Assessment of dairy sheep carcass composition with X-ray Computed Tomography

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Background

X-ray

Computed tomography

(CT)

&

Image analysis protocols

- ✓ Innovative tools for objective carcass evaluation in farm animal species
- ✓ Meat sheep: mostly live animals, prior to slaughter, breeding purposes

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Background

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Image analysis protocols

- ✓ Innovative tools for objective carcass evaluation in farm animal species
- ✓ Meat sheep: mostly live animals, prior to slaughter, breeding purposes
- ✓ Dairy sheep ?
- ✓ Easy to use ?

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Objective

To test for post-mortem assessment of dairy sheep carcasses:

i. a CT-acquisition protocol, with automated settings and compare with a protocol with manually set parameters

ii. two image analysis protocols.

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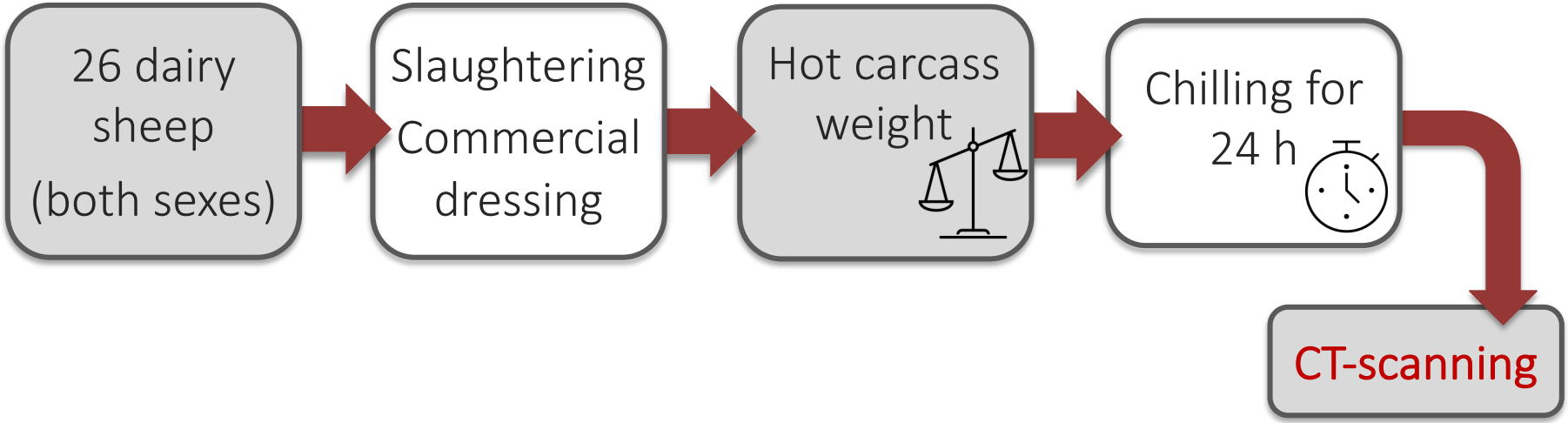
Materials & Methods



