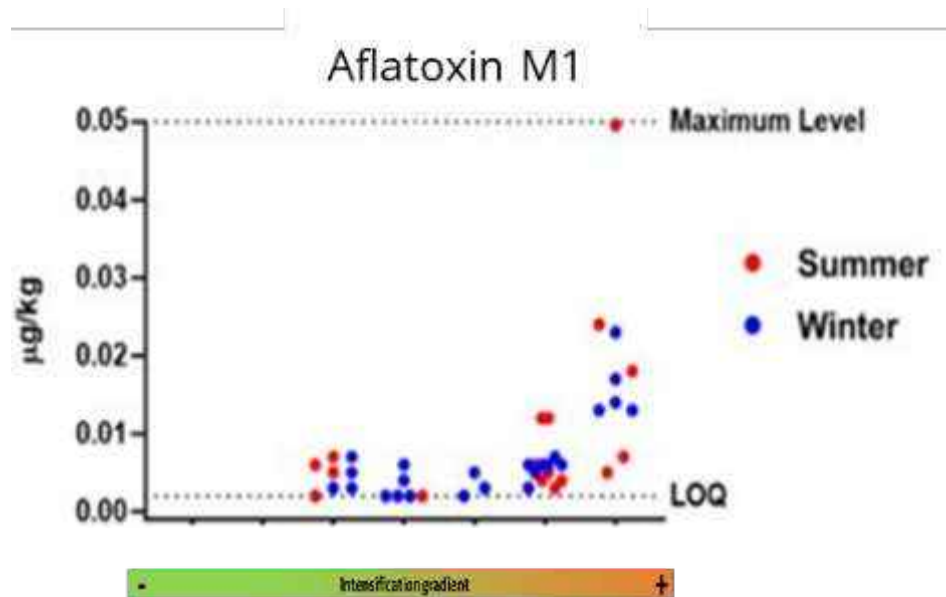
Enniatins are emerging toxic compounds made by *Fusarium*

*standard deviation in brackets

Mycotoxins and plant toxins in raw milk

Maximum level*

- Aflatoxin M₁ 0.05 µg/kg raw milk



Enniatins are emerging toxic compounds made by *Fusarium*,
Beauvericin is made by *Fusarium* and *Beauveria*



