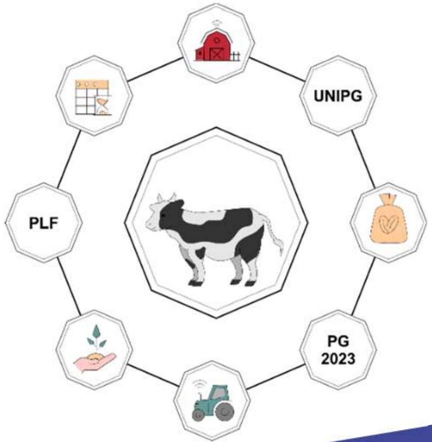
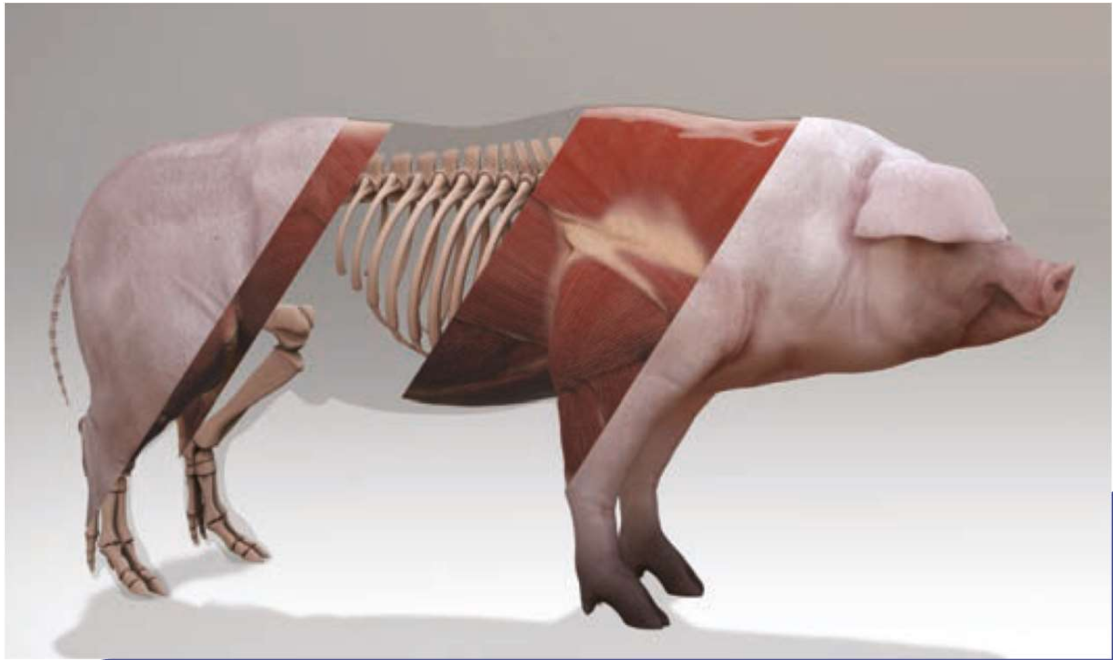
Using non-destructive and non- invasive image techniques to assess carcass and meat traits



Severiano R Silva

In Animal Science the questions related with determination (prediction) of the body composition or carcass composition are difficult to answer



Kongsro (2015)

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What is the body composition of this sheep

http://www.yellowkorner.com/en/artists/yann-arthus-bertrand-51.html

How many lean meat has this ram

http://www.nationalsheep.org.uk/know-your-sheep/sheep-breeds/

What is the relationship between muscle and bone of these carcasses

Boman et al. (2010)

What is the level of body fat depots of this ewe

Those questions are very difficult to answer unless the animals were slaughtered. Then it is possible apply two gold standard methods to determine composition

The gold standard – # 1 dissection

Cuts yield %

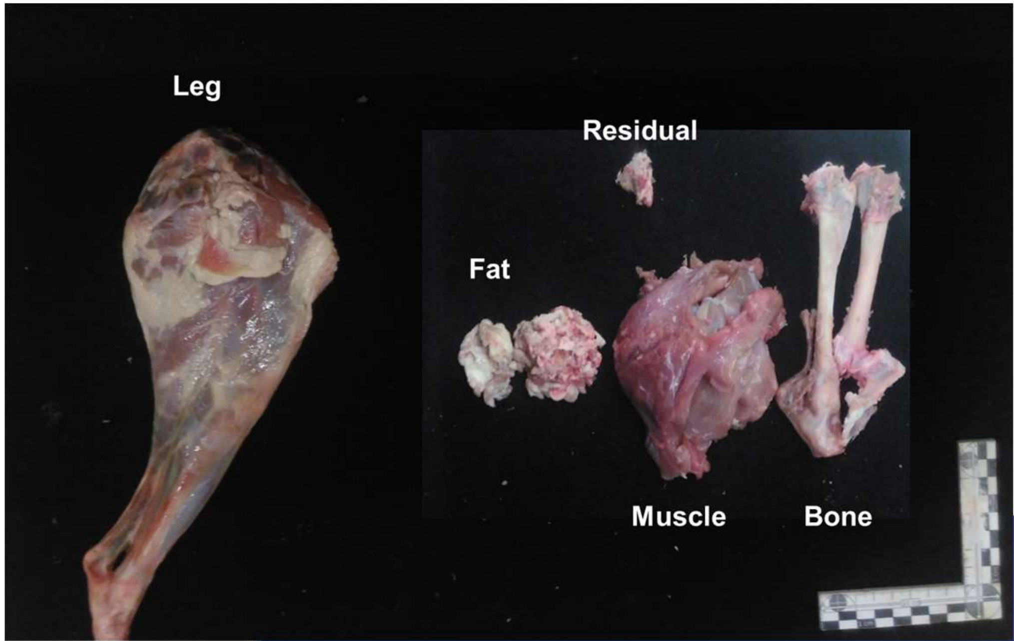
Muscle %

Fat %

Bone %

FAIM Lutz Bunger & team

The cuts were dissected into the muscle (M), fat (F) and bone (B).



The gold standard – #2 chemical analysis

Protein %

Moisture %

Fat %

Ash %

Silva et al. 2015

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The gold standard is destructive, laborious and time-consuming. Furthermore at the end there is no animal (carcass) to tell the story

Therefore

In vivo and post-mortem non-destructive, fast, consistent and objective **methods are necessary**

Over the years, numerous techniques have been developed, adapted and transferred to animal science to understand the body composition and carcass composition of animals

Various Methods

- ^{40}K counting; Bioelectrical Impedance; Velocity of Ultrasound; Total Electrical Conductivity (TOBEC)

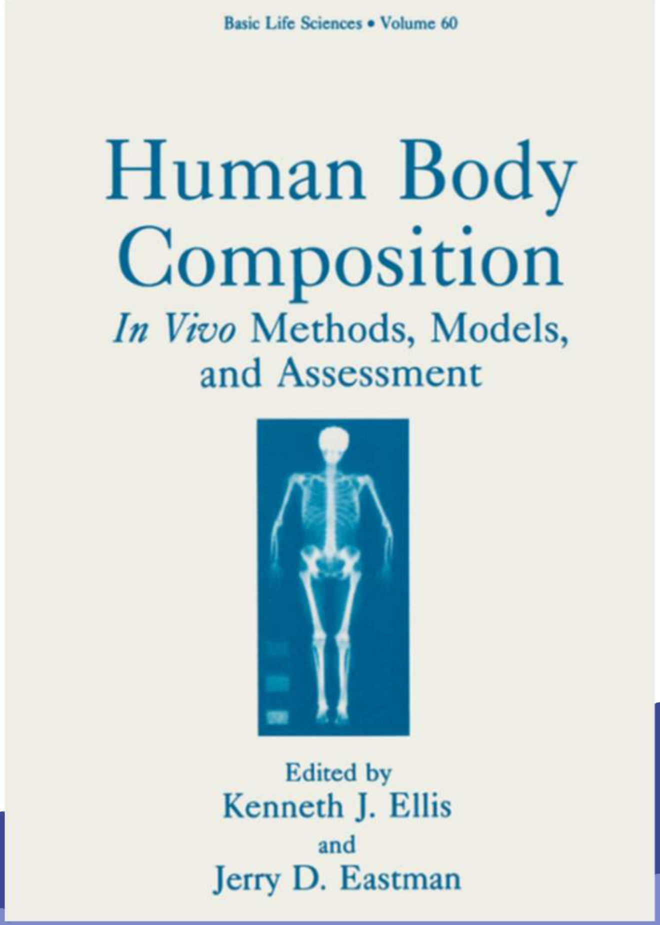
Spectroscopic Methods

- Near-infrared spectroscopy; Hyperspectral Imaging; Raman

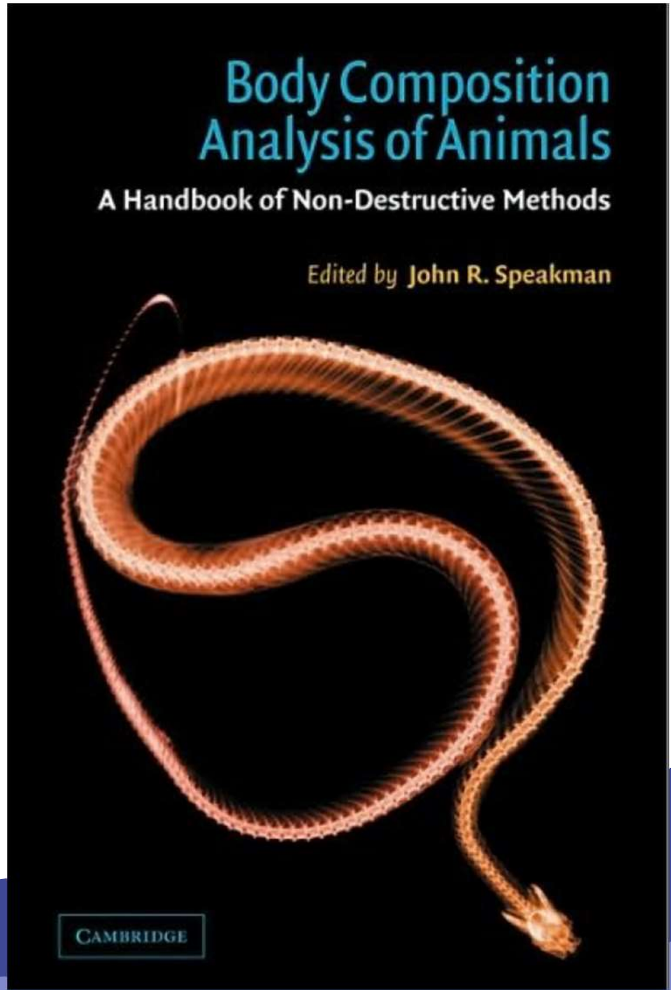
Imaging Methods

- Ultrasound; Computed Tomography (CT); Magnetic Resonance Imaging (MRI); Dual-Radiation X-Ray Absorptiometry (DXA); Video Image Analysis (VIA); Computer Vision Systems (CVS)

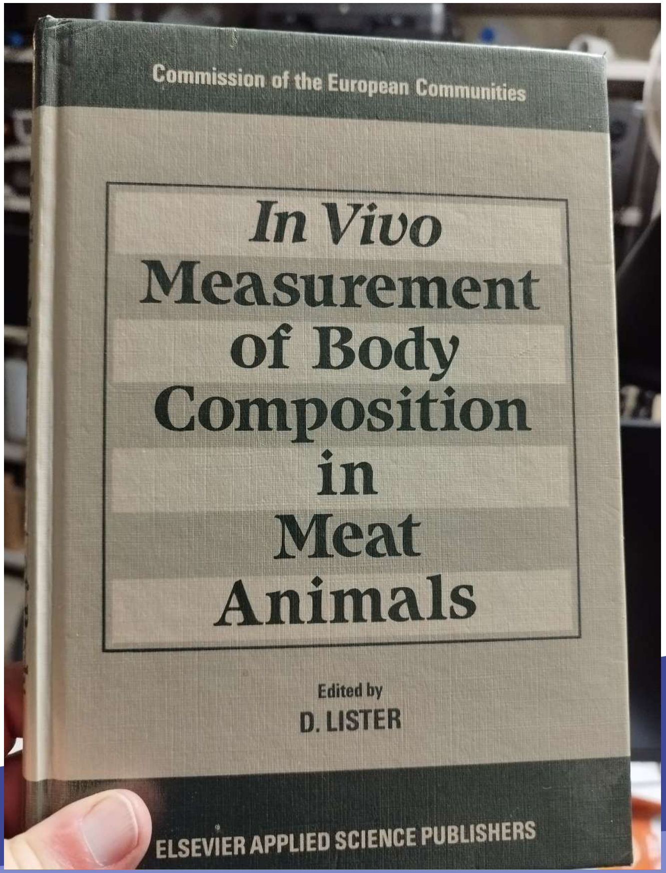
Main target of these techniques: human body composition



Animals


Body Composition
Analysis of Animals
A Handbook of Non-Destructive Methods
Edited by John R. Speakman
CAMBRIDGE

Meat Animals



Los Alamos National Laboratory: ^{40}K

Los Alamos Lab

After WWII and beginning of the Cold War Los Alamos Lab had capabilities that were used for animal science. Project ^{40}K

Estimating the body composition of a living subject by whole-body ^{40}K counting is feasible because of the direct relation of potassium to lean body mass and its indirect relation to fat.

Potassium in nature is present with three isotopes: ^{39}K (93,3%), ^{40}K (0,0117%) and ^{41}K (6,7%)

Potassium-40 is a radioactive isotope of potassium which has a very long half-life of 1.251×10^9 years.

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Whole-body counting

268 WHOLE-BODY COUNTING

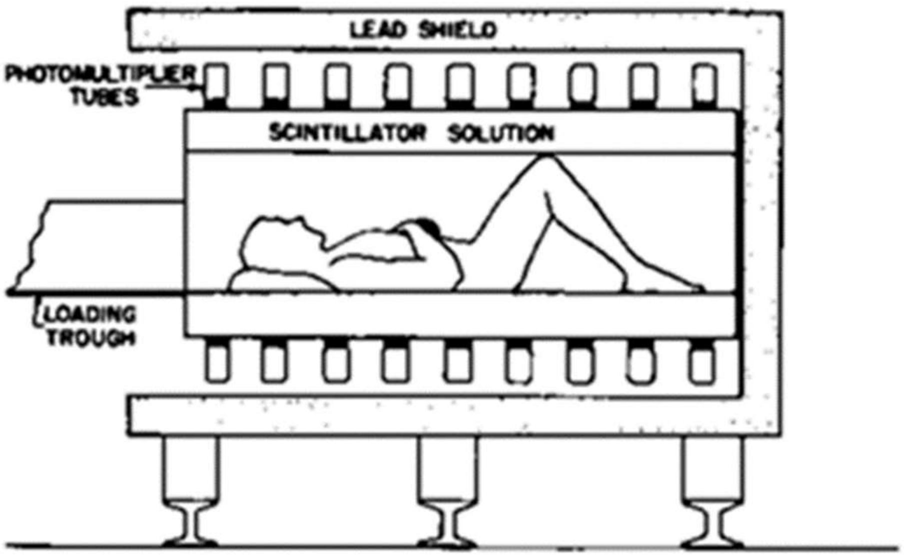
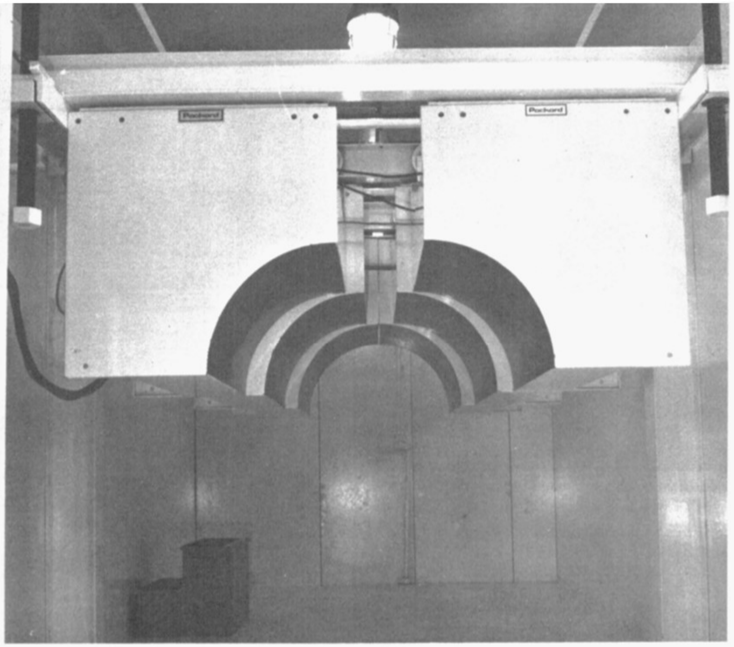


FIGURE 1 Schematic cross section of a 4-pi liquid scintillation human counter (HUMCO I).

Anderson, 1967

Whole-body counting

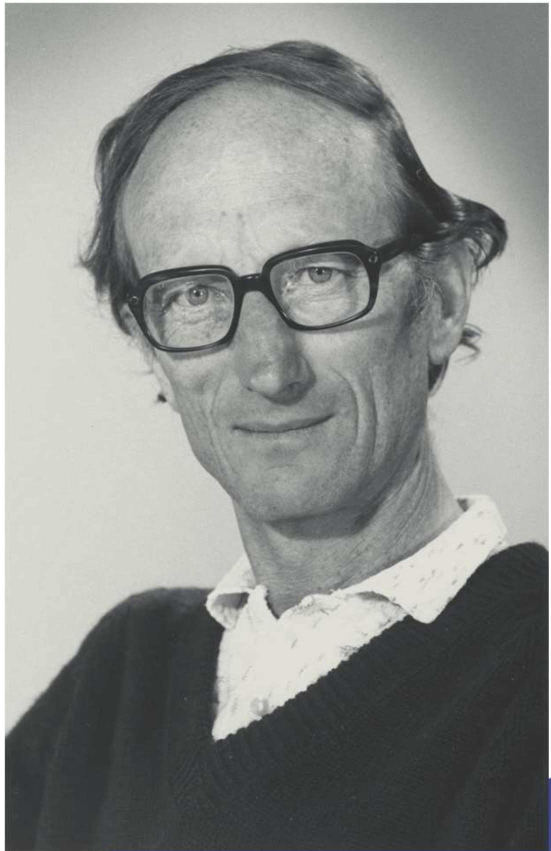


The detector is divided into three sections. Each section is composed of two tanks.

Cow in position for counting.

UMC, 1968

Alan Kirton (1933-2001)



ANNALS OF THE NEW YORK ACADEMY OF SCIENCES

RELATIONSHIPS BETWEEN POTASSIUM CONTENT AND BODY COMPOSITION*†

A. H. Kirton, A. M. Pearson

First published: September 1963 | https://doi.org/10.1111/j.1749-6632.1963.tb17087.x | Citations: 9

* This study was supported in part by funds provided by research grants No. AM04172-03 provided by the National Institute of Health.
† Journal Article 3092, Michigan Agricultural Experiment Station, East Lansing.

RELATIONSHIPS BETWEEN POTASSIUM CONTENT AND BODY COMPOSITION*†

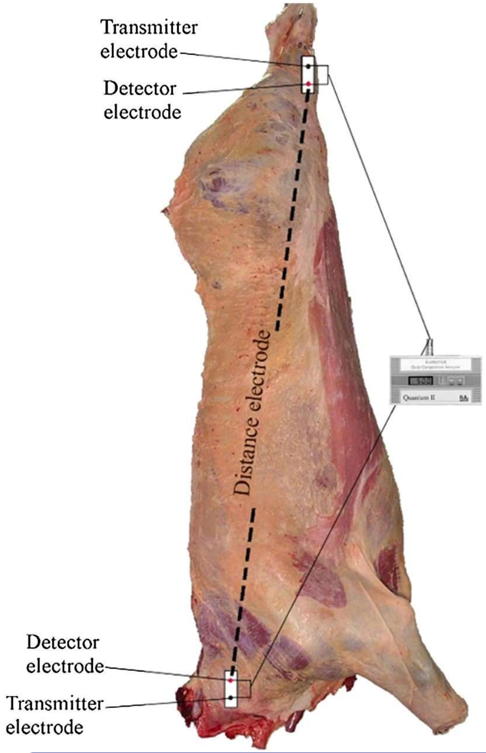
A. H. Kirton‡ and A. M. Pearson
Michigan State University, East Lansing, Mich.

Research workers in many fields would have use for a method that would permit the accurate estimation of the composition of live animals. At the present time, no such method is available. One of the nondestructive methods currently being investigated is the use of the natural gamma radioactivity of potassium-40 for predicting animal composition. Since many of the workers in this field are present at this conference, it is assumed that their work will be reviewed in the appropriate papers and no formal review of literature will be given herein.