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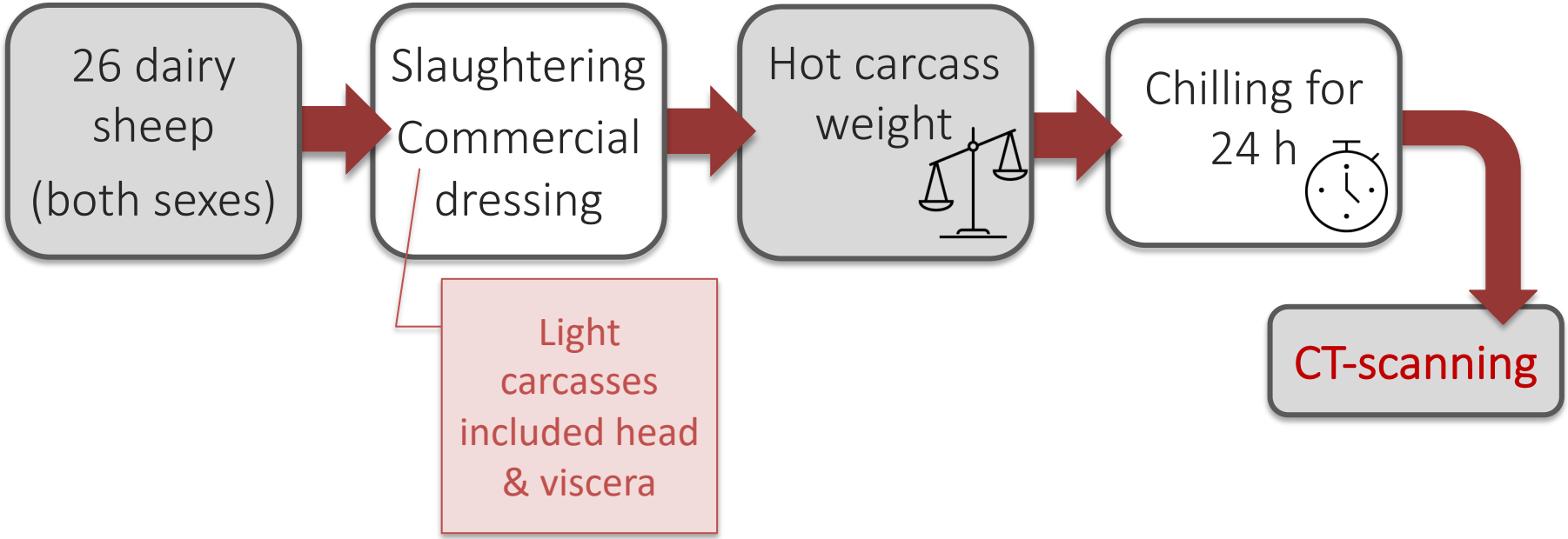

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Materials & Methods

CT-scanning

- Optima CT520 (GE)
- 4 heavy carcasses ➡ 2 CT scanning protocols
- CT1 ➡ automated, dose efficiency parameters, commonly used in medical practice
- CT2 ➡ manually set parameters, standard throughout scanning
- Remaining 22 carcasses scanned only with CT1

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Materials & Methods

CT-scanning

	CT1	CT2
Field of View – FoV	246*246 - 500*500	Large
Tube current range (mA)	49-345	80
Tube tension (kV)	120	140
Acquisition matrix	512 x 512	512 x 512
Slice thickness (mm)	0.625	0.625
Convolution Kernel	STANDARD (soft tissues)	STANDARD (soft tissues)
Type of scanning	Spiral	Spiral
Dose efficiency (Optidose)	Active	Inactivated

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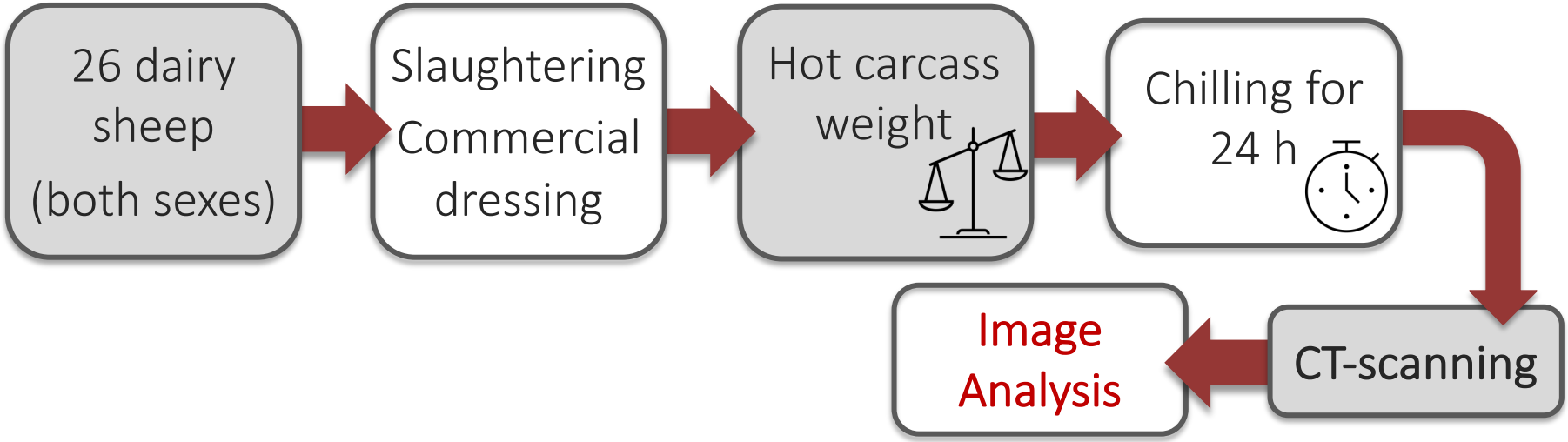