Persistent organic pollutants

PFAS, Dioxins, PCBs

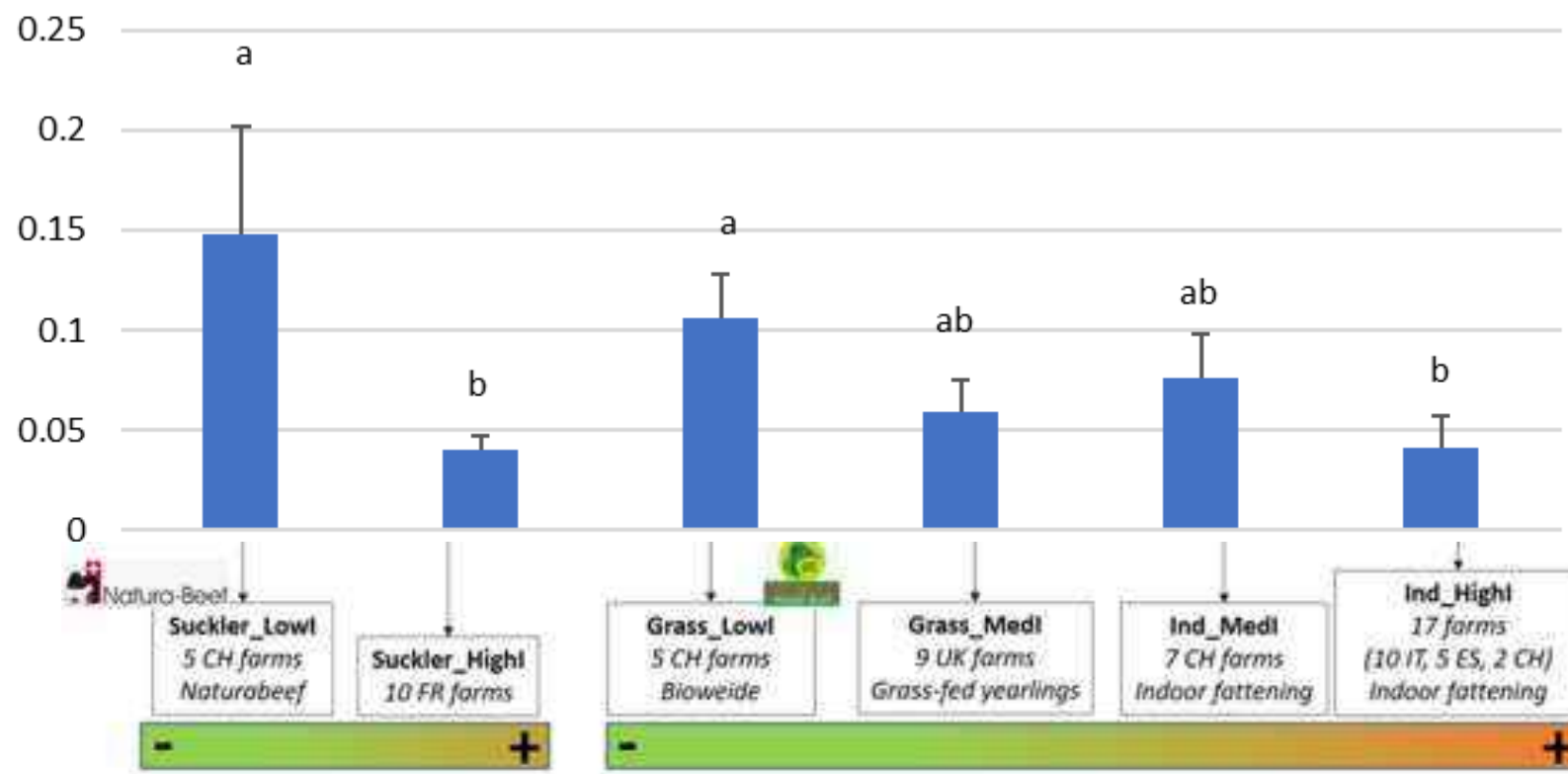
All compounds for which maximum levels exist,
were below them



Sum of dioxins, furans and dioxin-like PCBs

WHO-PCDD/F-PCB-TEQ (TEF 2005) upper bound
(pg/g wet weight)