Los Alamos Lambs

Ten lambs with a mean liveweight of 88 lb. were used to study the

Bioelectrical impedance analysis BIA



Leighton et al., 2022

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Bioelectrical impedance analysis BIA

Animal, page 1 of 7 © The Animal Consortium 2017
doi:10.1017/S1751731117002580

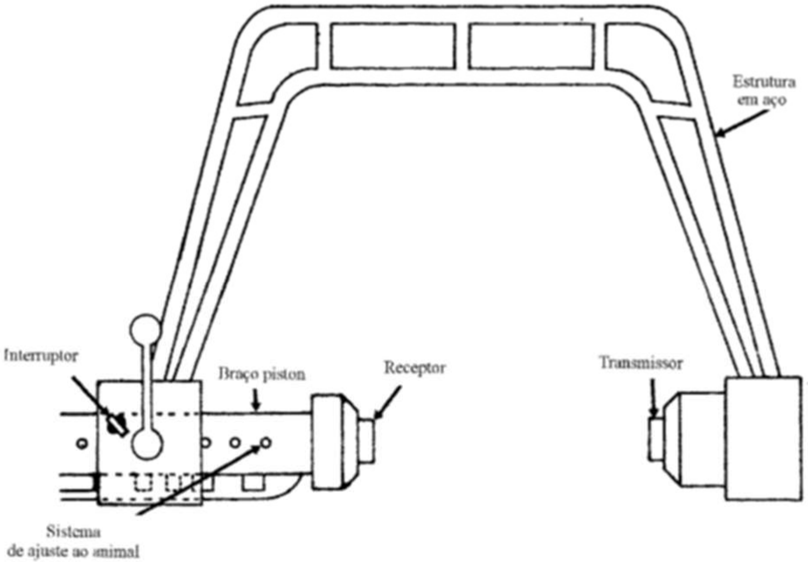
animal

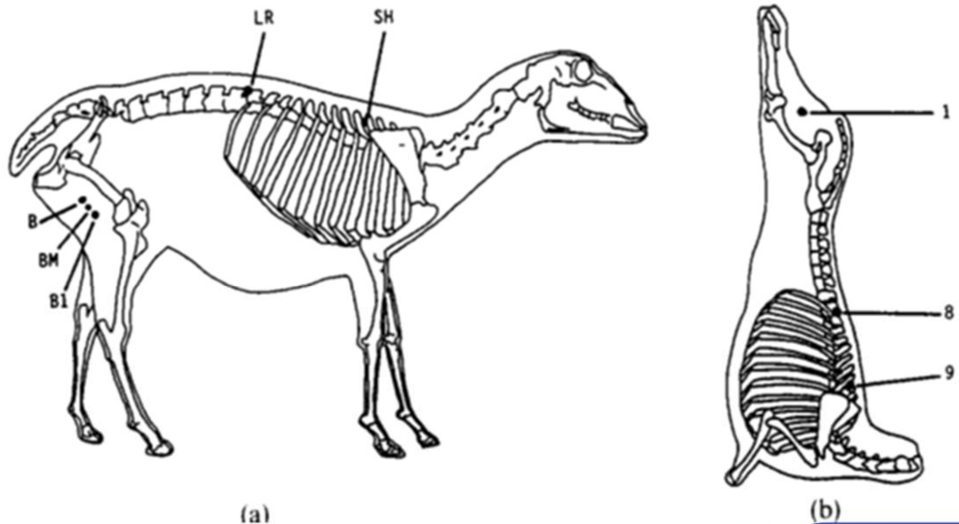
Application of bioelectrical impedance analysis in prediction of light kid carcass and muscle chemical composition

S. R. Silva[1], J. Afonso[2†], A. Monteiro[3], R. Morais[4], A. Cabo[1], A. C. Batista[1], C. M. Guedes[1] and A. Teixeira[5]

model predicting muscle chemical fat weight combined CCW and Z, explaining 85.6% (P < 0.01) of the variation observed. These results indicate BIA as a useful tool for prediction of light kids' carcass composition.

Velocity of Ultrasound





(a) (b)

Miles et al.

Velocity of Ultrasound

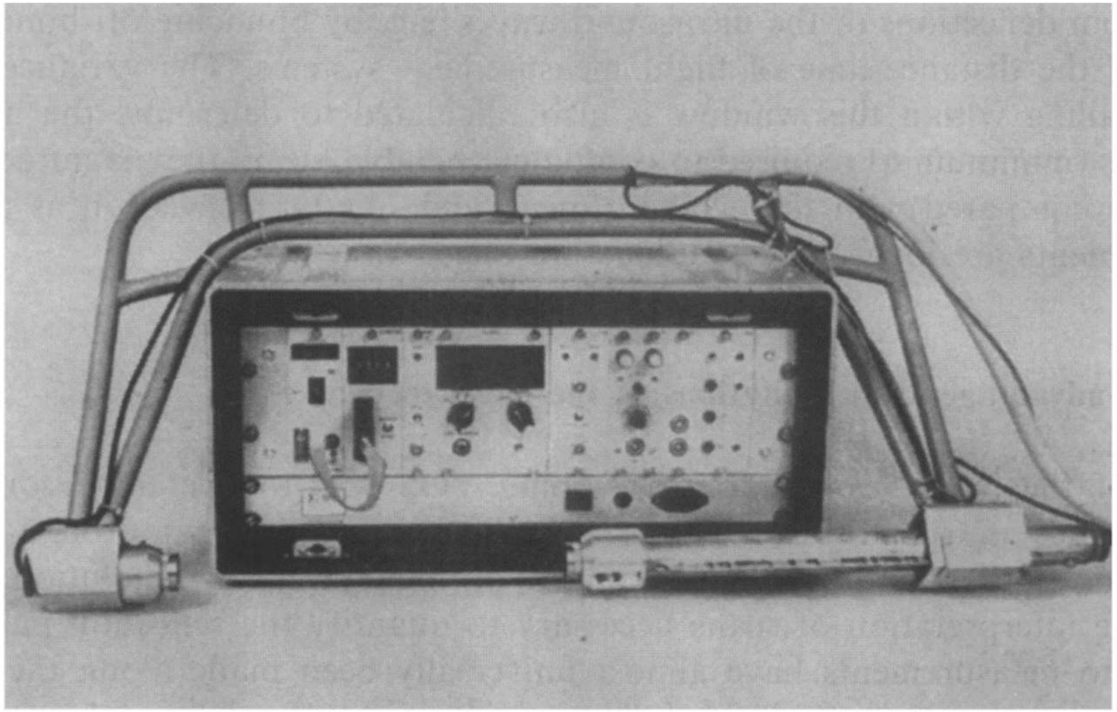


Fig. 1. The original VOS equipment, showing the 'big' measuring frame (for use on the hindquarters of cattle) and the signal generating and measuring box.

Fisher 1997

Total Body Electrical Conductivity (TOBEC)

TOBEC
has been introduced as a rapid, safe, and non-invasive method suitable for the estimation of fat-free mass.

The TOBEC operates on the principle that organisms placed in an electromagnetic field perturb the field to a degree that depends on the amount and volume of distribution of electrolytes present.

This disturbance is electronically monitored, obtaining an electrical conductivity value.

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Meat Science 166 (2020) 108153

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

ELSEVIER

Preliminary investigation for the prediction of intramuscular fat content of lamb *in-situ* using a hand- held NIR spectroscopic device

Stephanie M. Fowler[a,b,*], Stephen Morris[c], David L. Hopkins[a,b]

[a] Cooperative Research Centre for Sheep Innovation, Armidale NSW 2350, Australia
[b] NSW Department of Primary Industries, Centre for Red Meat and Sheep Development, Cowra NSW 2794, Australia
[c] Wollongbar Primary Industries Institute, NSW Department of Primary Industries, Wollongbar NSW 2477, Australia

Fig. 1. Measurement of a lamb topside *in-situ* with a Halo® hand-held NIR device.

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Figure 5-10. Three different NIR devices have been tested in the pilot trial in the beef abattoir

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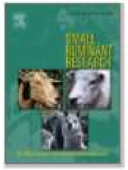
Small Ruminant Research
Volume 126, May 2015, Pages 40-43



Short communication

An approach to predict chemical composition of goat *Longissimus thoracis et lumborum* muscle by Near Infrared Reflectance spectroscopy

Alfredo Teixeira [a, b], António Oliveira [a, b], Katia Paulos [a, b], Ana Leite [a, b], Anabela Marcia [a], André Amorim [a], Etelvina Pereira [a], Severiano Silva [b, d], Sandra Rodrigues [a, c]

Show more

Figure 1. Process sample preparation and subsequent NIR Master analysis.

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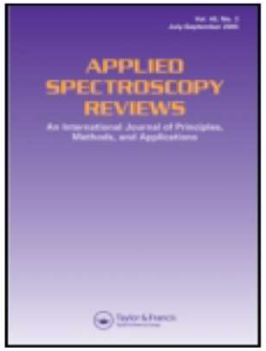

Taylor & Francis
Taylor & Francis Group

Applied Spectroscopy Reviews

ISSN: 0570-4928 (Print) 1520-569X (Online) Journal homepage: https://www.tandfonline.com/loi/laps20

NIR Spectroscopy and Imaging Techniques for Evaluation of Fish Quality—A Review

Dan Liu, Xin-An Zeng & Da-Wen Sun

To cite this article: Dan Liu, Xin-An Zeng & Da-Wen Sun (2013) NIR Spectroscopy and Imaging Techniques for Evaluation of Fish Quality—A Review, Applied Spectroscopy Reviews, 48:8, 609-628, DOI: 10.1080/05704928.2013.775579

To link to this article: https://doi.org/10.1080/05704928.2013.775579

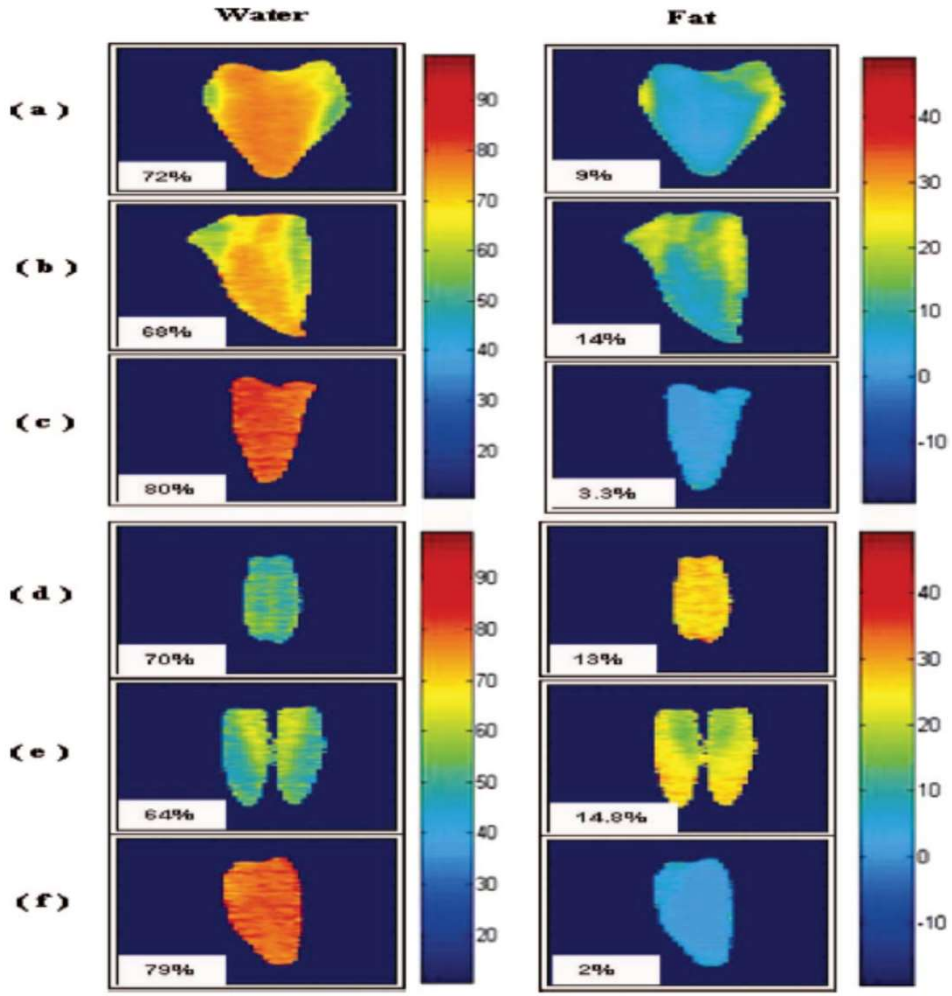

Figure 2. Water and fat distribution maps in fillets of (a) Atlantic halibut, (b) catfish, (c) cod, (d) herring, (e) mackerel, and (f) saithe. Values in left bottom corners represent the average concentrations of water and fat in the whole fillet (38). (Color figure available online.)

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Journal of Food Engineering 174 (2016) 92–100

Contents lists available at ScienceDirect

Journal of Food Engineering

journal homepage: www.elsevier.com/locate/jfoodeng

ELSEVIER

Lamb muscle discrimination using hyperspectral imaging: Comparison of various machine learning algorithms

CrossMark

Jose Antonio Sanz [a,*], Armando M. Fernandes [b,c,1], Edurne Barrenechea [a], Severiano Silva [d,e,1], Virginia Santos [d,e,1], Norberto Gonçalves [b,f,1], Daniel Paternain [a], Aranzazu Jurio [a], Pedro Melo-Pinto [b,f,1]

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[b] CITAB – Centre for the Research and Technology of Agro-Environmental and Biological Sciences, Universidade de Trás-os-Montes e Alto Douro, 5000-801 Vila Real, Portugal
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[e] Departamento de Zootécnia, Escola de Ciências Agrárias e Veterinárias, Universidade de Trás-os-Montes e Alto Douro, 5000-801 Vila Real, Portugal
[f] Departamento de Engenharias, Escola de Ciências e Tecnologia, Universidade de Trás-os-Montes e Alto Douro, 5000-801 Vila Real, Portugal

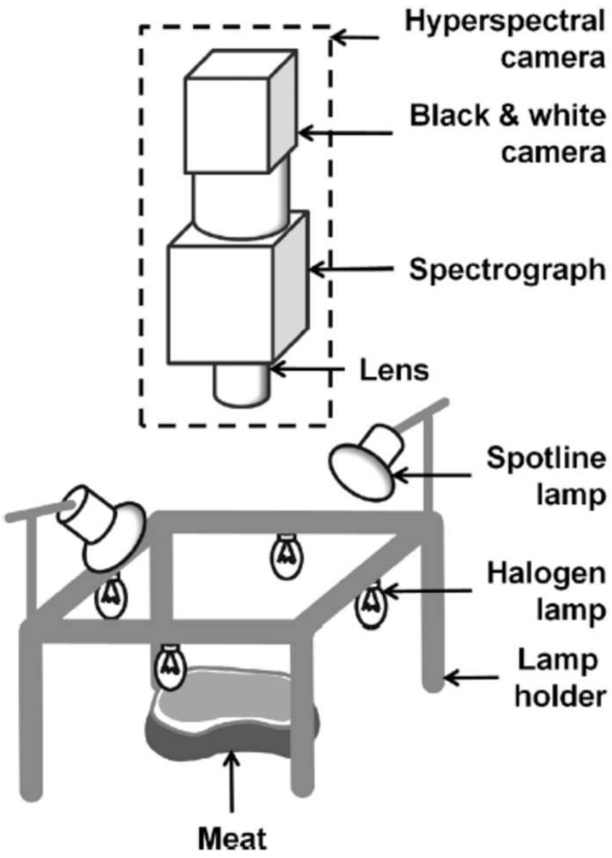
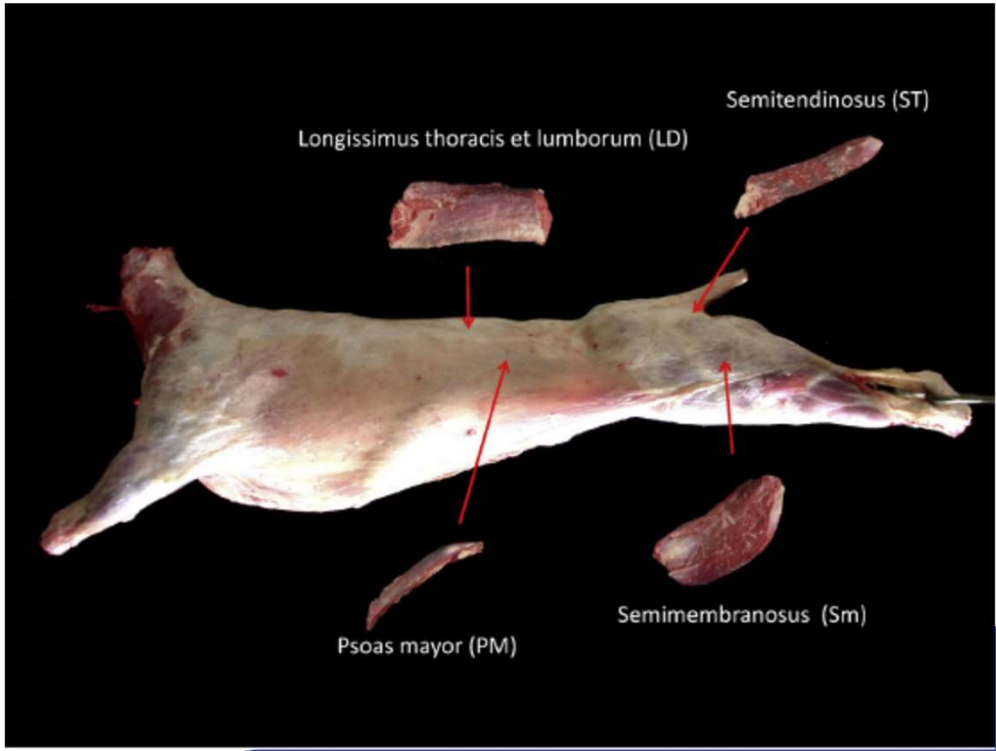


Fig. 2. Hyperspectral imaging setup.

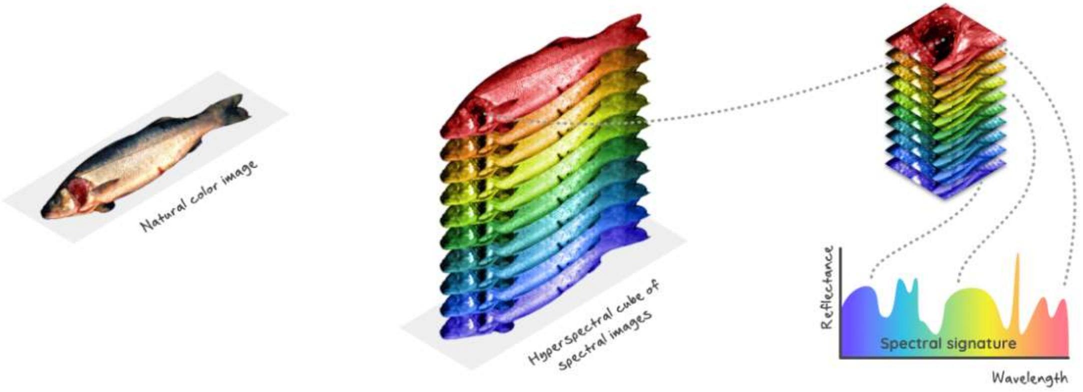


condi food

Human eye

Hyperspectral camera

Hyperspectral image



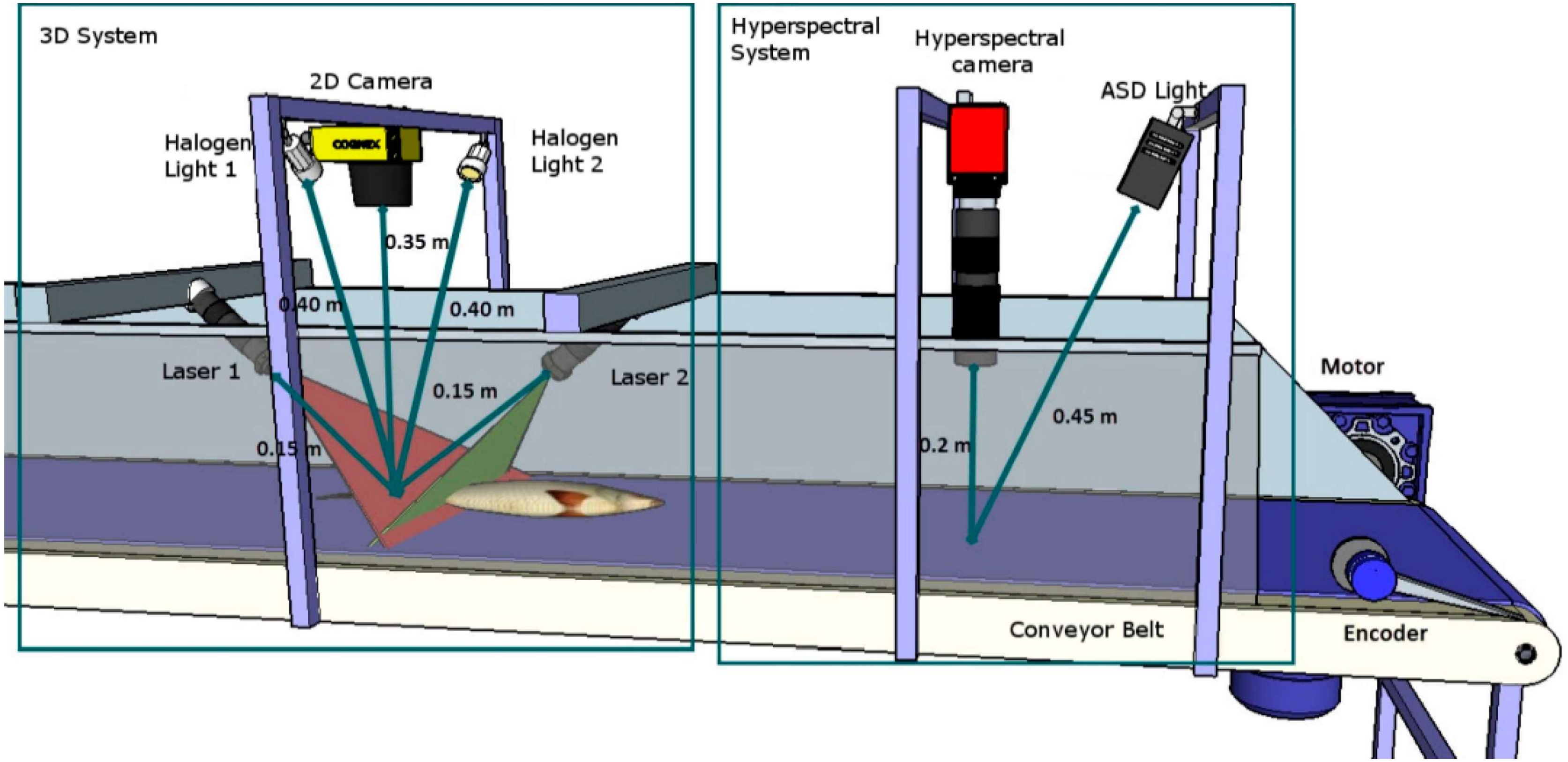
What is hyperspectral imaging?

The human eye sees the world in three colors: red, green and blue (RGB). By mixing the amount of these three colors all other colors are created. A similar process is used for creating colors on television, computer screens, mobile phones and colour printing.

Hyperspectral food inspection

Hyperspectral food inspection makes use of hyperspectral imaging and has a number of advantages above classic inspection methods.