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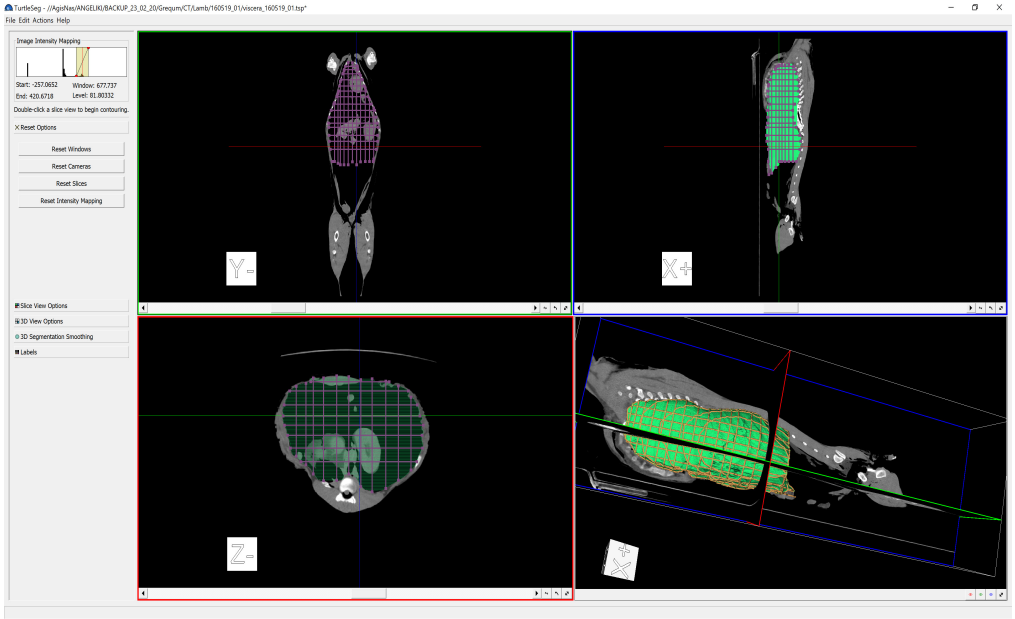
Materials & Methods

Image Analysis

Light carcasses:

- Viscera segmentation (TurtleSeg 1.2.1)
- Semi-manual contouring



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Materials & Methods

Image Analysis

- All carcasses ➡ 2 image analysis protocols (IAPs)
- Different thresholds (Hounsfield Unit range – HU)

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Image Analysis

- All carcasses ➡ 2 image analysis protocols (IAPs)
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Materials & Methods

Image Analysis

- All carcasses → 2 image analysis protocols (IAPs)
- Different thresholds (Hounsfield Unit range – HU) → Voxels allocated to muscle / fat / bone tissue

Tissue Volumes × Tissue Densities → Fat weight / Muscle weight → Bone weight (subtraction of fat & muscle weight from carcass weight)

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Materials & Methods

Image Analysis

- All carcasses → 2 image analysis protocols (IAPs)
- Different thresholds (Hounsfield Unit range – HU) → Voxels allocated to muscle / fat / bone tissue

	Muscle density	Fat density	Muscle tissue HU range	Fat tissue HU range	Bone tissue HU range
IAP-1	1.04	0.95	0-120	(-200) - (-1)	>120
IAP-2	1.06	0.95	0-200	(-200) - (-1)	>200