Max. level* 0,5 pg/g wet weight





Microbes and microbial resistance genes



Campylobacter and E. coli in chicken feces

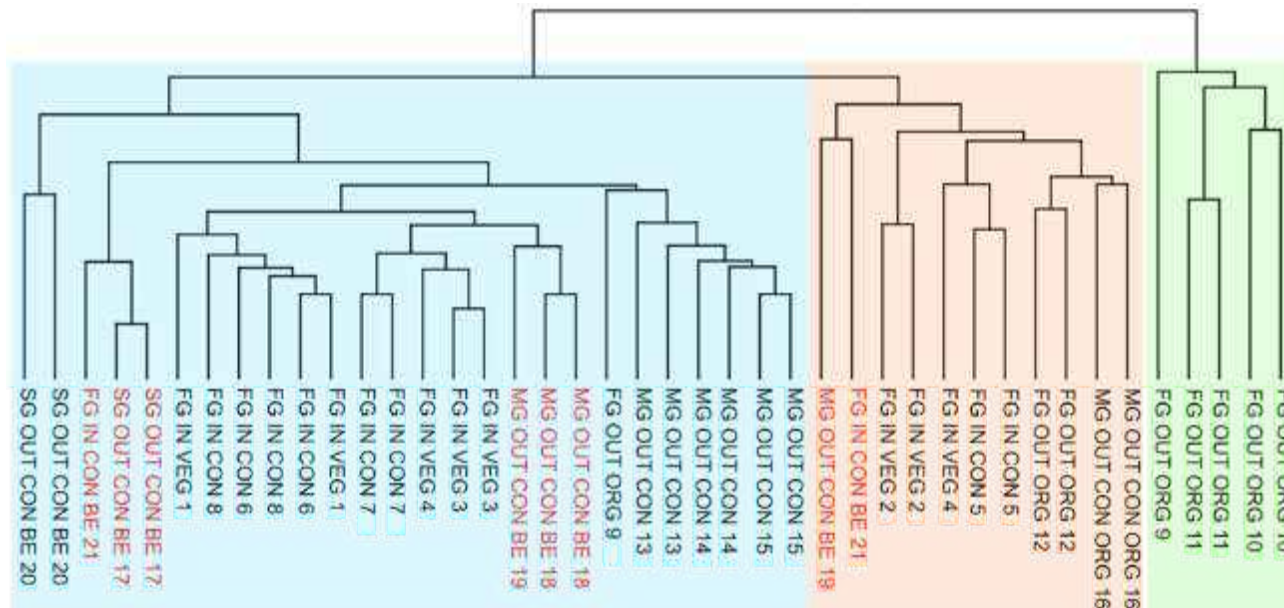
Number of positive and negative samples

		Outdoor Slow	Outdoor Medium	Outdoor Fast_Heavy	Indoor Fast-med	Indoor Fast	Indoor Fast_Heavy
<i>Campylobacter</i> spp	present	6	7	0	4	3	9
	absent	17	7	5	5	7	8
<i>Escherichia coli</i>	present	1	1	0	2	0	1
	absent	22	13	5	7	10	16

In total, 37% were positive for *Campylobacter* spp. (*C. lari*i, *C. jejuni*i, *C. coli*) and 6% for *Escherichia coli*.

→ No clear pattern between farm typologies

Antibiotic resistance genes in chicken feces



Identification of 265 genes encoding resistance to 16 antibiotic classes

Cluster blue: fast- and medium-growing genotypes fed a conventional diet including animal fat

Cluster red: diet has no influence

Cluster green: including fast growing genotypes fed a 100% vegetable-based diet

Conclusions

- All measured parameters for which EU maximum levels exist were well below these thresholds for all farm typologies.
- Access to pasture or more extensive green forage-based feeding does not result in a general increase in the investigated safety-relevant parameters (at least in areas without known contamination with the before-mentioned contaminants).
- Observed differences might partly be related to location/region.
- The antibiotic resistance gene profiles found in poultry fecal samples showed some clustering according to production-related factors. Further investigation is needed.

Thank you for your attention

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A harmonized methodological framework for
multi-criteria assessment of intrinsic quality

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Lucille Rey-Cadilhac, INRAE



The need for a multi-criteria assessment of the intrinsic quality

‘One quality’ with environ., welfare, intrinsic quality, ...



Assessing the quality of  from the diversity of production systems that coexist in the EU

Systems with gradient of inputs related to intensification (feed, fertilizer, land, ...) *Caumette et al., 2026*

Intrinsic quality of the product

Many traits measured in link with 4 principles of quality
→ Need to aggregate information to have a clearer view