Non-destructive & 100% inspection


3D System
2D Camera
Halogen Light 1
Halogen Light 2
0.35 m
0.40 m
0.40 m
Laser 1
Laser 2
0.15 m
0.15 m
Hyperspectral System
Hyperspectral camera
ASD Light
0.45 m
0.2 m
Motor
Encoder
Conveyor Belt

SCIENTIFIC REPORTS
natureresearch

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OPEN

Prediction of various freshness indicators in fish fillets by one multispectral imaging system

Received: 24 October 2018

Sara Khoshnoudi-Nia[1] & Marzieh Moosavi-Nasab[2]

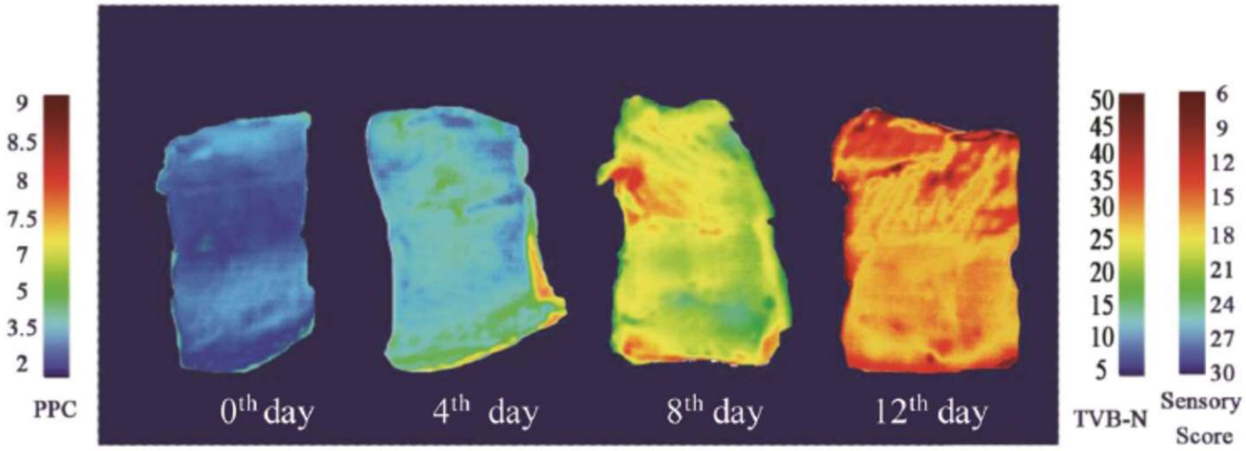

Figure 3. Distribution maps of freshness quality of rainbow-trout fillets stored at 4 °C for 12 days.

Raman technology

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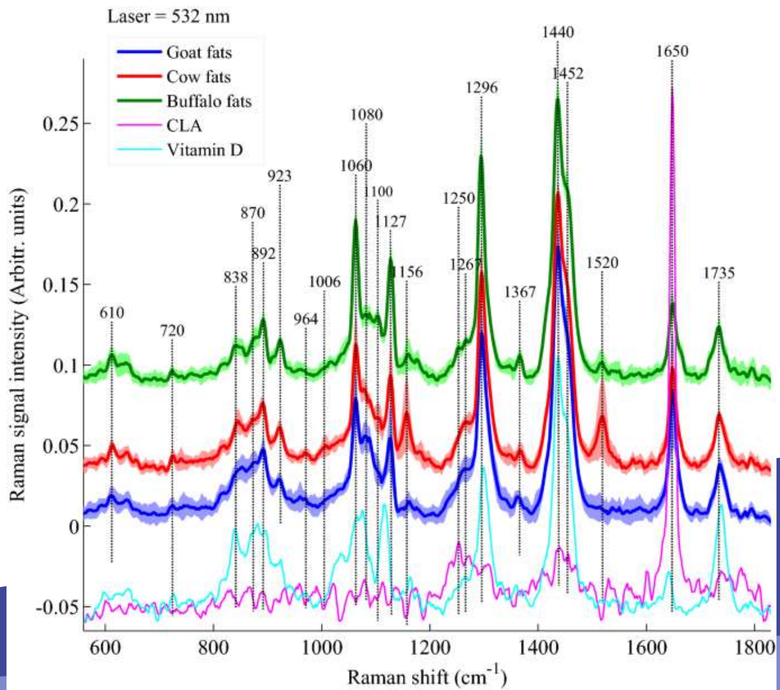
Springer Link

Original Article | Published: 21 May 2020

Raman spectroscopy based characterization of cow, goat and buffalo fats

M. Saleem, Ayyaz Amin & Muhammad Irfan

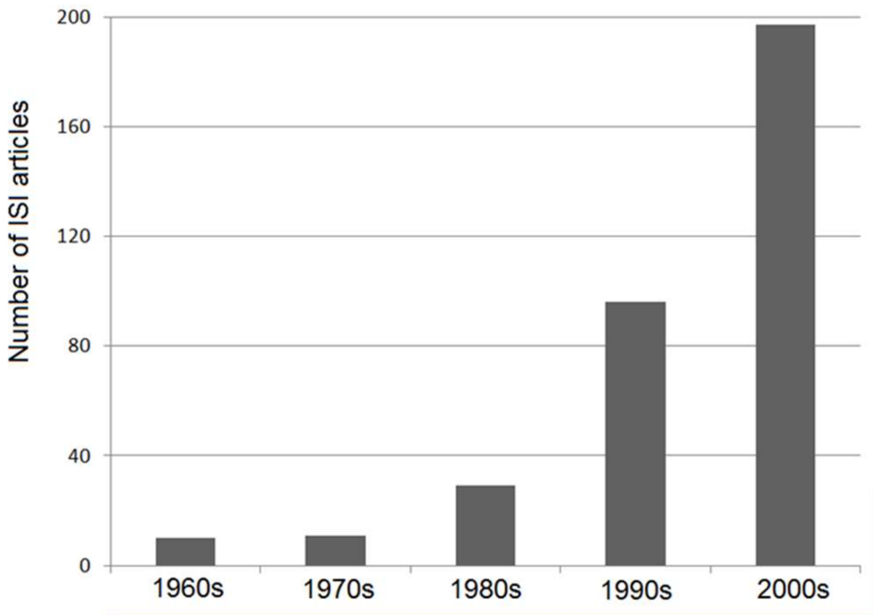
Journal of Food Science and Technology **58**, 234–243 (2021) | Cite this article



Real-Time Ultrasonography – RTU

The RTU is an imaging technique that has an important role in animal science

Evolution of the number of ISI papers related with use of RTU applied to carcass. RTU has been extensively used in farm species as a tool for genetic evaluation.



Silva & Cadavez (2012)

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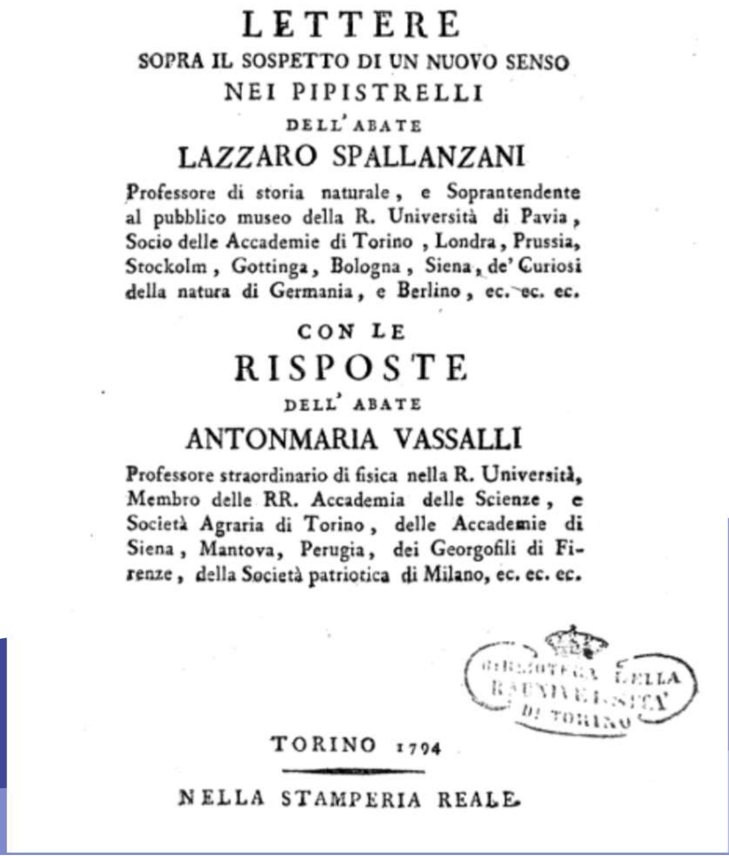
In 1794 the Italian priest and physiologist Lazzaro Spallanzani (1729-1799) show that bats emit high-frequency sound waves and hear the echoes



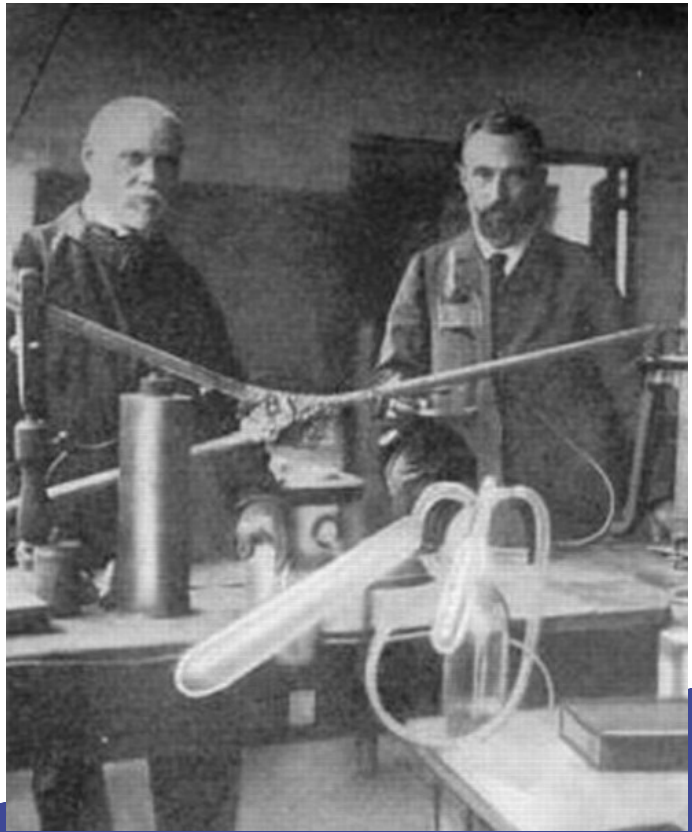
LETTERE
SOPRA IL SOSPETTO DI UN NUOVO SENSO
NEI PIPISTRELLI
DELL' ABATE
LAZZARO SPALLANZANI
Professore di storia naturale, e Soprantendente al pubblico museo della R. Università di Pavia, Socio delle Accademie di Torino, Londra, Prussia, Stockolm, Gottinga, Bologna, Siena, de' Curiosi della natura di Germania, e Berlino, ec. ec. ec.

CON LE
RISPOSTE
DELL' ABATE
ANTONMARIA VASSALLI
Professore straordinario di fisica nella R. Università, Membro delle RR. Accademia delle Scienze, e Società Agraria di Torino, delle Accademie di Siena, Mantova, Perugia, dei Georgofili di Firenze, della Società patriotica di Milano, ec. ec. ec.

TORINO 1794

NELLA STAMPERIA REALE

March 1880: The Curie brothers discover piezoelectricity

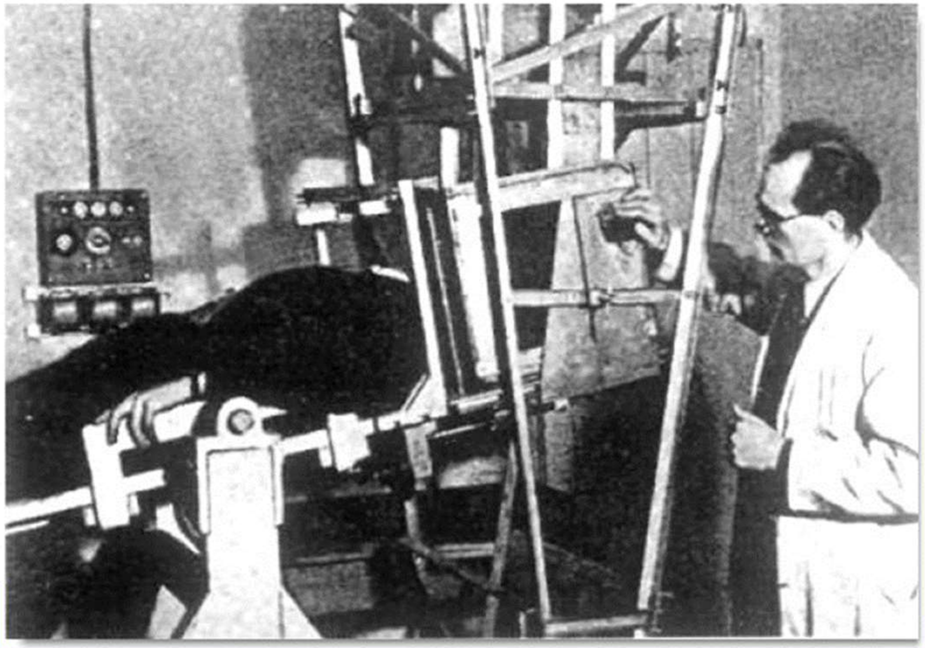


ult.rsmjournals.com

During WWI and WWII important advances in ultrasound have been achieved

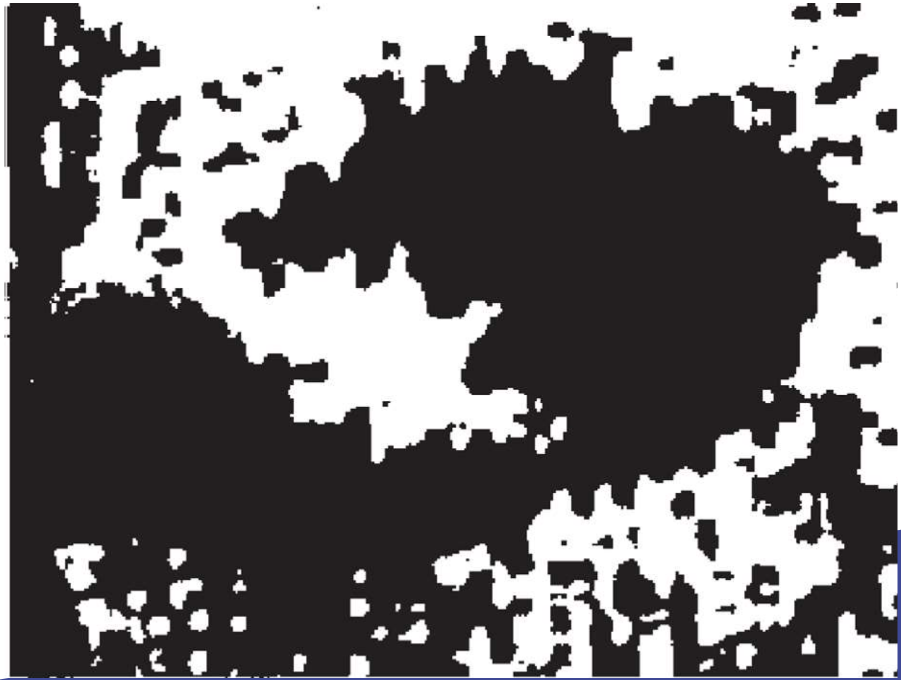
http://www.gizmodo.com.au/

Ultrasound: 1946 Karl Dussik, together with his brother Friederich, a physicist, attempted to locate brain tumors and the cerebral ventricles by measuring the transmission of ultrasound beam through the skull.



Woo (2006)

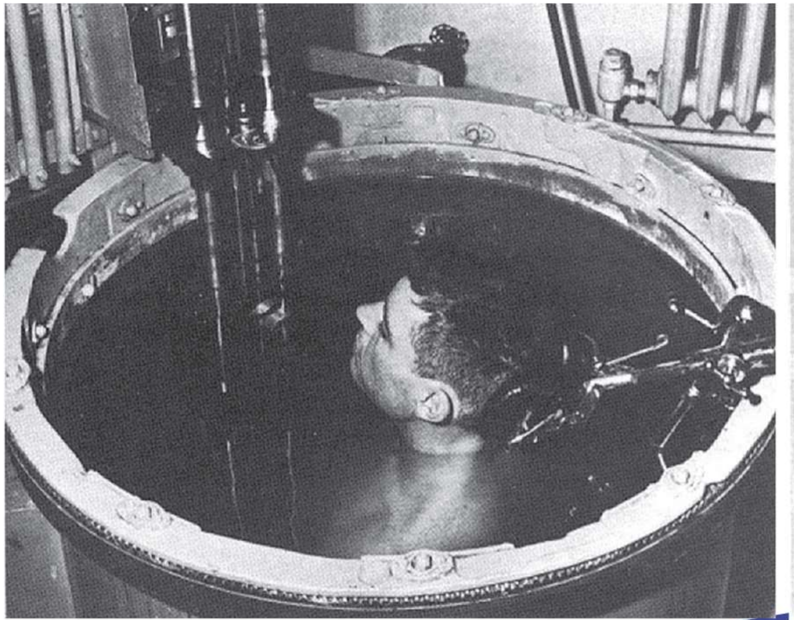
Dussik ultrasound image. This poor quality image represents a milestone for the history of ultrasonography

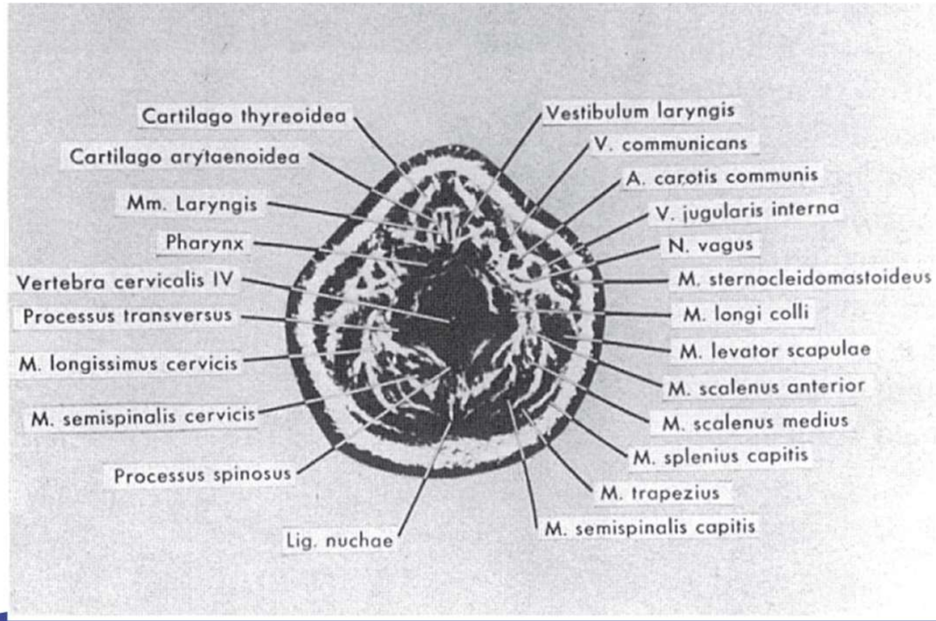


John Julian Wild in1950 report echoes from soft tissues (like muscle or fat)

Woo (2006)

Ultrasound: By the end of 50s first 2D images of anatomical structures. This equipment uses a WWII bomber scrap



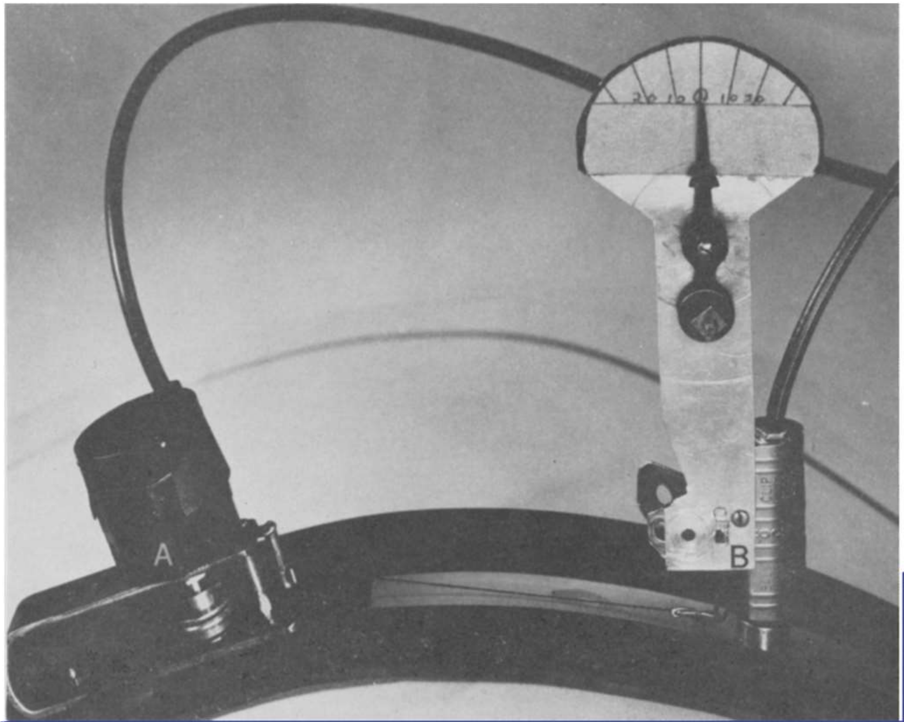


Woo (2006)

In animal science the first study appears in 1957. Stouffer uses an enormous ultrasound A-mode machine. The machine was originally used to detect failures in metal structures.