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Materials & Methods

Statistical Analyses

Paired sample t-tests
or
Wilcoxon signed-rank tests

} CT1 & CT2 comparison

t-tests
or
Mann-Whitney U tests

} Comparison of IAPs with available dissection data

- Same population
- Similar sheep (sex, weight at slaughter)
- N=101

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Results

Comparison of CT protocols

	95% confidence intervals (CI)				
	Mean difference	Lower CI	Upper CI	*t*-statistic	*p*-value
Muscle volume	140.16	-75.53	355.84	2.07	0.13
Fat volume	-12.15	-57.40	33.09	-0.85	0.46
Bone volume	-67.46	-107.87	-27.06	-5.31	<0.05
Muscle weight	145.76	-78.55	370.07	2.07	0.13
Fat weight	-11.55	-54.53	31.43	-0.85	0.45
Bone weight	-134.22	-327.05	58.62	-2.22	0.11
Fat content	0.00	0.00	0.00	-0.66	0.56

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Results

Comparison of CT protocols

	95% confidence intervals (CI)				
	Mean difference	Lower CI	Upper CI	*V*-statistic	*p*-value
Muscle content	0.00	0.00	0.01	9	0.25
Bone content	0.00	-0.01	0.00	1	0.25

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Results

Comparison of IAP estimates with dissection data

Descriptive statistics

	n	Mean muscle weight – *in g* (+/-SD)	n	Mean fat weight– *in g* (+/-SD)	n	Mean bone weight – *in g* (+/-SD)	n	Mean carcass weight – *in g* (+/-SD)
IAP-1	26	8,061.01 (3,549.982)	26	3,548.14 (2,605.417)	23	7,350.41 (2,253.212)	26	18,646.15 (7,743.758)
IAP-2	26	8,484.82 (3,726.188)	26	3,548.14 (2,605.417)	23	6,899.56 (2,110.208)	26	18,646.15 (7,743.758)
Dissection	101	7,556.79 (3,176.830)	101	3,843.50 (2,897.174)	101	2,495.15 (912.158)	101	19,230.19 (7,838.185)

*SD: standard deviation, n: sample size

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Results

Comparison of IAP estimates with dissection data

Descriptive statistics

	n	Mean muscle content % (+/-SD)	n	Mean fat content % (+/-SD)	n	Mean bone content % (+/-SD)
IAP-1	26	43.14 (5.583)	26	17.32 (5.996)	12	33.66 (3.411)
IAP-2	26	45.42 (5.803)	26	17.32 (5.995)	12	31.26 (3.242)
Dissection	101	46.41 (4.599)	101	20.08 (6.708)	101	15.99 (3.378)

*SD: standard deviation, n: sample size

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Results

Comparison of IAP-1 with dissection data

	95% confidence intervals (CI)				
	Mean difference	Lower CI	Upper CI	W-statistic	*p*-value
Muscle weight (g)	-504.22	-992.11	-16.32	1,403	0.59
Fat weight (g)	295.36	-99.29	690.02	1,310	0.99
Bone weight (g)	-4,855.26	-5,141.12	-4,569.41	2,313	<0.001
Muscle content (%)	3.27	1.67	4.87	834	<0.01
Fat content (%)	2.76	1.05	4.47	1,008	0.07
Bone content (%)	-17.67	-19.03	-16.30	1,212	<0.001

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Results

Comparison of IAP-2 with dissection data

	95% confidence intervals (CI)				
	Mean difference	Lower CI	Upper CI	W-statistic/ *t*-statistic	*p*-value
Muscle weight (g)	-928.03	-1,420.50	-435.56	1,494	0.28
Fat weight (g)	295.36	-99.29	690.02	1,310	0.99
Bone weight (g)	-4,404.41	-4,687.30	-4,121.52	2,303	<0.001
Muscle content (%)	0.99	-0.63	2.61	-0.93	0.36
Fat content (%)	2.76	1.05	4.47	1,008	0.07
Bone content (%)	-15.26	-16.61	-13.91	1,212	<0.001

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Conclusion

✓ CT-protocols ➡ automated CT1 can replace CT2

✓ IAP-2 ➡ Better estimates muscle tissue compared to IAP1

✗ Bone tissue estimations are more complex ➡ Further investigation

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