At the farm level



For 3 products

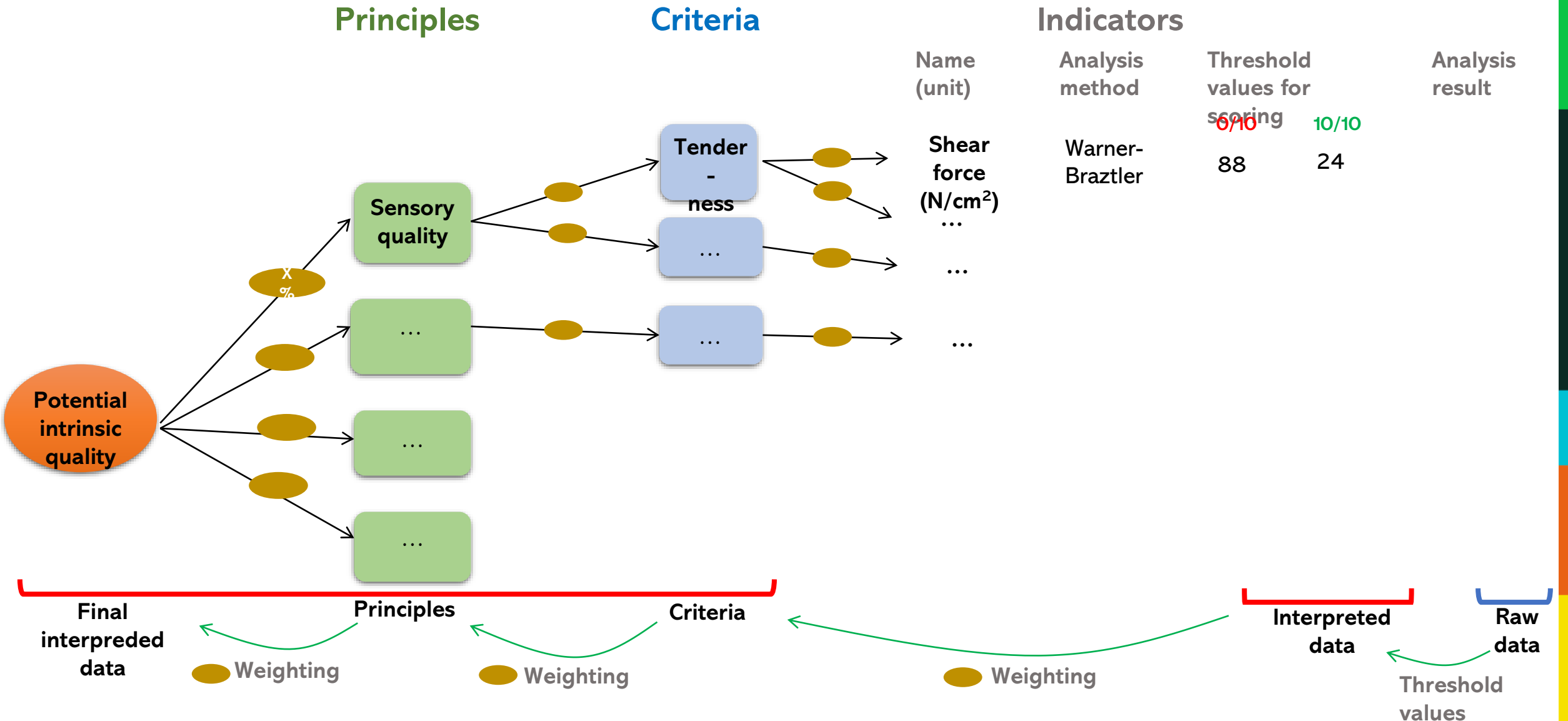


→ Objectives:

- 1) To develop of a multi-criteria assessment (MCA) of the intrinsic quality with a common structure & methodology for the 3 products
- 2) To explore the link between the intrinsic scores & intensification level



Method of development of the MCA



Step 1 – Definition of the global framework (1/2)