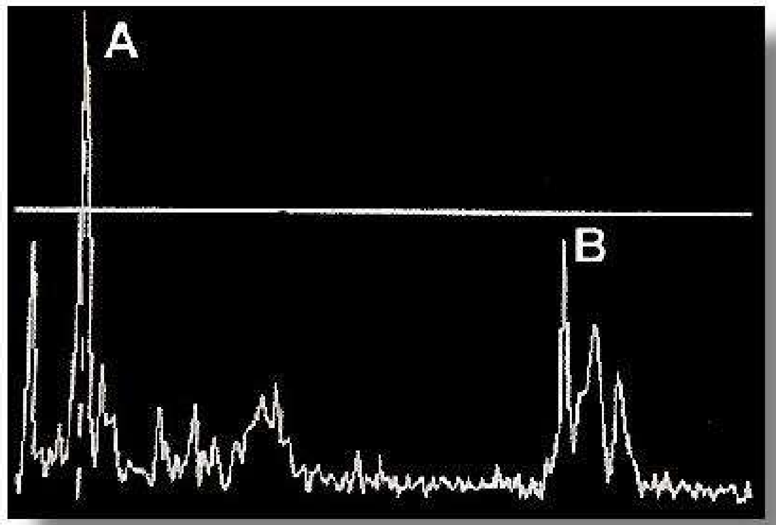
Stouffer (2004)

Detail of the transducer and angle deflection device which are manually moved over the hide



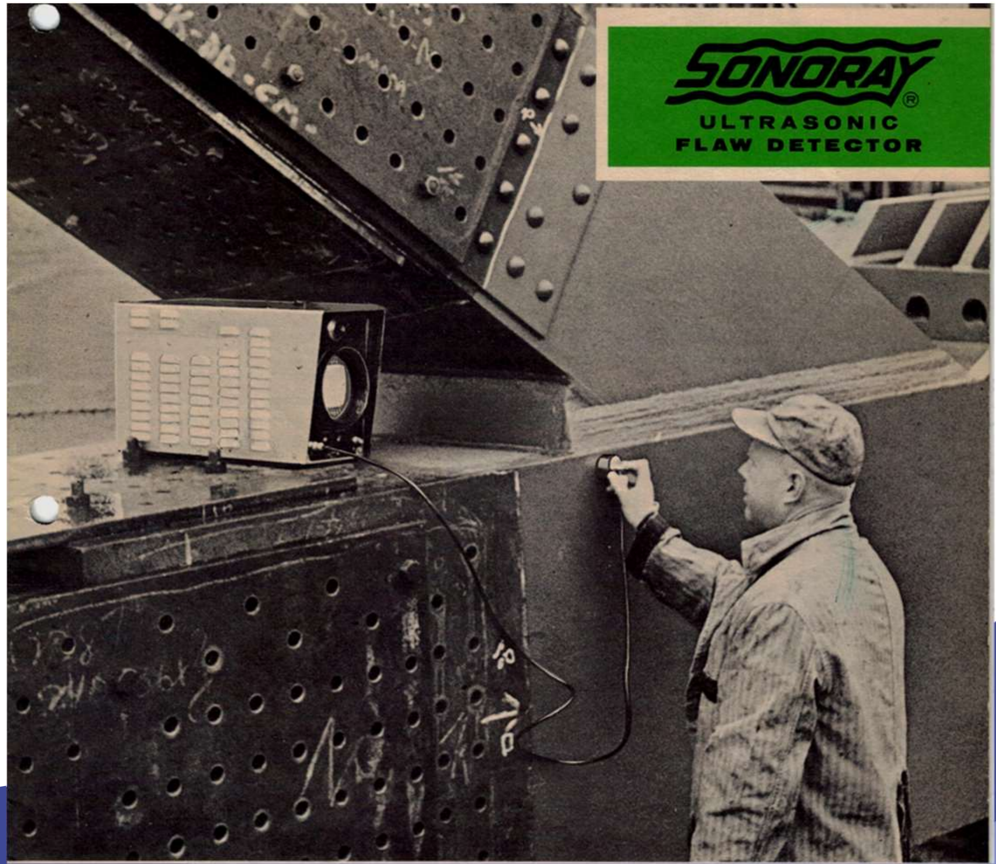
Stouffer et al. (1960)

A-mode image. In this kind of ultrasound image each peak represents a echo from different tissues. Typically the carcass traits were measured directly from the image using a mm scale



http://www.ob-ultrasound.net/sliceabd.html

Advance to Branson Ultrasonic A mode unit with Intensity Modulated Signal 1960



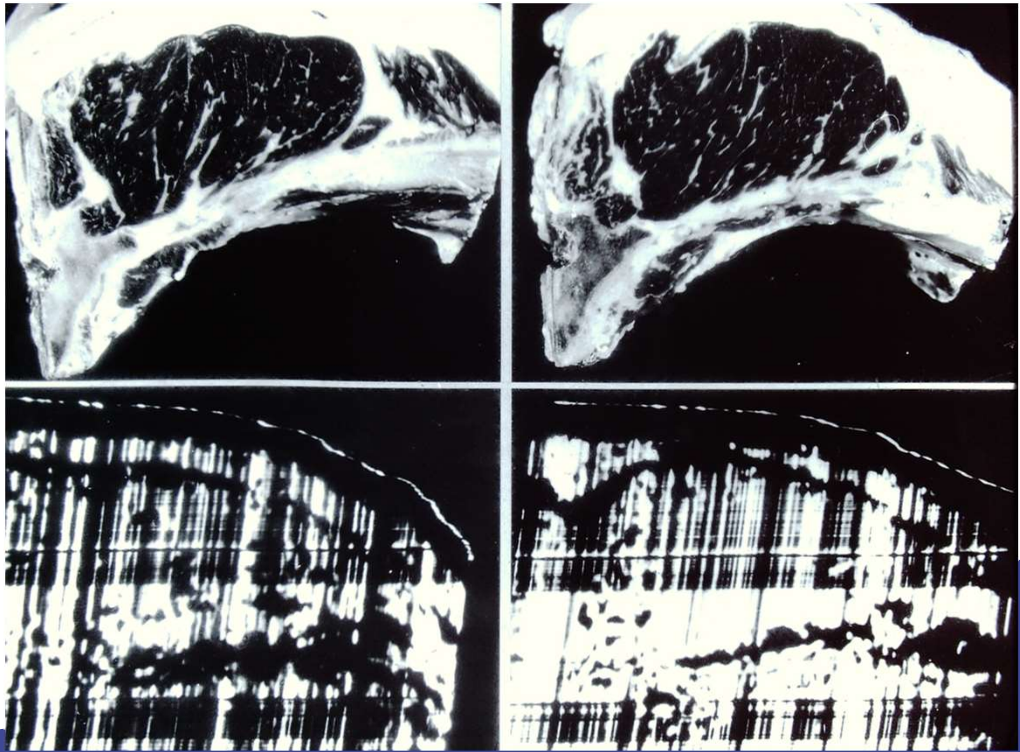
Later Stouffer and graduate student Max Wallentine with a prototype mechanical B-scan unit on a Branson model 6 metal flaw detector

Stouffer (2004)

Figure 4. First scanner for the rib eye area with A-mode baseline recording using the Sperry Reflectoscope metal flaw detector equipped with the Polaroid camera and the mechanism to synchronize the transducer movement with the camera (Stouffer J.R. Author's personal collection).

Silva & Stouffer, 2019

One of the first B-mode cross-sectional image of longissimus dorsi muscle



Stouffer (1998)

Ultrasound

Figure 5. Scanogram, commercial mechanical B-scanner, model 721 produced by Ithaco Inc. being used for examination of a pig (Stouffer J.R. Author's personal collection).

Silva & Stouffer, 2019

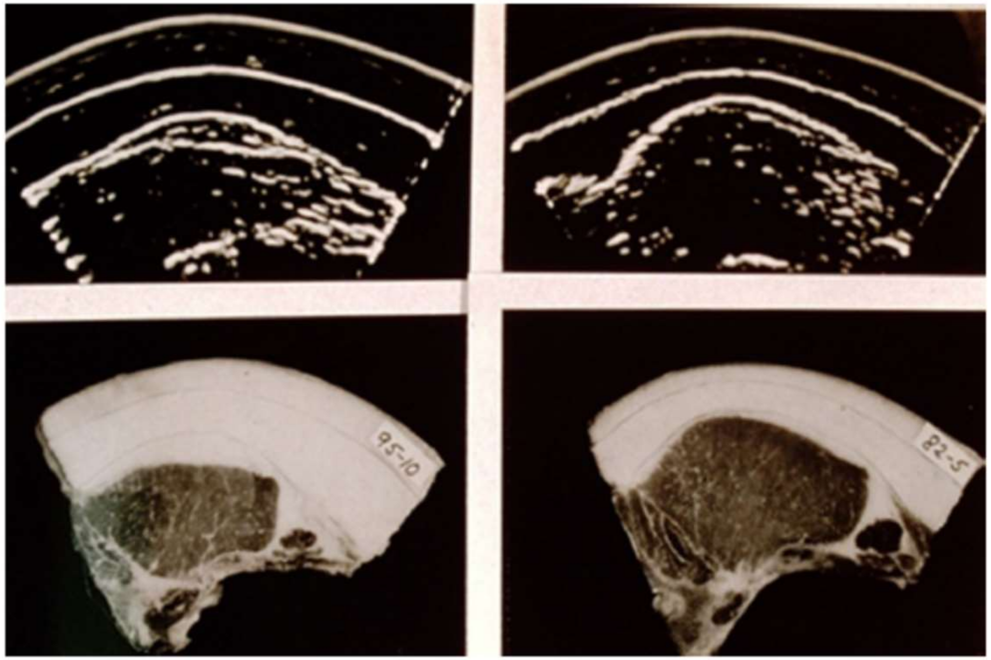
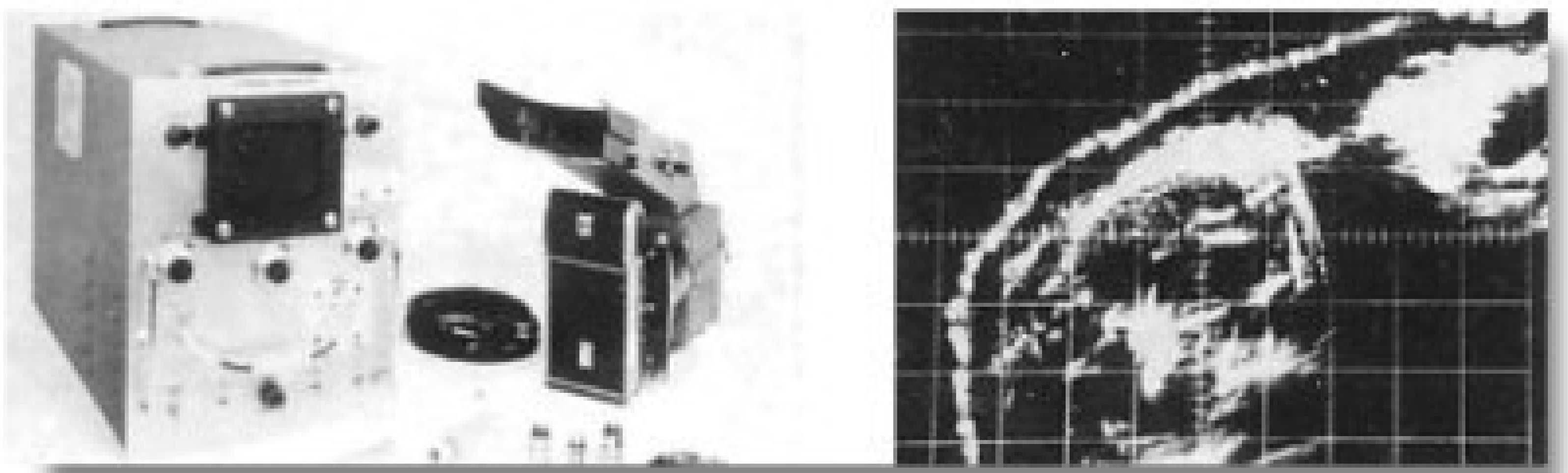


Figure 6. Examples of cross-sectional Scanogram images (top) and the equivalent cut (bottom) (Stouffer J.R. Author's personal collection).

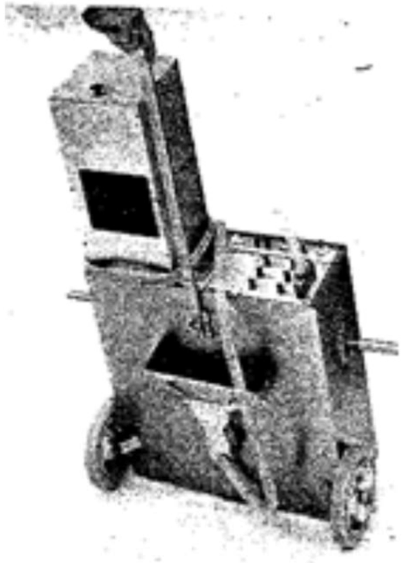
Silva & Stouffer, 2019

In 1962 first real time ultrasonography equipment

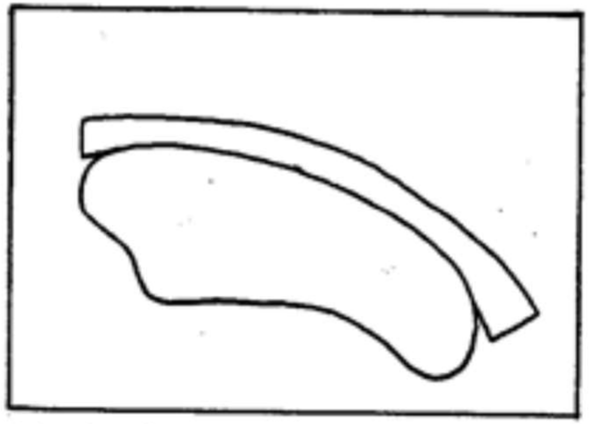


Woo (2006)

1980 SFK Danscanner



Cross section of pig



Fat and meat areas drawn after photo above

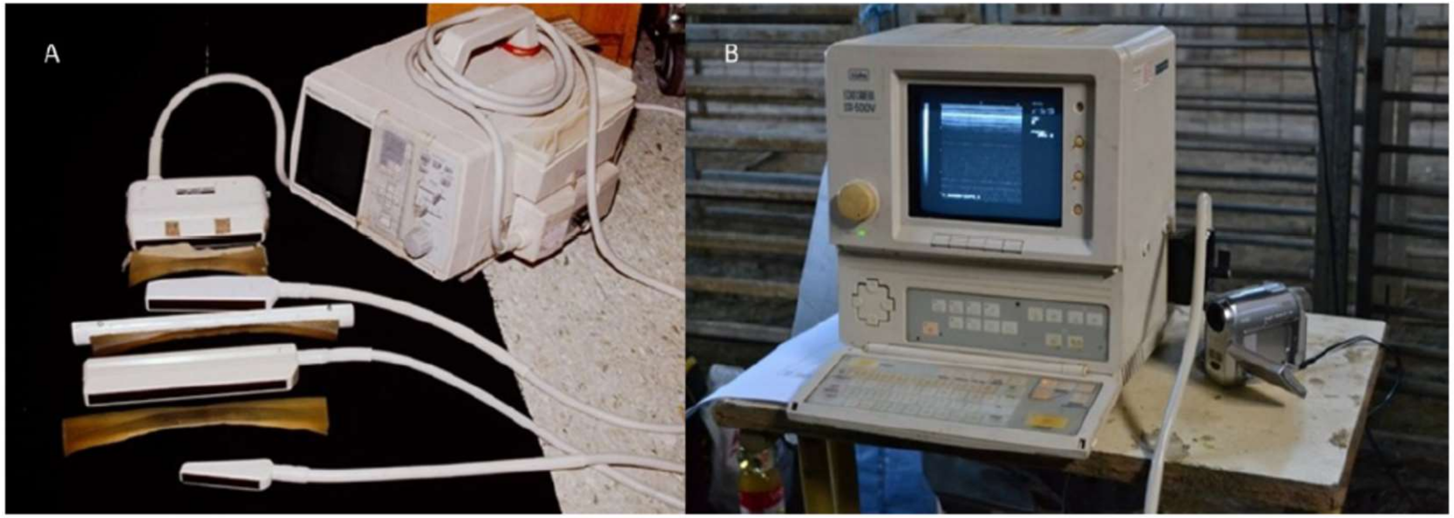
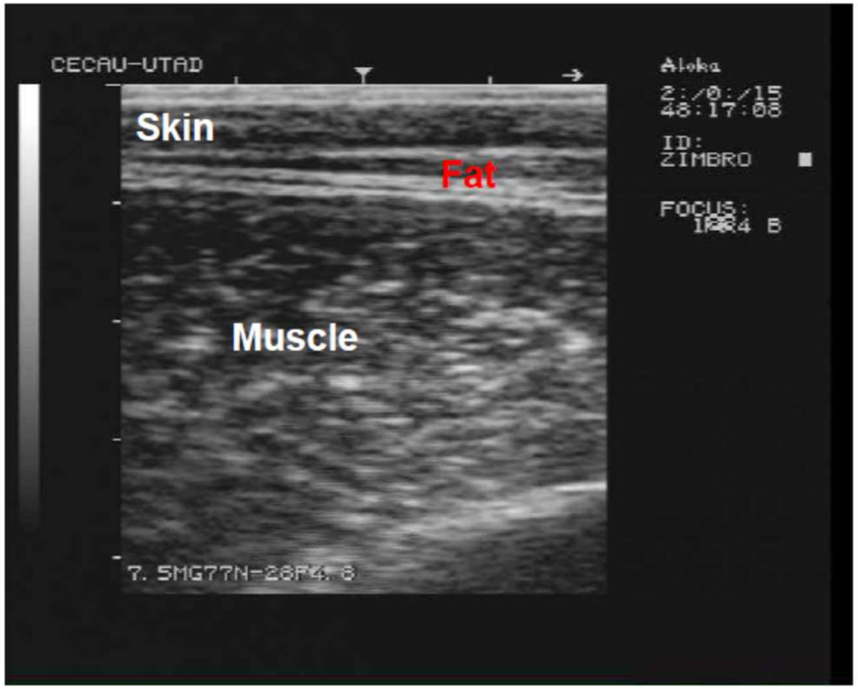


Figure 7. Aloka 210 scanner with several linear ultrasound probes and specially shaped standoff guides for each species (A) (Stouffer J.R. Author's personal collection) and Aloka SSD 500V equipped with a video camera to image capture (B) (Silva S.R. Author's personal collection).

Silva & Stouffer, 2019

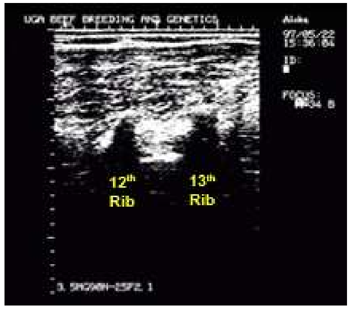
Example of a RTU image



[redacted]

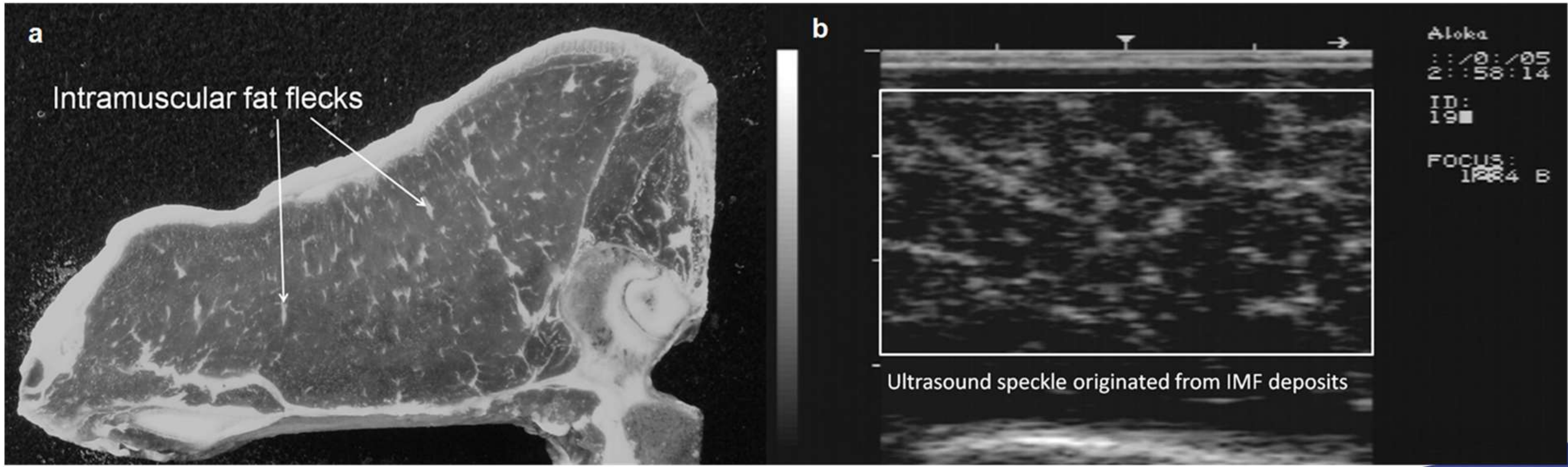
RTU image capture training

McLaren et al. (1991)


UGA BEEF BREEDING AND GENETICS
12th
Rib
13th
Rib


UGA BEEF BREEDING AND GENETICS

Ultrasound



Silva & Cadavez (2012)

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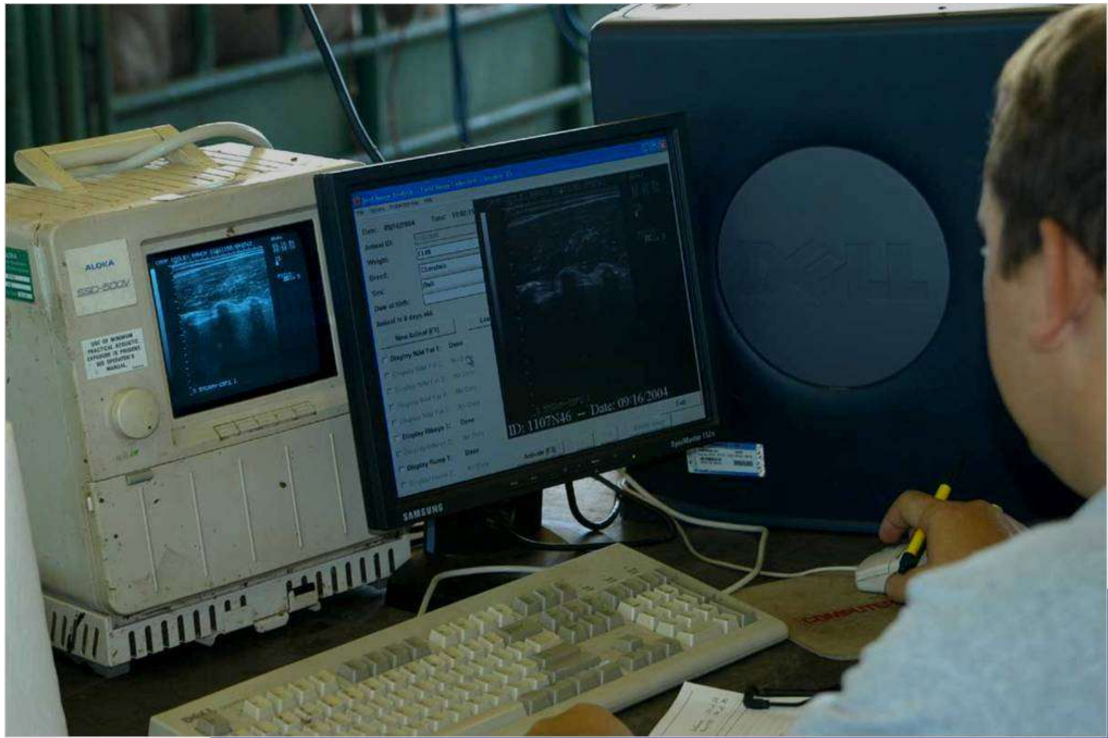
Image analysis training



www.bifconference.com/bif2006/newsroom/JacksonLoren.ppt

Ultrasound

Figure 1. Use of ultrasound technology on live mirror carp (*Cyprinus carpio*)