From the core scientific working group

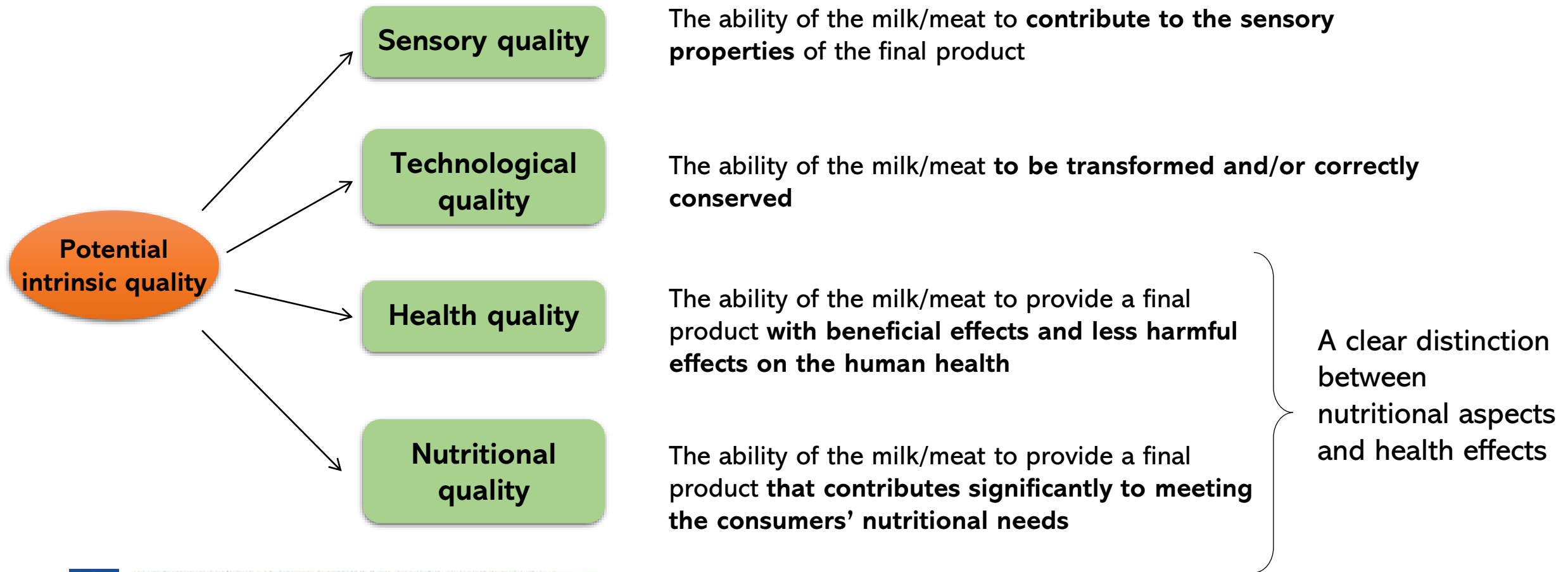
4 persons from MCA + 1 reference person per product (cow milk, beef & chicken meat):

- **Generic evaluation** applicable to all European dairy cow/beef/chicken farms
- **Scale:**
 - At the farm's gate → potential quality for the final product
 - Year scale
- **Targeted product:**
 - Cow Milk: **standard UHT milk** semi-skimmed, standardized, indirect UHT (140°C-4s)
 - Beef Meat: **striploin steak**, 10d-aging, grilled at 55°C (internal T°), stunned prior exsanguination
 - Chicken Meat: **breast** without grinding, 5d-aging, cooking at 72°C –internal T°), same slaughter cond.

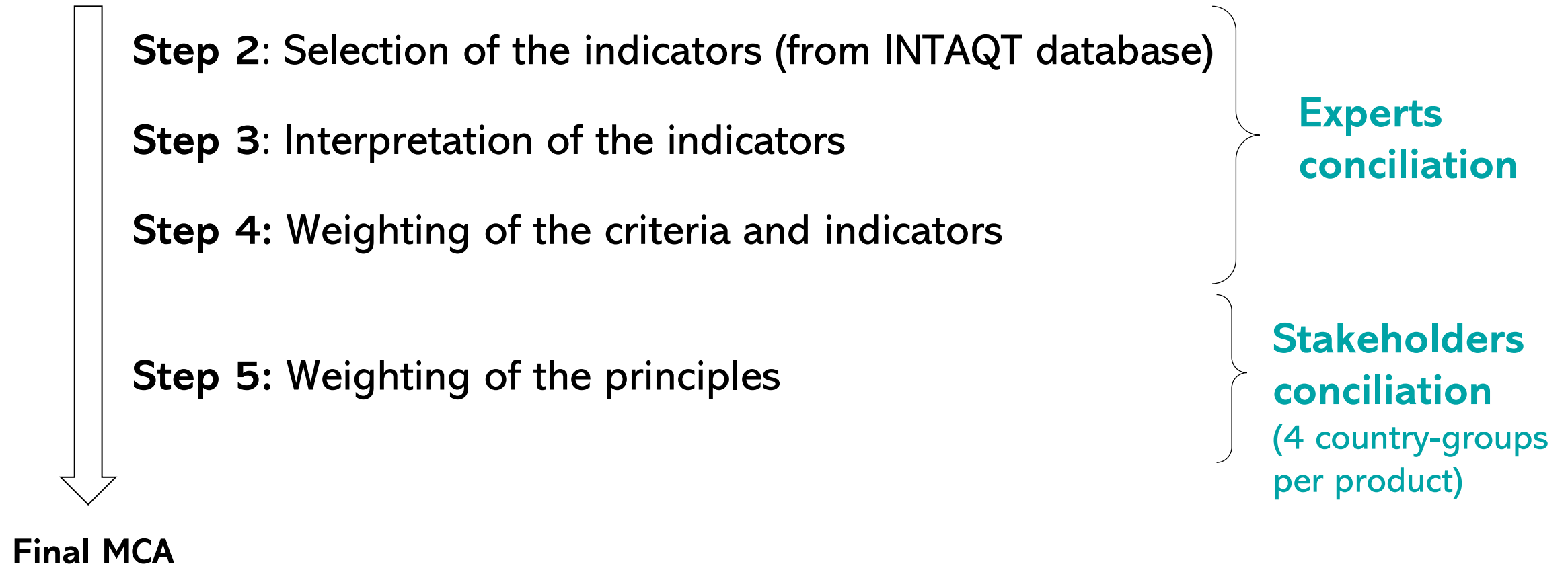


Step 1 – Definition of the global framework (2/2)

Definition of the **principles** (from Rey-Cadilhac et al., 2021) and the **criteria of the assessment** :



Nexts steps in conciliation



Conciliation between experts - Methodology

Conciliation intra-product (except for safety dimension) with a 3-step process:



4 EU
experts per
meeting

3h-online meeting
→ reach consensus

Revise written summary

Conciliations done

Step 2: Indicators selection for each product:

- 2 meetings for nutritional and health (excluding sanitary) principles
- 1 meeting for sensory and technological principles

+ 1 common meeting for sanitary principle

Steps 3 & 4: Interpretation of indicators & Weighting of the criteria and indicators for each product:

~ Idem Step 2

Step 5: Weighting of the principles for each product:

4 country-meetings with representative of the sector

10 experts
conciliation
meetings

11 experts
conciliation
meetings

12 EU stakeholders
conciliation
meetings



Example: MCA of the intrinsic quality of milk

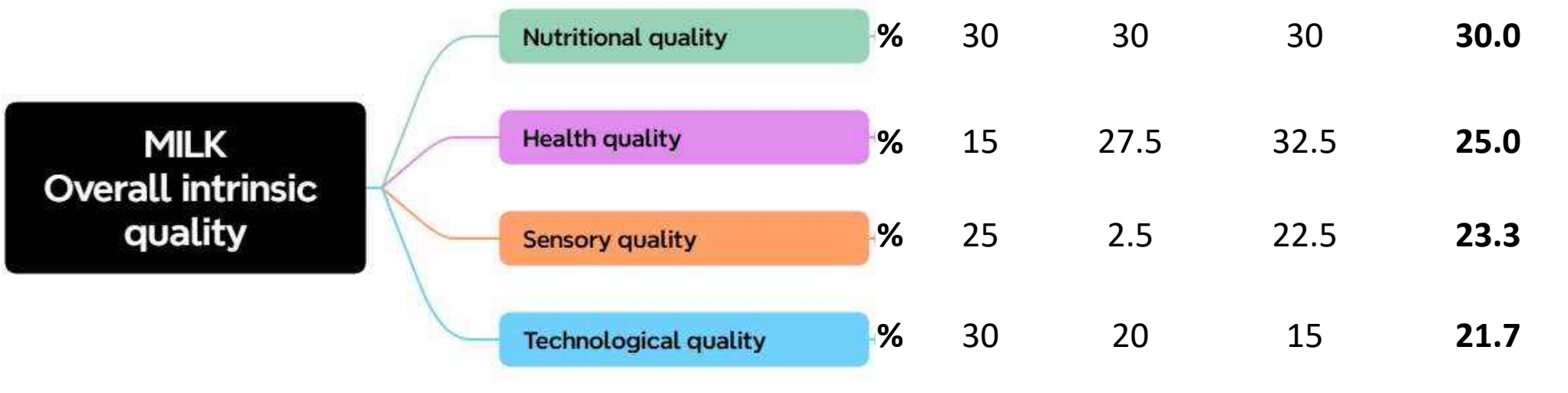
Indicators:
2 nutritional
21 health including 11 safety
9 sensory
4 technological