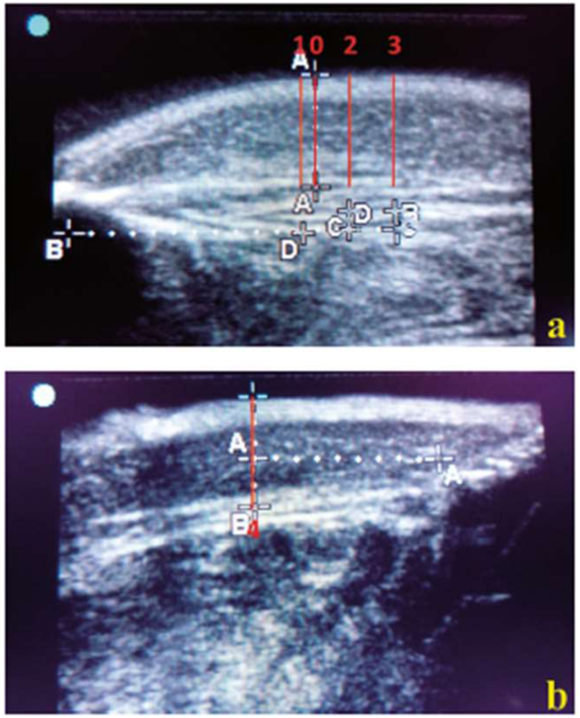
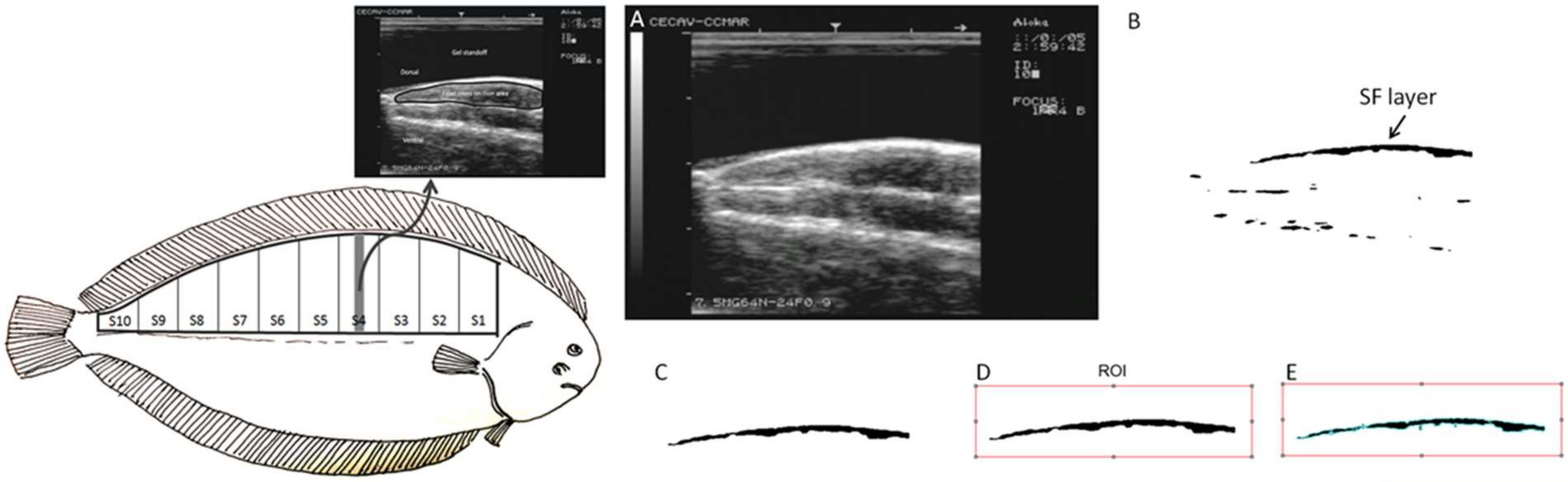


Figure 2. Measuring the back fat layer-thickness using ultrasound images; the cranial part of the back fat layer (a) and the back fat in the region of the dorsal fin (b)

Maas et al. 2015

Ultrasound



Silva et al. 2016

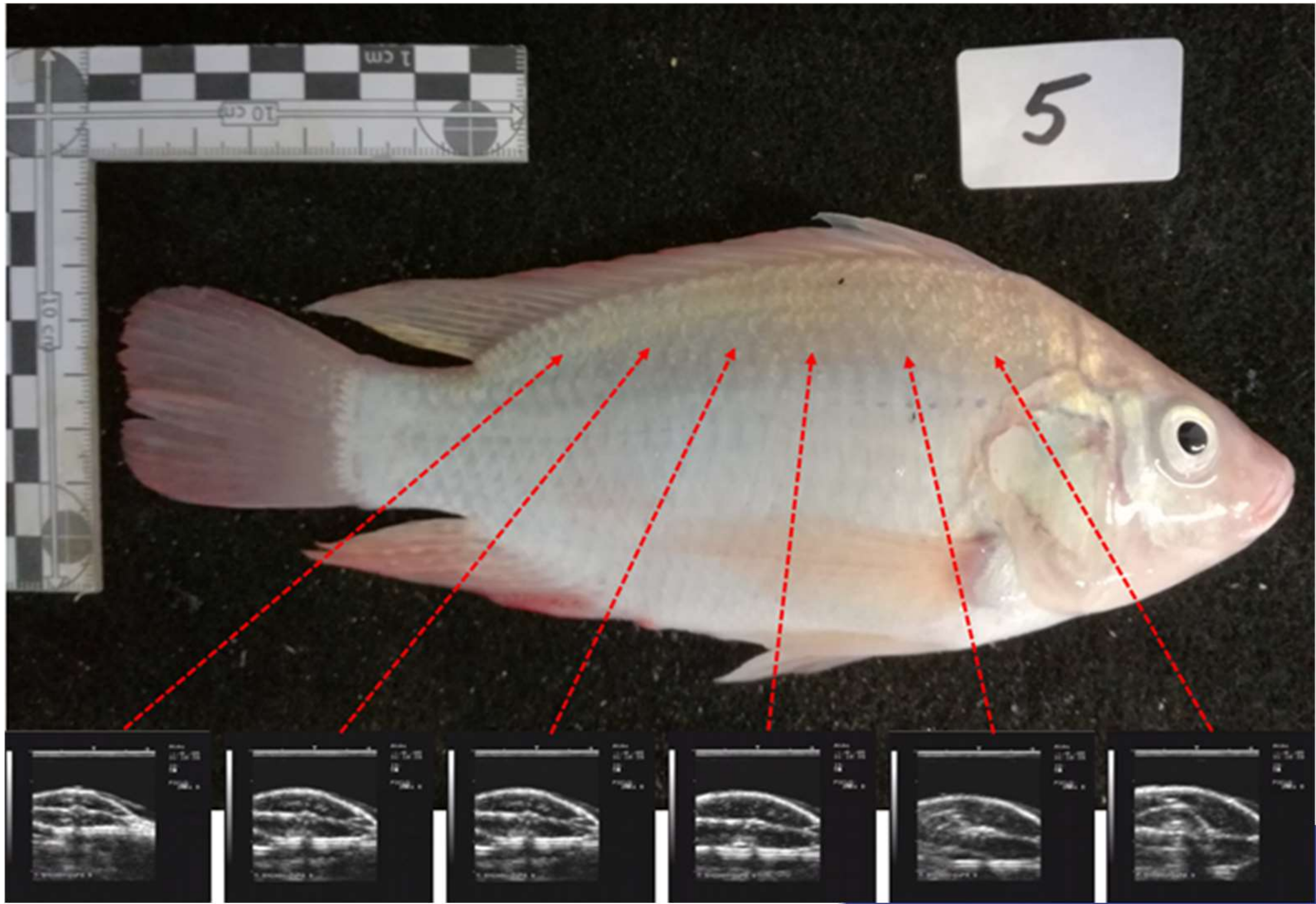


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Figure 1. Example of a tilapia fish image with arrows indicating the RTU image capture points and the respective RTU images

animals

MDPI

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Article

In Vivo Ultrasound Prediction of the Fillet Volume in Senegalese Sole (*Solea senegalensis*)

João Afonso [1,*], Cristina Guedes [2], Alfredo Teixeira [3,4], Paulo Rema [5] and Severiano Silva [2]

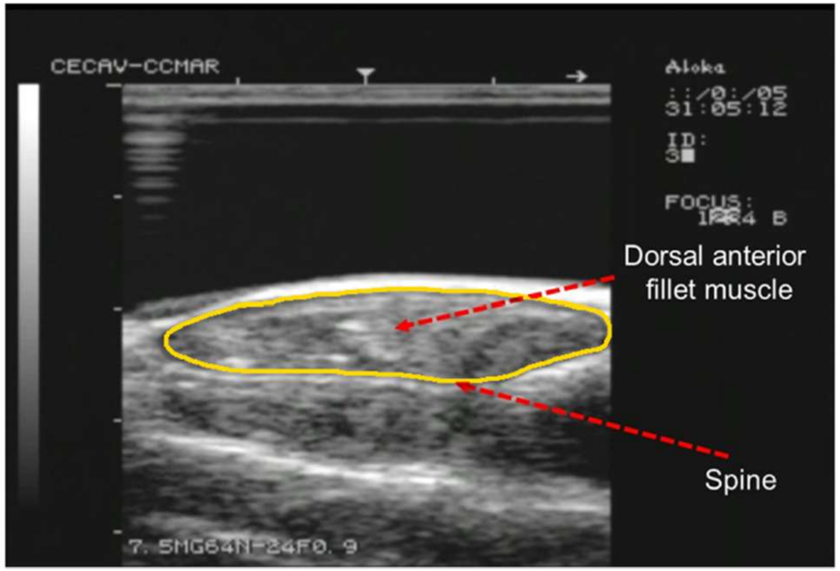

Figure 1. Example of a RTU cross-sectional image acquired with a 7.5 MHz probe at S_3 position. Arrows indicate the spine and right dorsal fillet muscle. The outline of the fillet section is highlighted in yellow.

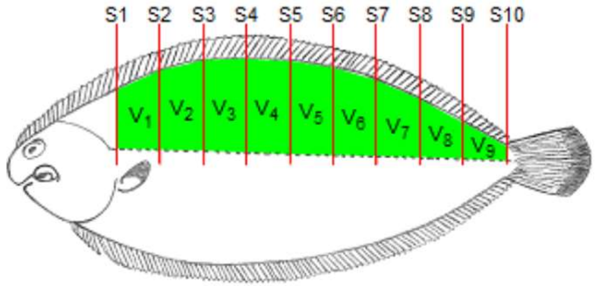

Figure 2. Schematic representation of the location of the cross-sectional RTU slices (S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9 and S_{10}).

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Research in Veterinary Science 133 (2020) 180–187

Contents lists available at ScienceDirect

Research in Veterinary Science

journal homepage: www.elsevier.com/locate/rvsc

ELSEVIER

Simultaneously prediction of sheep and goat carcass composition and body fat depots using *in vivo* ultrasound measurements and live weight

Luís G. Dias[a], Severiano R. Silva[b], Alfredo Teixeira[a,*]

[a] CIMO, Instituto Politécnico de Bragança, 5300-253, Portugal
[b] CECAV, Universidade de Trás-os-Montes e Alto Douro, 5001-801, Portugal

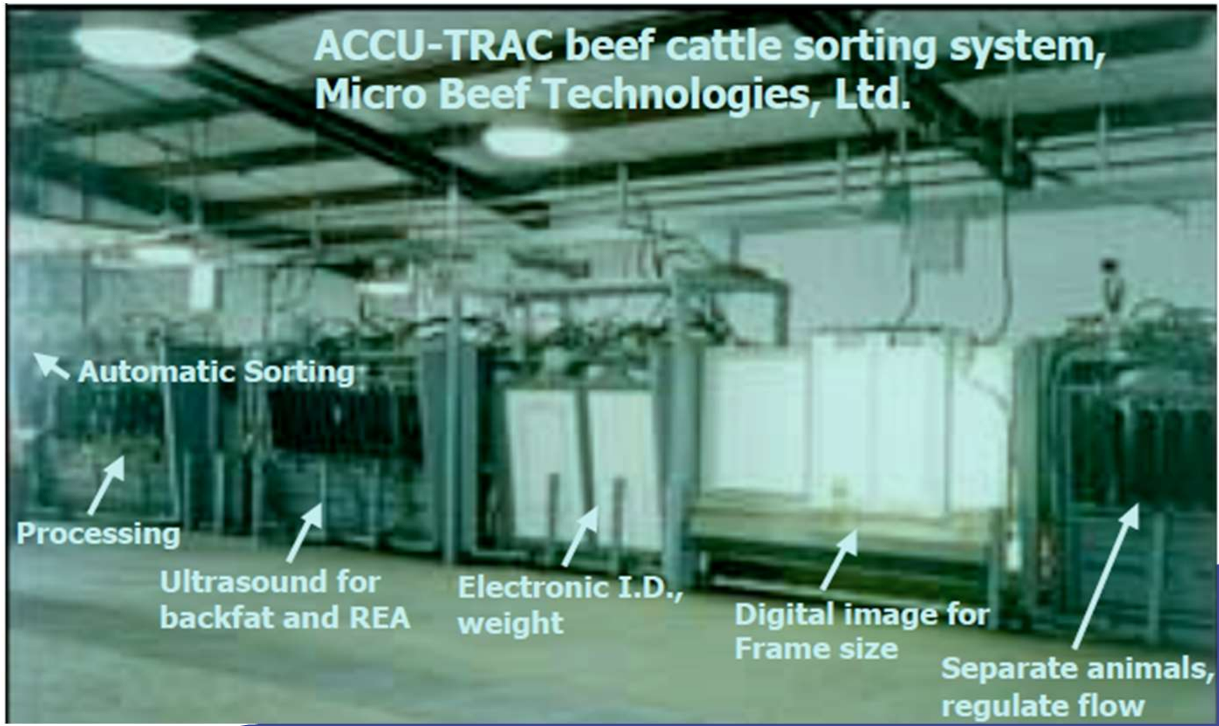
and validated by a test group. Overall, high accuracy (adj R^2) was obtained from the linear relationship between predicted and experimental values of the group test for each of the nine dependent variables, with values varying between adj R^2 0.88 and 0.98.

Joint ventures for ultrasound equipment and software development. The ultrasound market is global with multiple players. Human medicine is a giant business.

http://www.aloka.com/

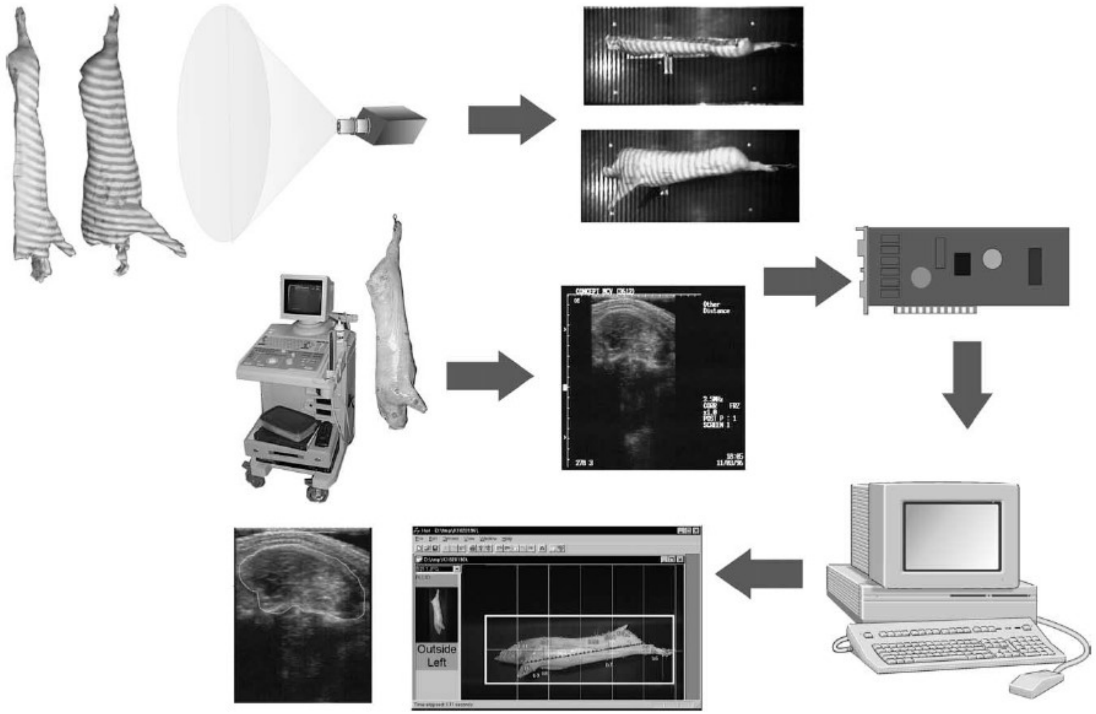
Versatile and more performant RTU equipment

Integration RTU with other systems to have a full information about animals



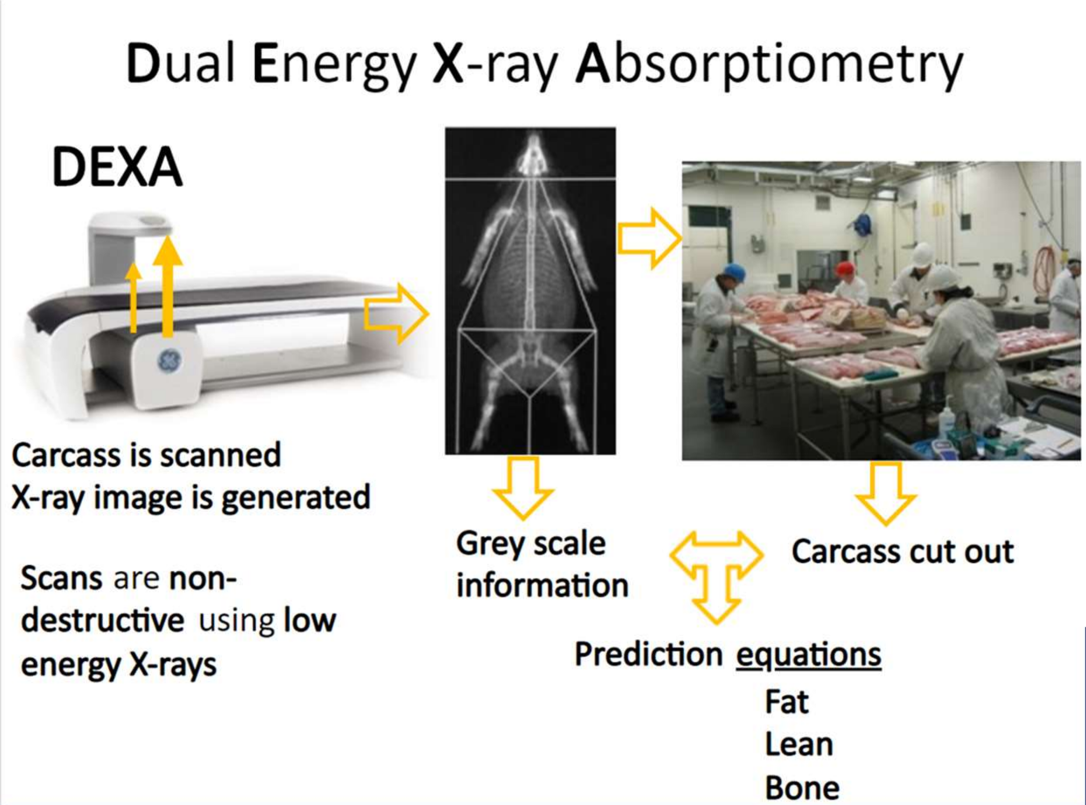
Paisley (2009)

Integration with other systems. RTU and VIA



Fortin et al. (2003)

Dual-radiation X-ray absorptiometry (DXA)



Dual-radiation X-ray absorptiometry (DXA)

Scholz et al. 2021

Dual-radiation X-ray absorptiometry (DXA)

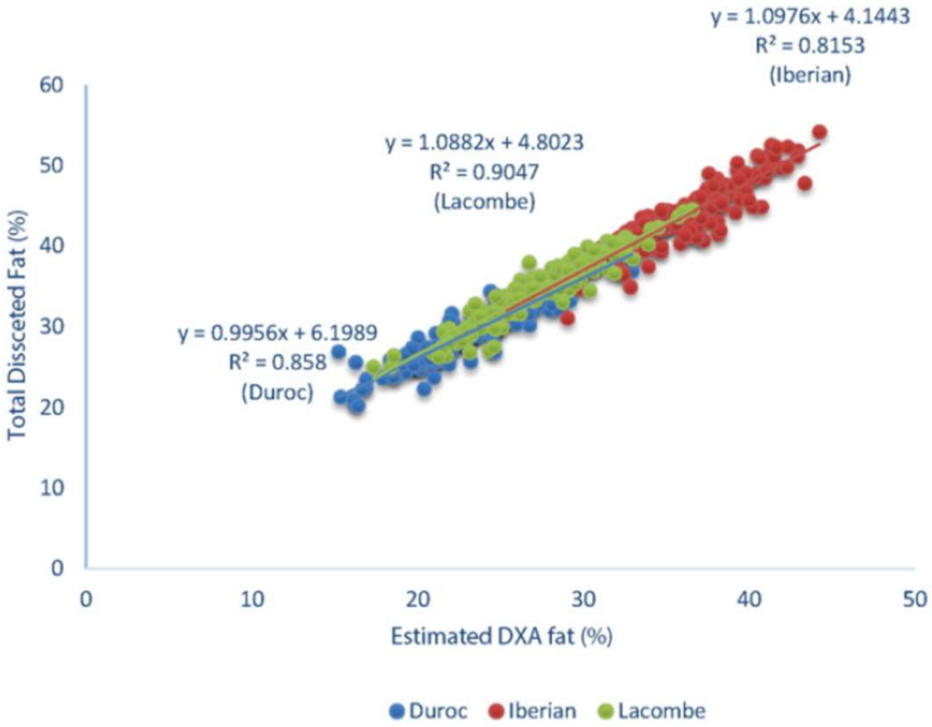


Fig. 1. Carcass side DXA fat data based on the three sire breeds.