Example: MCA of the intrinsic quality of milk

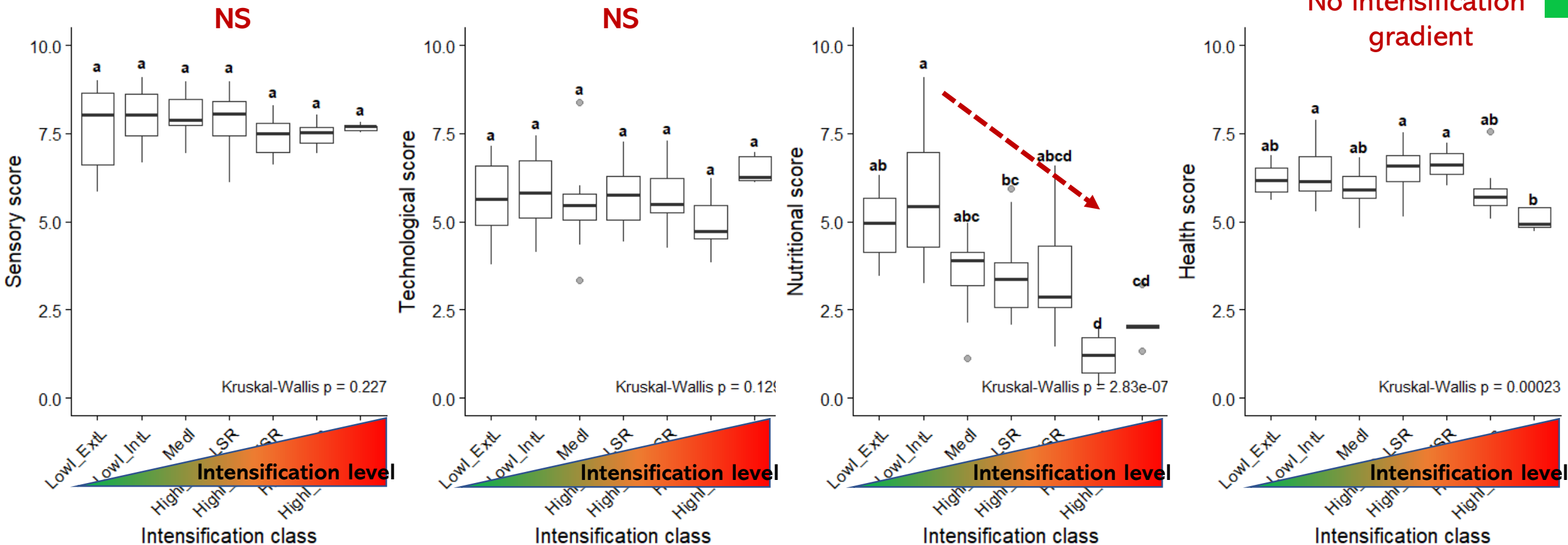
Stakeholders consultation results



Data from F. Bedoin, Idele



Example: Milk quality scores × dairy systems intensity



Conclusion



3 multicriteria assessments of the intrinsic quality were developed

- Common methodology and structure
- Product specific: need to adapt for other products

Allowed to **compare systems along an intensification gradient**

Perspectives:

- **Calculation of global scores** with stakeholders weightings
- **Look at compromise** between principles of intrinsic quality, as well as between intrinsic, environmental and welfare dimensions of 'One Quality'

Thanks to the EU farmers, data and samples collectors and experts

Thank you for your attention!