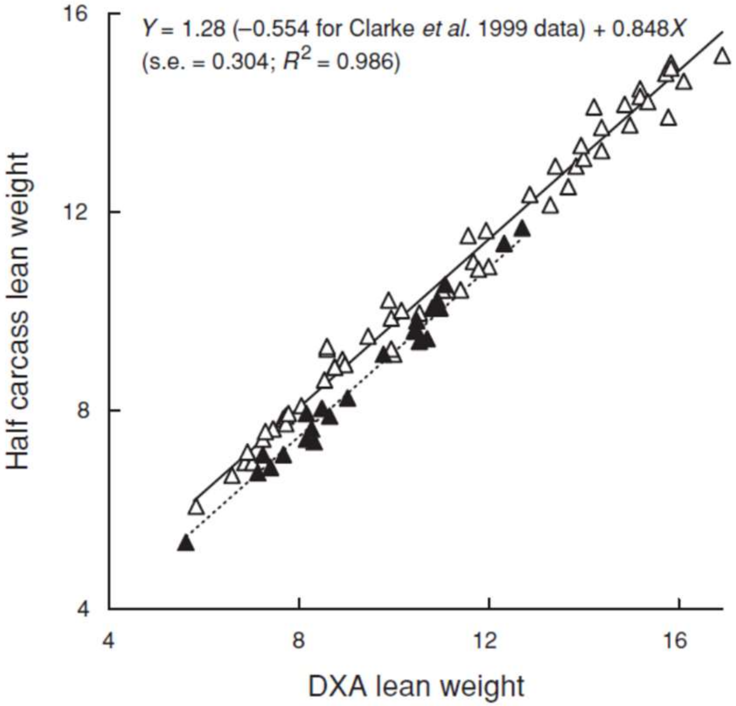
Soladoye et al.2016

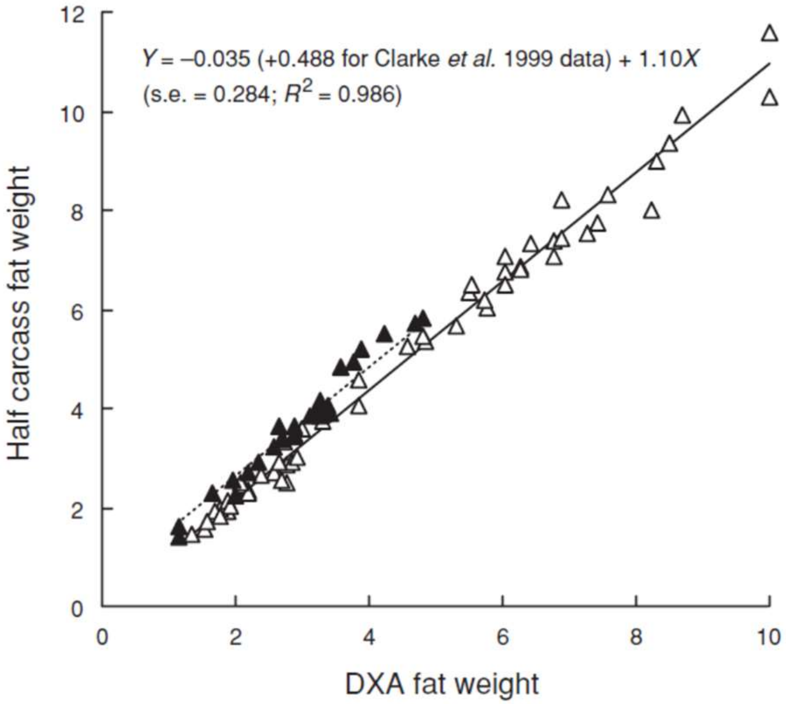
Dual-radiation X-ray absorptiometry (DXA)

Figure 1: DXA scanning of a lamb *in vivo* and of a lamb carcass

Scholz et al. 2010

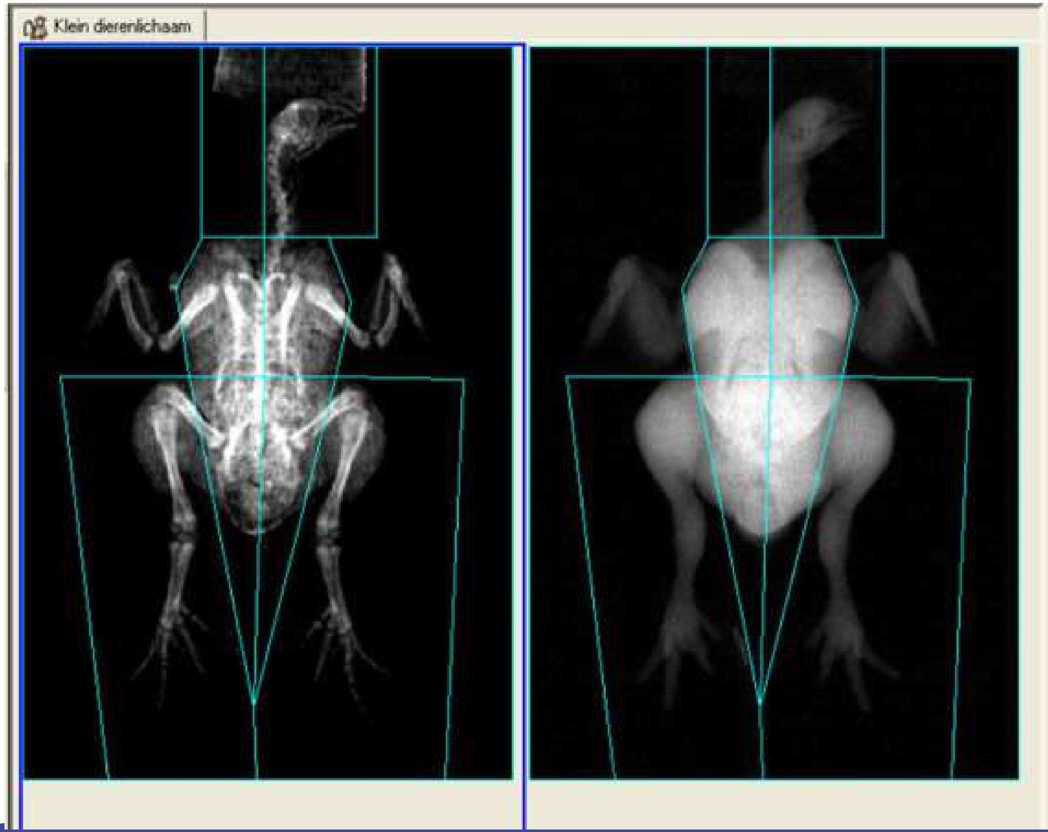
Dual-radiation X-ray absorptiometry (DXA)





Dunshea et al. 2007

Dual-radiation X-ray absorptiometry (DXA)



Schallier et al. 2019

Magnetic resonance imaging (MRI)

Fig. 20: Positioning of the large body coil to examine the thigh and gluteal region (the green arrow points to the back of the thigh and gluteal region

Bernau, 2011

Magnetic resonance imaging (MRI)

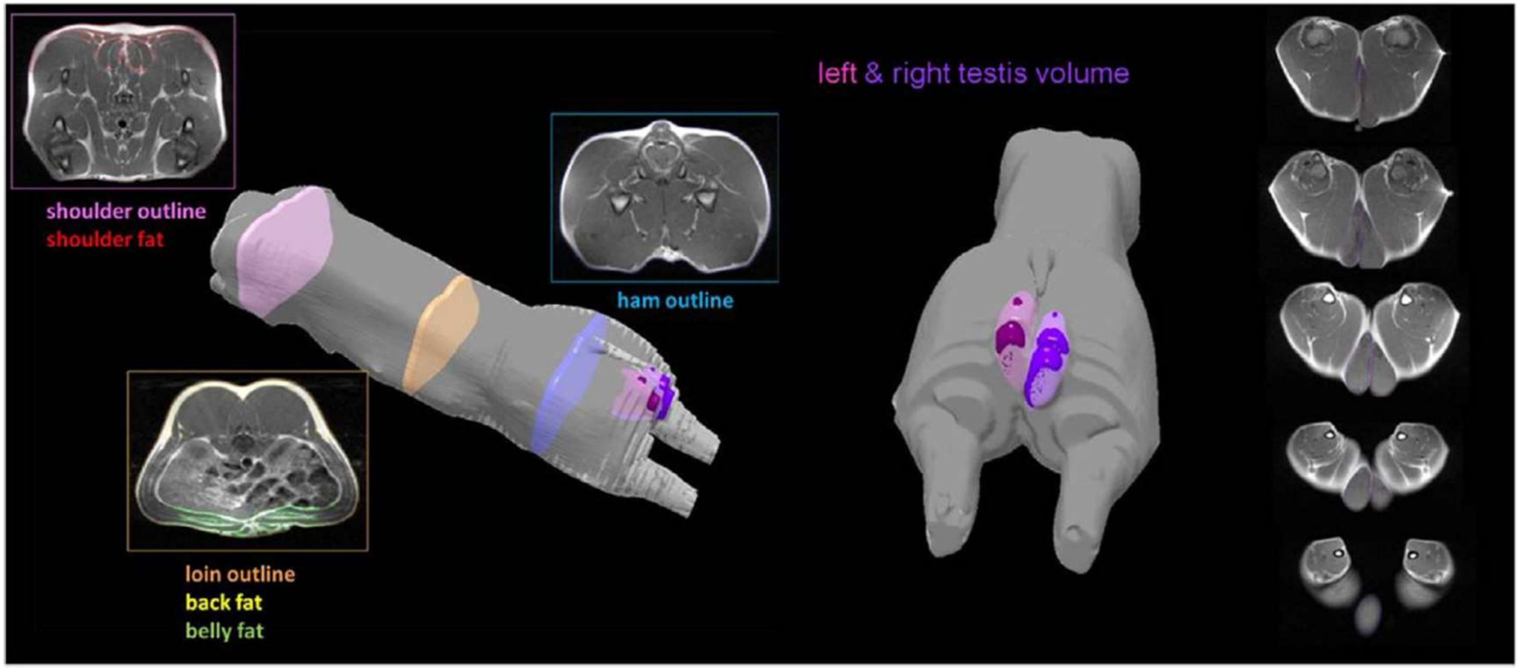


Fig. 1. 3D reconstruction of a pig examined without head, lower front and hind legs demonstrating the four body parts analyzed covering the body regions shoulder (shoulder outline, shoulder fat), "loin" (loin outline, back fat, belly fat), ham (ham outline) and testis (left & right).

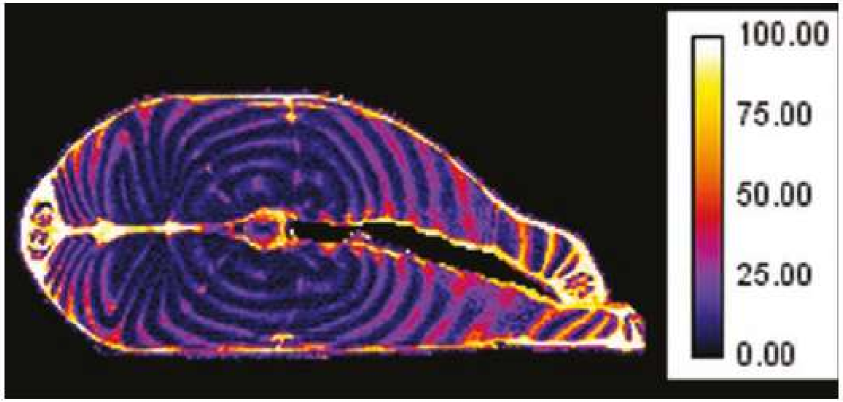
Bernau et al. 2018

Magnetic resonance imaging (MRI)

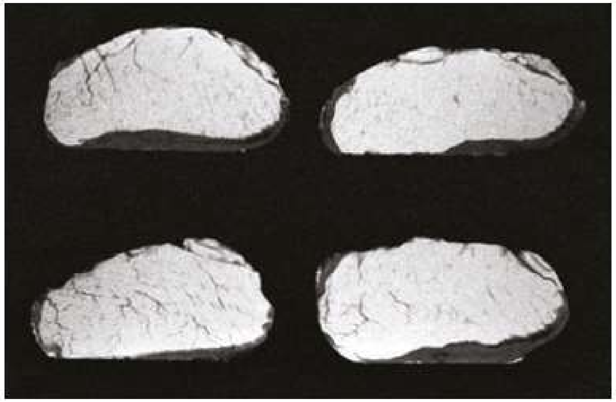
Scanning an anaesthetised live lamb

FAIM, 2015

Magnetic resonance imaging (MRI)



Map of fat content in fish



Quantification of intramuscular fat in pork loins

FAIM, 2015

Magnetic resonance imaging (MRI)

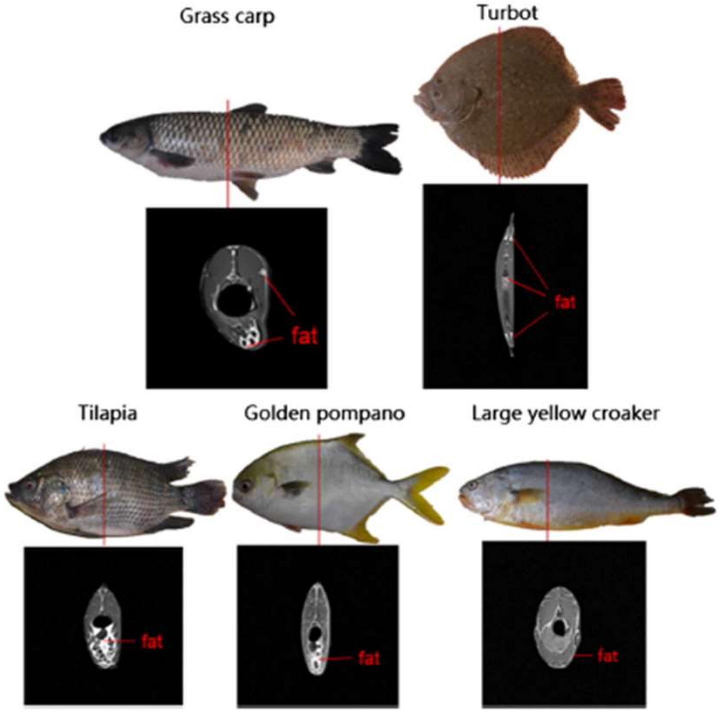
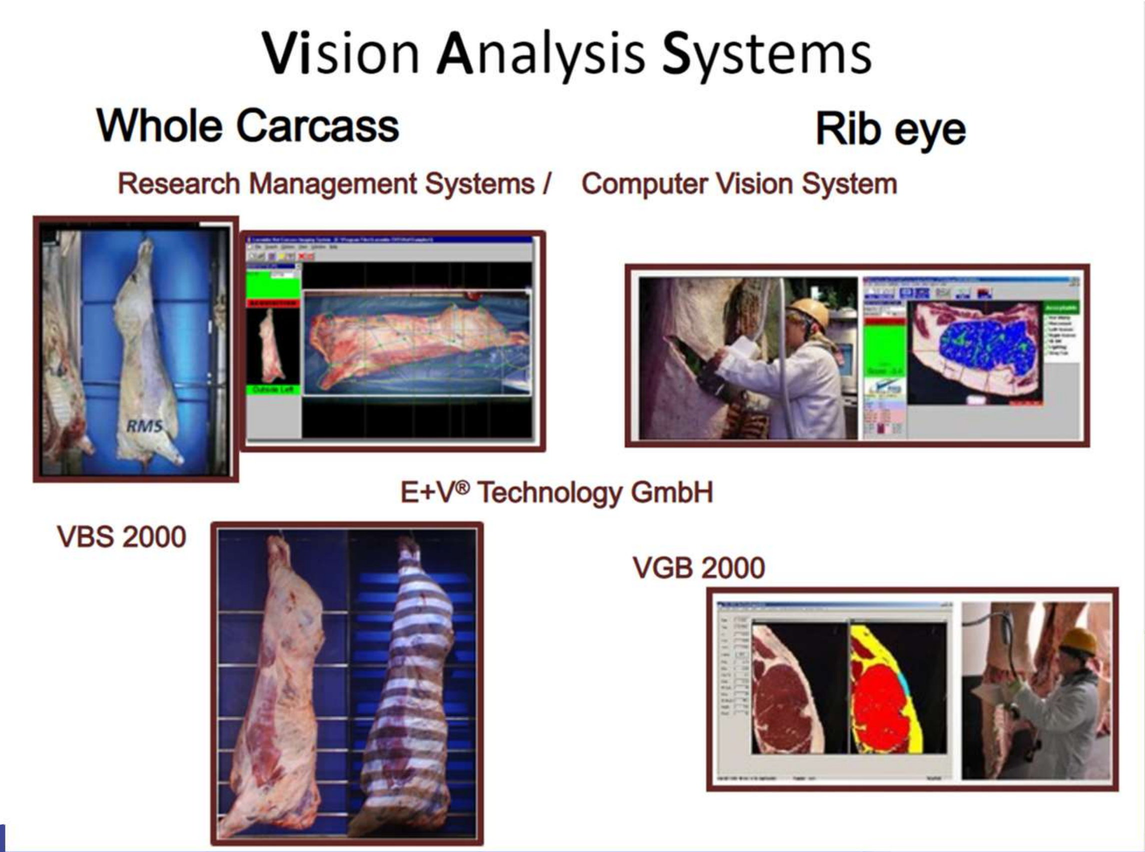


Fig. 6. The photos and transverse MRI slices of five fish species showing the differences of the distribution of adipose tissues between fishes. The red line indicates the anatomic position of the slices. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Lu, 2015

video image analysis (VIA) and computer vision systems (CVS)



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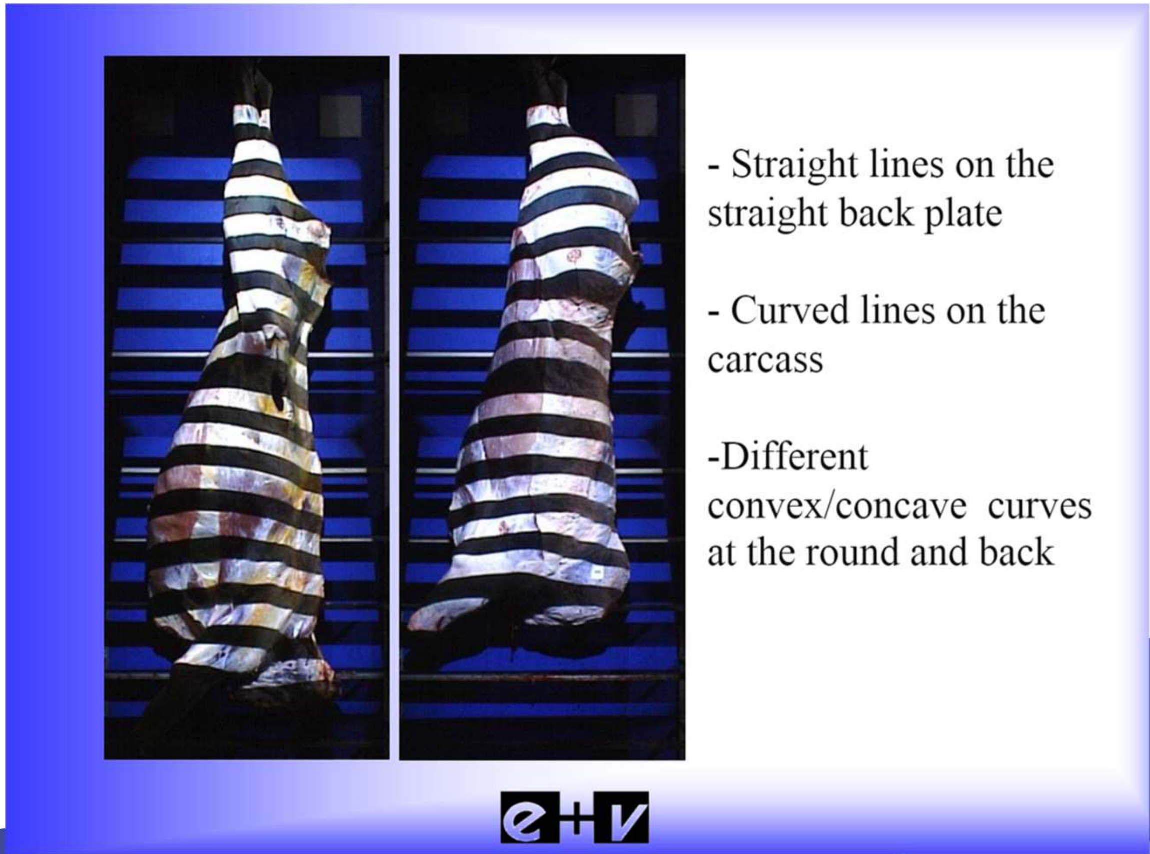
video image analysis (VIA) and computer vision systems (CVS)

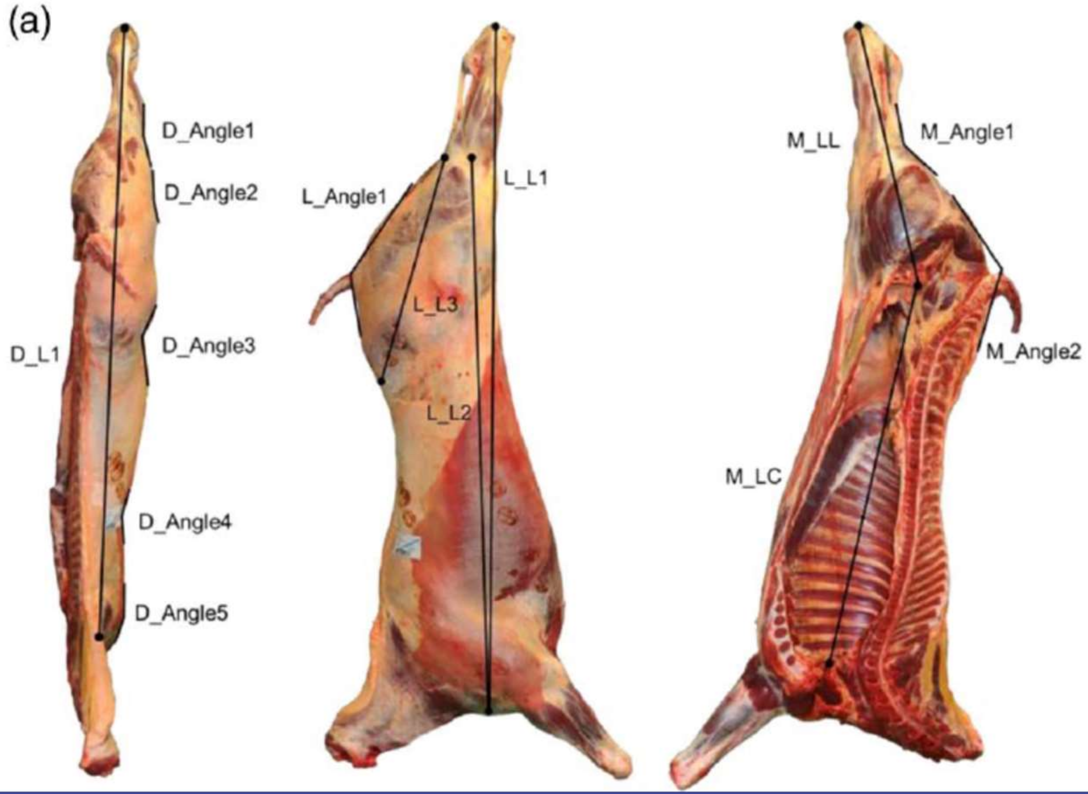


E+V Technology

video image analysis (VIA) and computer vision systems (CVS)

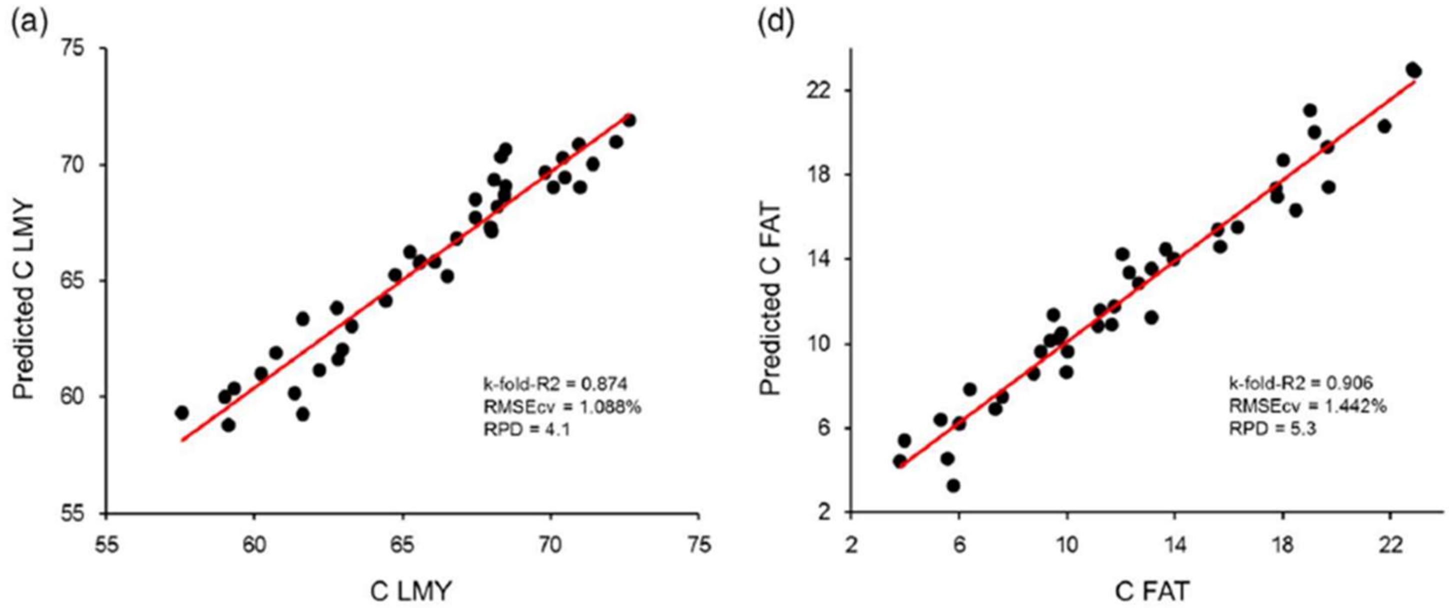
E+V Technology

video image analysis (VIA) and computer vision systems (CVS)



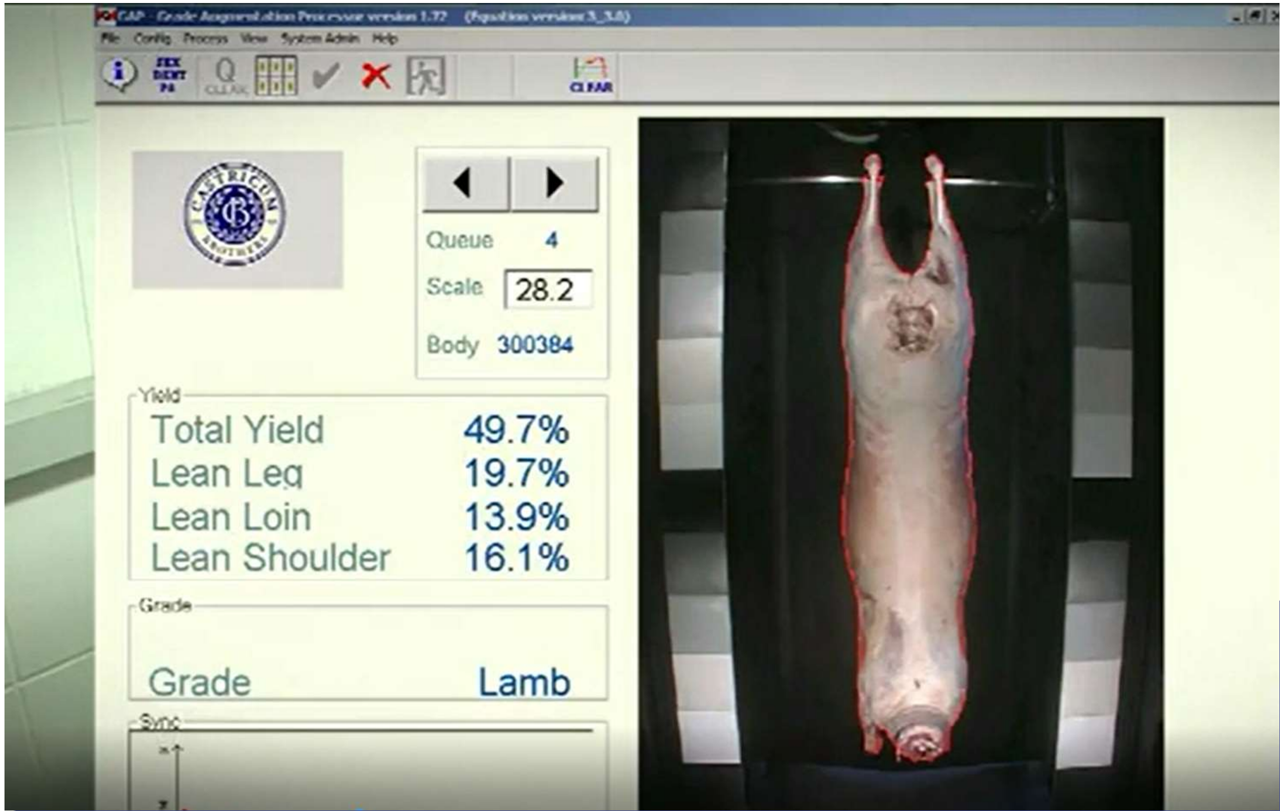
Lorenzo et al 2017

video image analysis (VIA) and computer vision systems (CVS)



Lorenzo et al 2017

video image analysis (VIA) and computer vision systems (CVS)



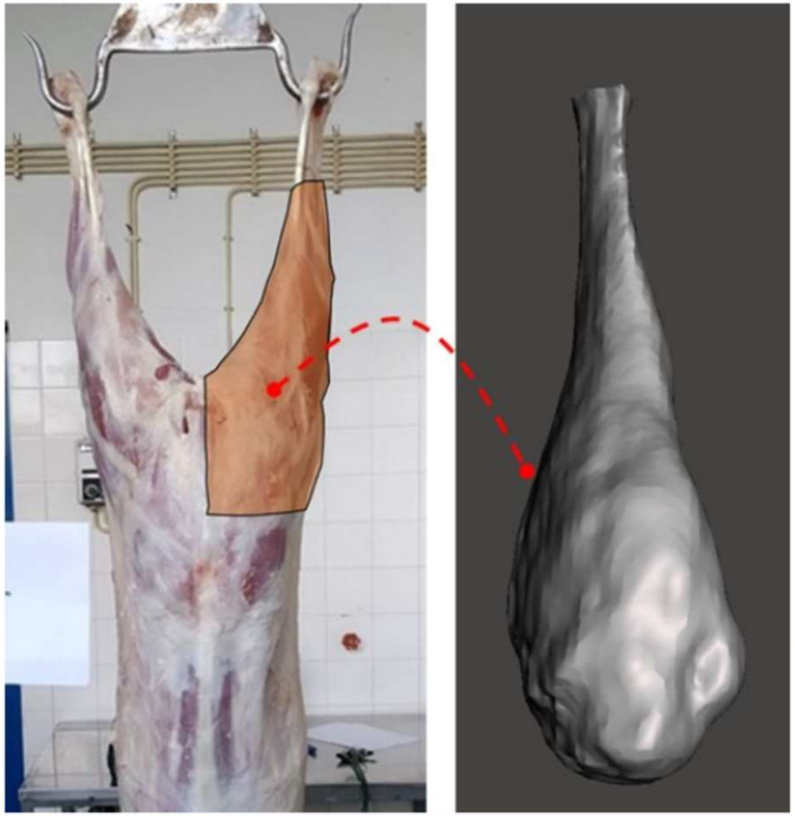
ViaScan

Material & Methods

3D image obtained by the Kinect sensor

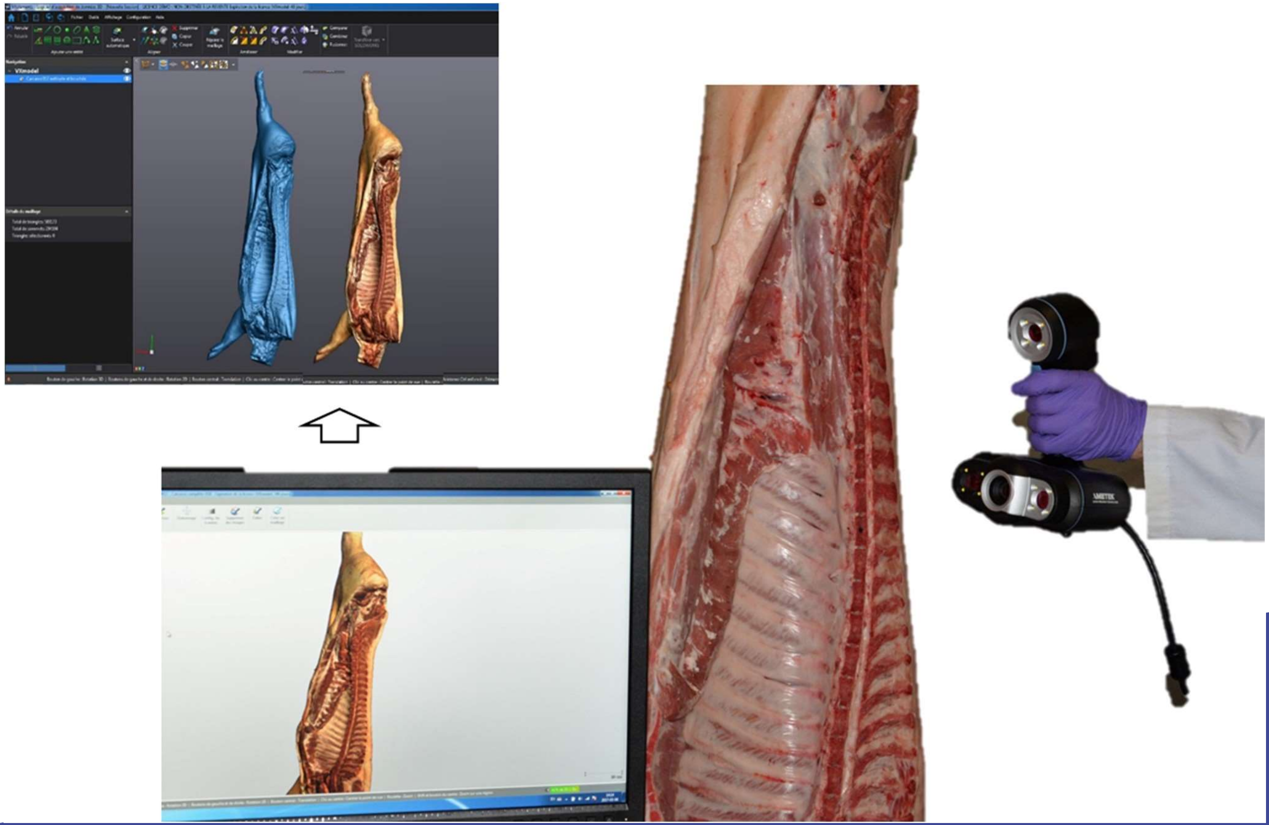
The volume of the leg was calculated from the 3D image

video image analysis (VIA) and computer vision systems (CVS)



Silva et al. 2022

video image analysis (VIA) and computer vision systems (CVS)



Leighton et al. 2022

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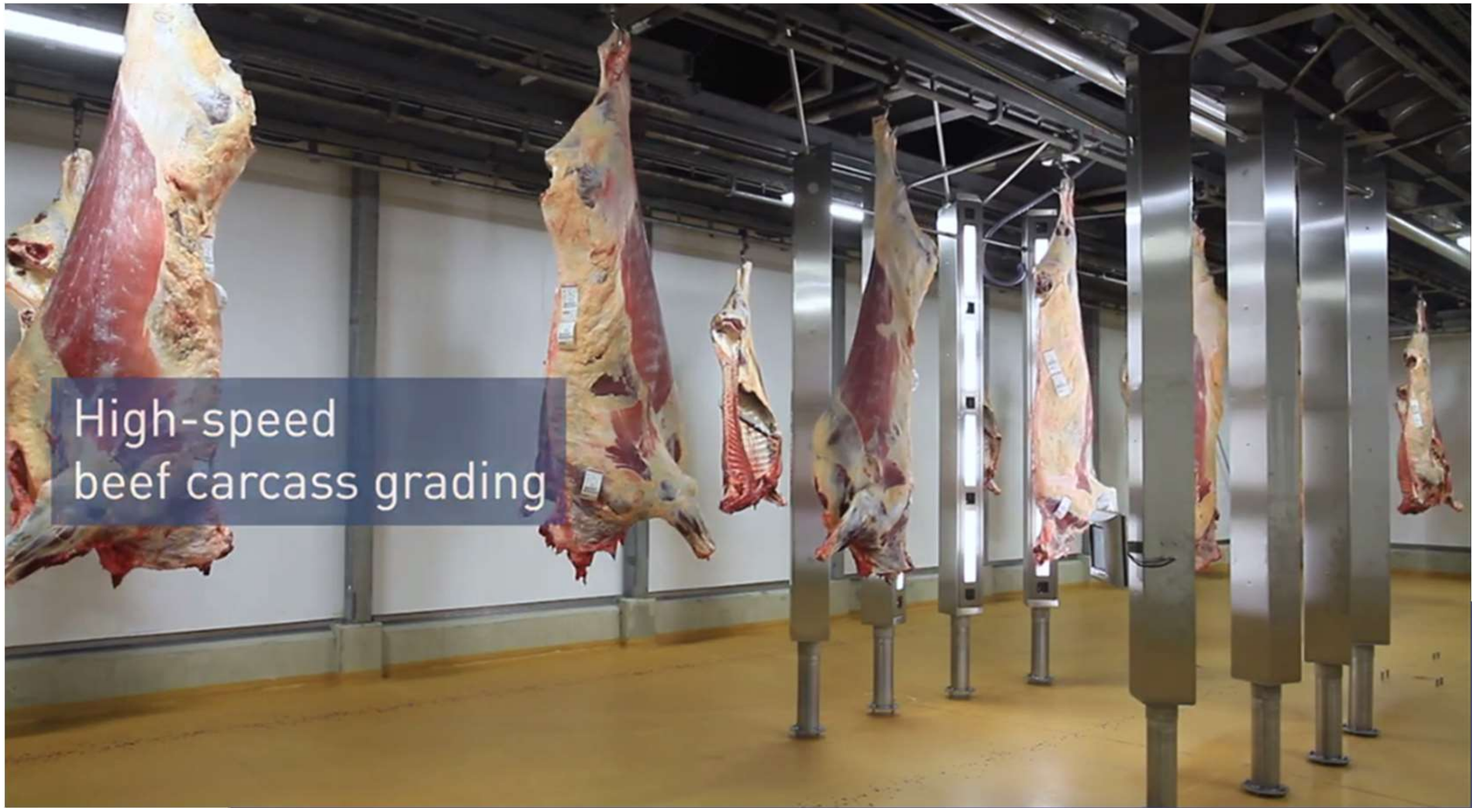
video image analysis (VIA) and computer vision systems (CVS)

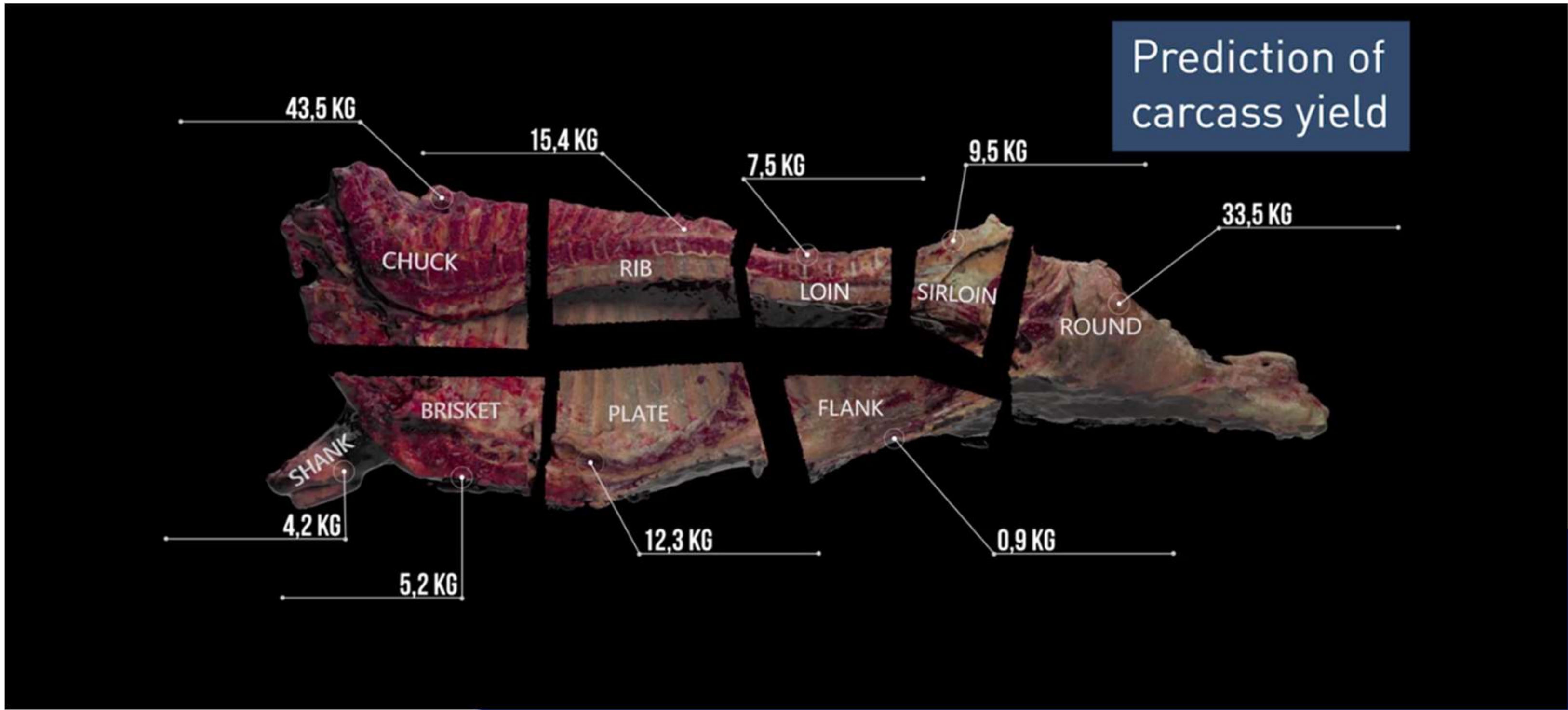


Frontmatec Beef Solutions | Beef Classification Center, BCC-3™

video image analysis (VIA) and computer vision systems (CVS)

Frontmatec Beef Solutions | Beef Classification Center, BCC-3™

video image analysis (VIA) and computer vision systems (CVS)