**Thank you for
your attention**

Lucille Rey-Cadilhac, INRAE

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- **INTAQT Final conference**
- **11th September 2026**
- **Hamburg, Germany**

INTAQT One Quality

WebApp demo

intaqt
one quality

Yann Guyot, ITAVI and Léo Darrigade,
INRAE



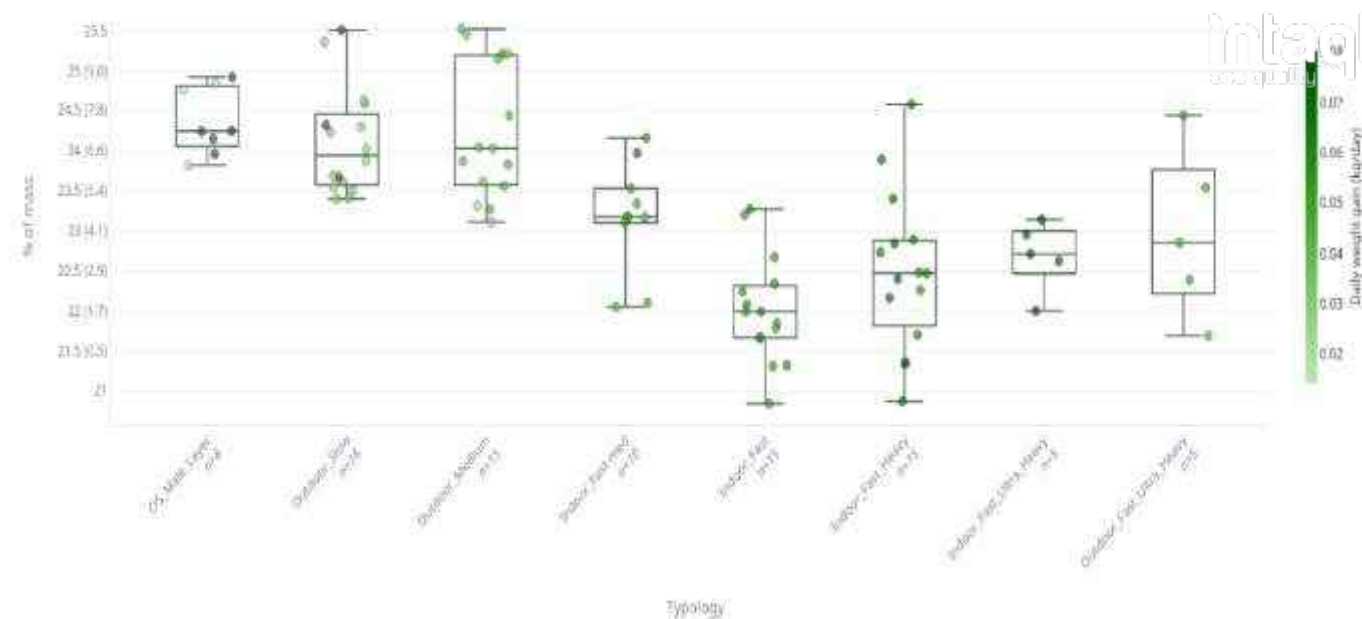
Data vizualisation

Explore the data we collected. Create graphs with farming practices, quality traits and scores data.

Predictions tool

Use pretrained random forests models to predict quality traits values and scores for a set of farming practices chosen by the user.

- **For whom** : anyone interested in understanding how product quality varies across farming systems and how farming practices may influence product quality.
- **Open source tools** : developed in Python using open source libraries.



Thank you for your attention

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