Frontmatec Beef Solutions | Beef Classification Center, BCC-3™

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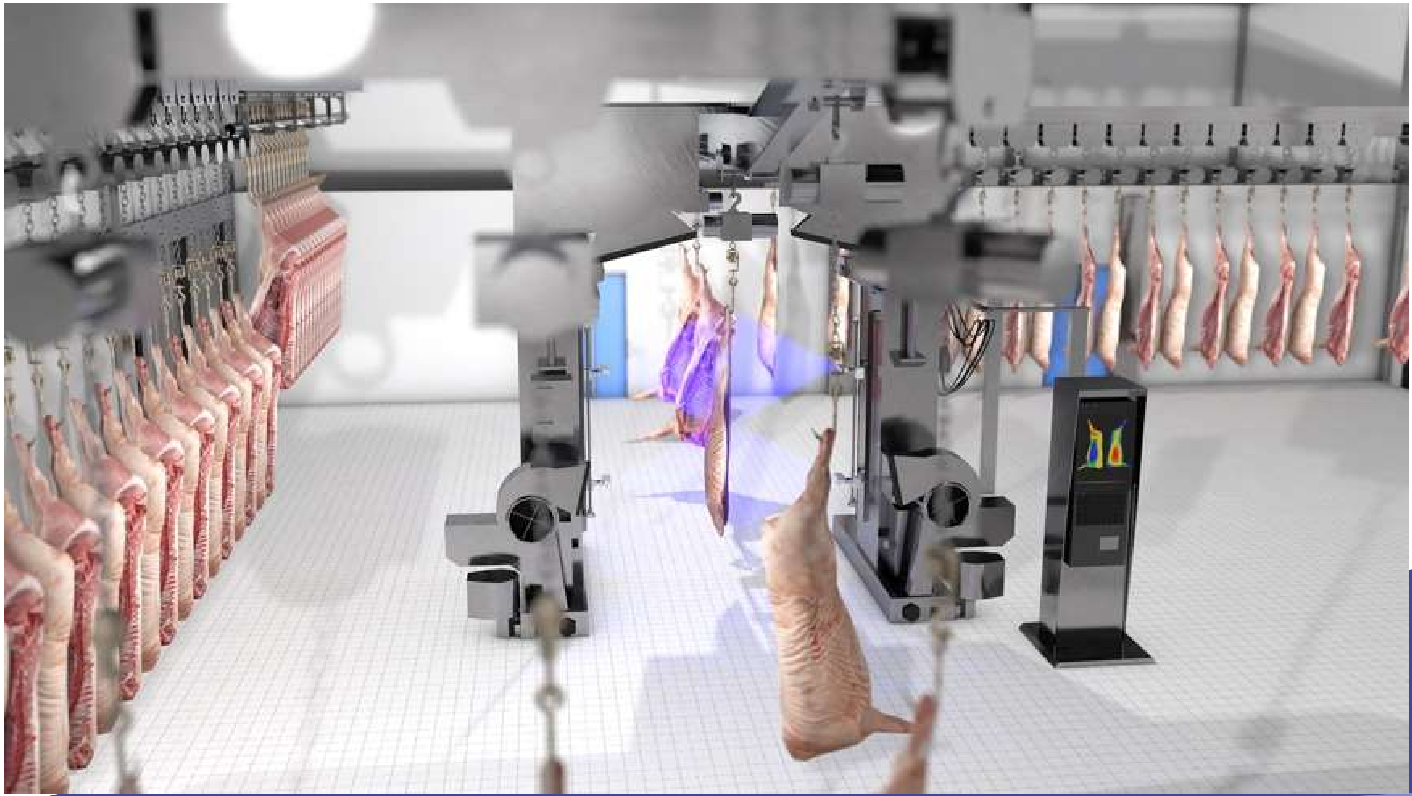
video image analysis (VIA) and computer vision systems (CVS)



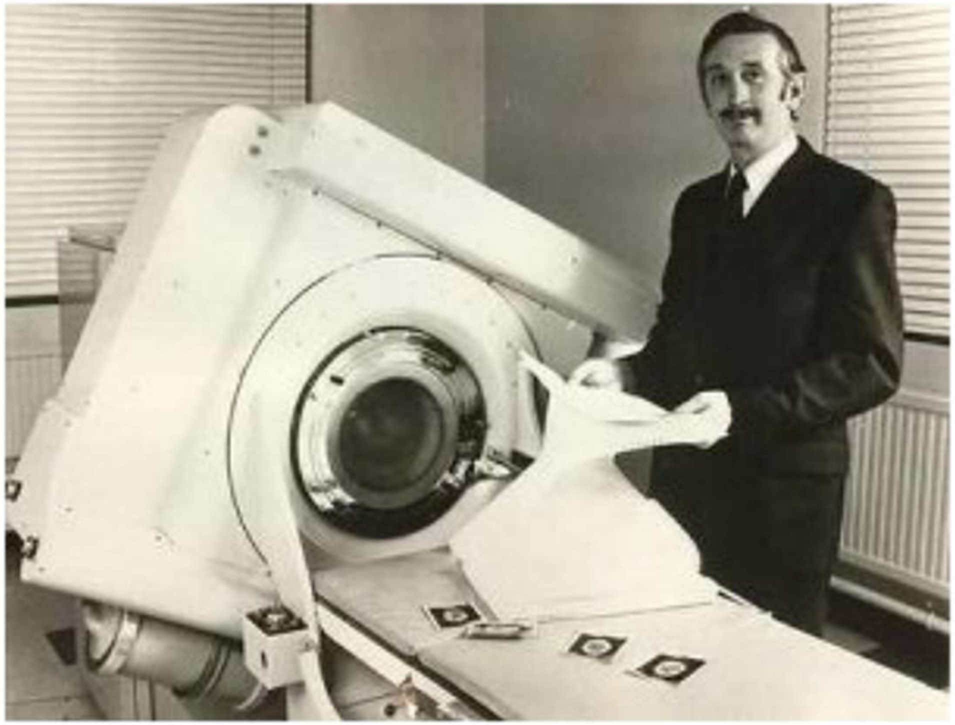
https://www.wenglor.com/en/Measurement-of-Half-Carcases-of-Pigs-Using-2D3D-Profile-Sensors/a/114

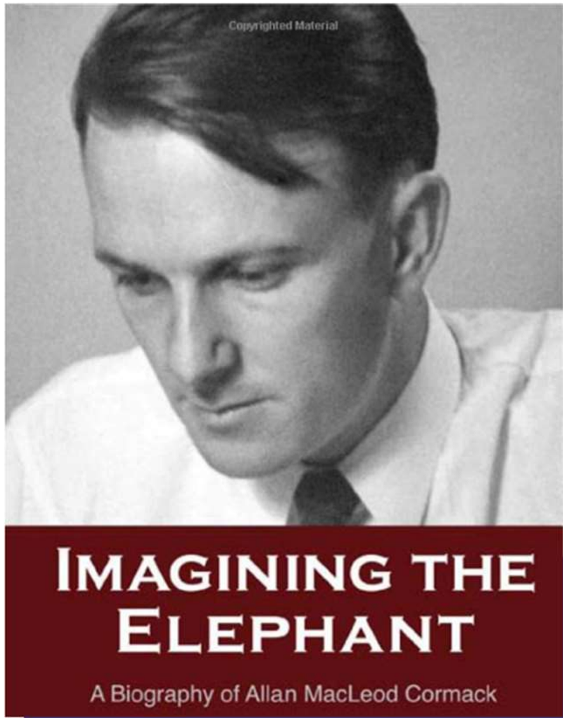
Computed tomography (CT)

How the Beatles funded the CT scan

Money from the Beatles' success convinced EMI to let one of its engineers pursue independent research. He ended up winning the Nobel prize for medicine.

Computed tomography (CT)





The Nobel Prize in Physiology or Medicine 1979
Allan M. Cormack, Godfrey N. Hounsfield

The Nobel Prize in Physiology or Medicine 1979

Allan M. Cormack
Prize share: 1/2

Godfrey N. Hounsfield
Prize share: 1/2

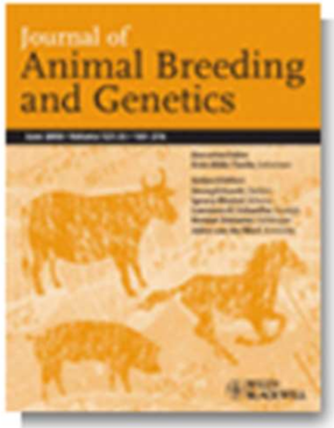
The Nobel Prize in Physiology or Medicine 1979 was awarded jointly to Allan M. Cormack and Godfrey N. Hounsfield *"for the development of computer assisted tomography"*

Computed tomography (CT)

In vivo estimation of body composition by computerized tomography

H. Skjervold[†], K. Grønseth[‡], O. Vangen[†], A. Evensen[‡]

Issue



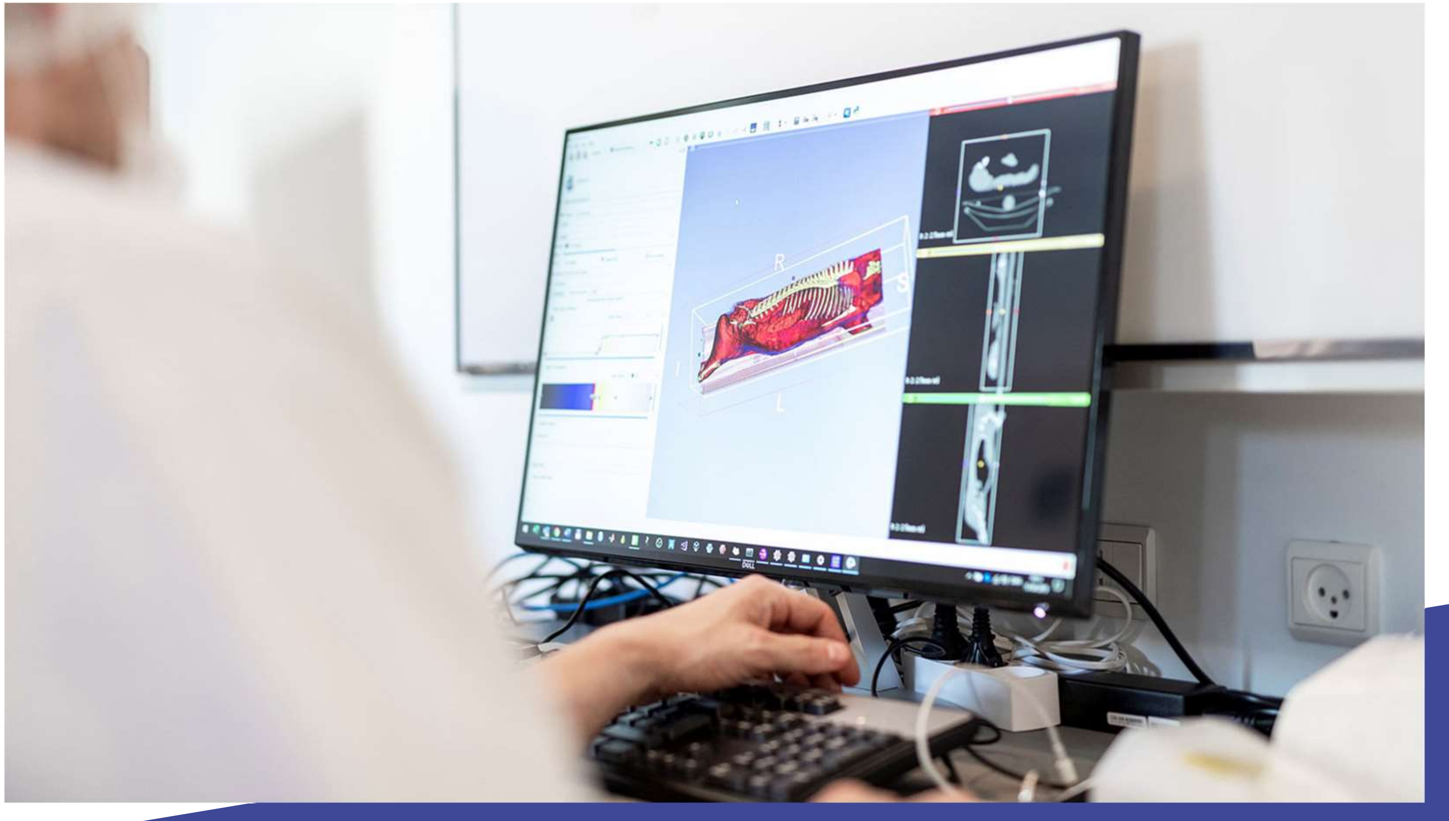
Zeitschrift für Tierzüchtung und Züchtungsbiologie

Volume 98, Issue 1-4, pages 77–79, January-December 1981

Computed tomography (CT)

Topigs Norsvin CT scan

Computed tomography (CT)



Danish Genetics

Computed tomography (CT)

SRUC

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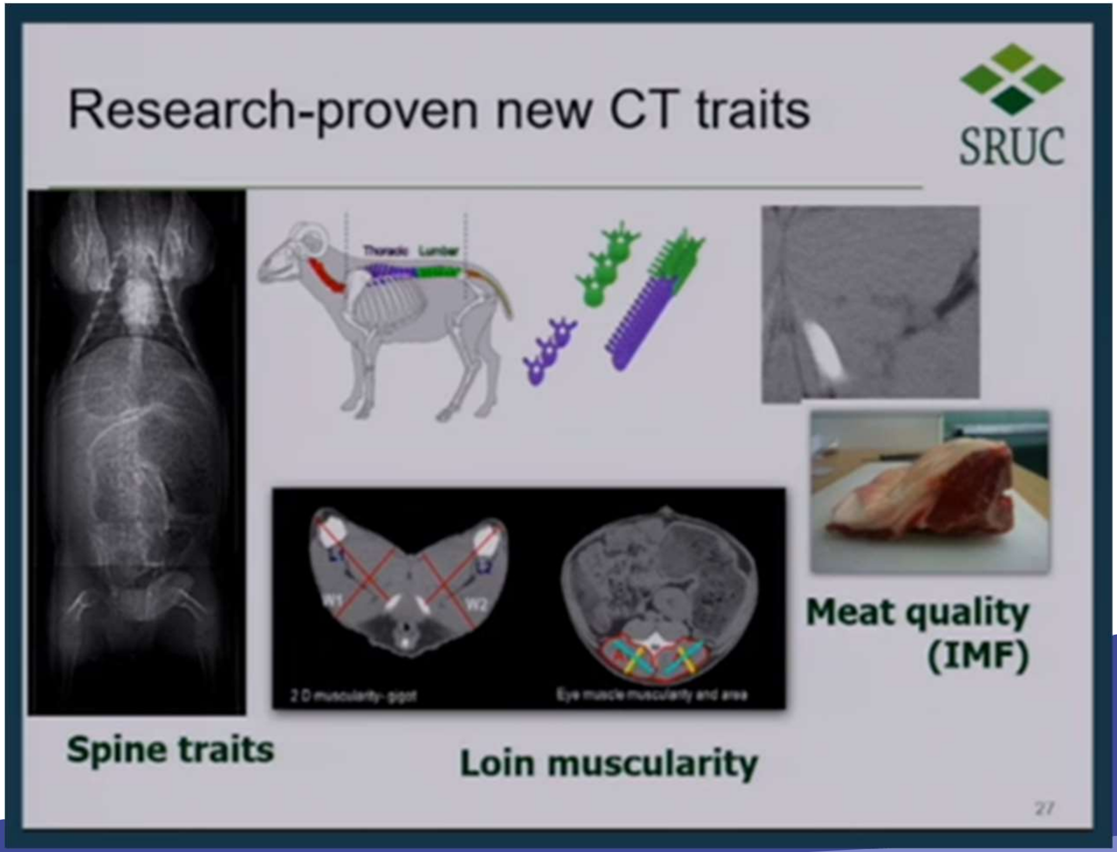
Integrating computed tomography into commercial sheep breeding in the UK: cost and value

L. Bunger[1], N. Clelland[1], K. Moore[1], K. McLean[1], J. Kongsro[2], N. Lambe[1]

Computed tomography (CT)



Lambe 2015

WORKSHOP
CARACTERÍSTICAS DA CARNE E DO LEITE DE CAPRINOS EM FUNÇÃO DO SISTEMA DE PRODUÇÃO
14 a 17 de junho de 2021, 18h-20h

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Methods 186 (2021) 68–78

Contents lists available at ScienceDirect

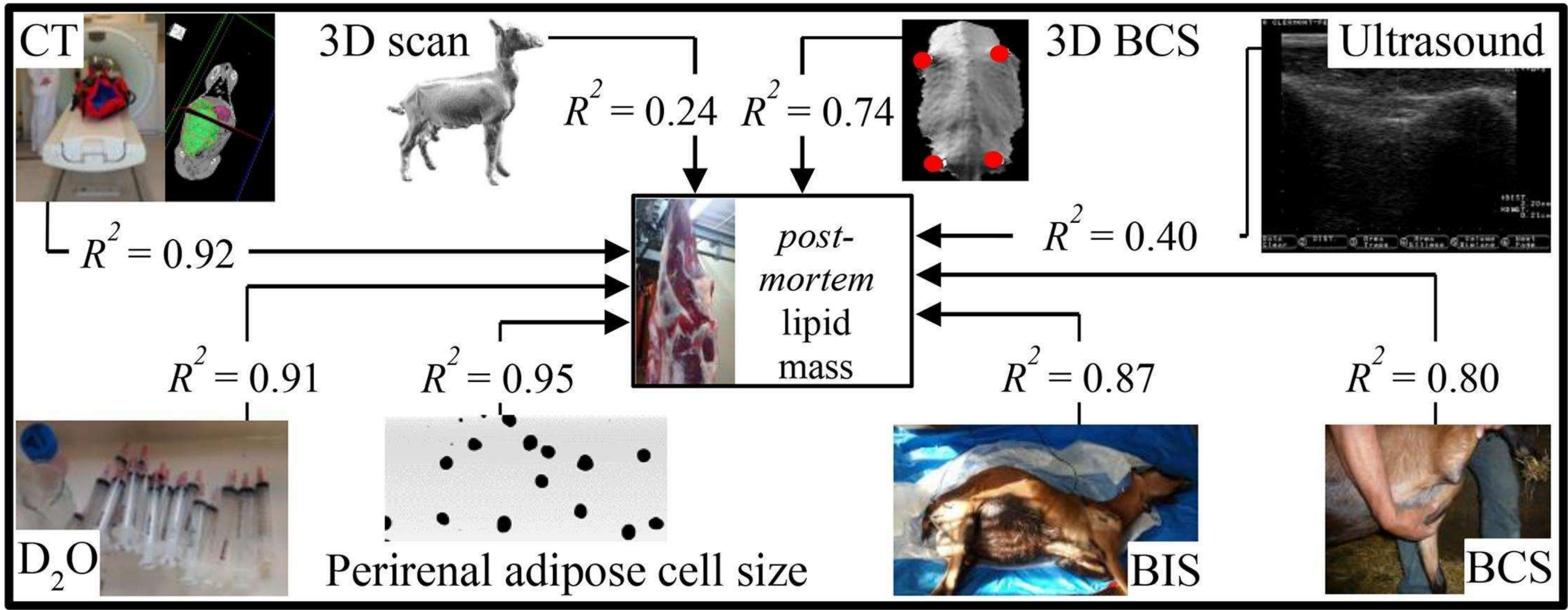
Methods

journal homepage: www.elsevier.com/locate/ymeth

Estimation of dairy goat body composition: A direct calibration and comparison of eight methods☆

Sylvain Lerch[a,*], Anne De La Torre[b], Christophe Huau[c], Mathieu Monziols[d], Caroline Xavier[a,e], Loïc Louis[f], Yannick Le Cozler[e], Philippe Faverdin[e], Philippe Lamberton[e], Isabelle Chery[g], Dominique Heimo[h], Christelle Loncke[i], Philippe Schmidely[i], José A.A. Pires[b,*]

[a] Agroscope, Ruminant Research Unit, Route de la Tioleyre 4, 1725 Posieux, Switzerland
[b] INRAE, Université Clermont Auvergne, Vetagro Sup, UMR Herbivores, 63122 Saint-Genès-Champanelle, France
[c] GenPhySE, Université de Toulouse, INRAE, ENVT, 31326 Castanet-Tolosan, France
[d] IFIP Institut du porc, 35650 Le Rheu, France
[e] PEGASE, INRAE, Institut Agro, 35590 Saint Gilles, France
[f] Université de Lorraine, AgroParisTech, INRAE, SILVA, 54000 Nancy, France
[g] IPHC, CNRS, Université de Strasbourg, 67037 Strasbourg, France
[h] Agroscope, Feed Chemistry Unit, Route de la Tioleyre 4, 1725 Posieux, Switzerland
[i] Université Paris-Saclay, INRAE, AgroParisTech, UMR Modélisation Systémique Appliquée aux Ruminants, 75005 Paris, France


CT
3D scan
3D BCS
Ultrasound
$R^2 = 0.24$
$R^2 = 0.74$
$R^2 = 0.92$
$R^2 = 0.40$
post-mortem lipid mass
$R^2 = 0.91$
$R^2 = 0.95$
$R^2 = 0.87$
$R^2 = 0.80$
D_2O
Perirenal adipose cell size
BIS
BCS

https://interspectral.com/3d-content-library/

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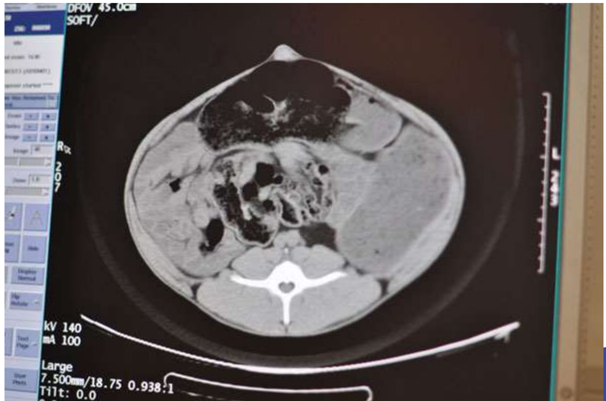
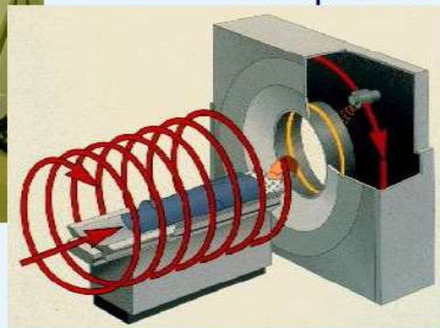
CT Scanning Sequence



New CT scanner at SAC (May 2002)

One slice scanner - but fit for spiral CT scanning



Captures entire anatomic regions as a continuous volume of contiguous slices

→ "Era" of 3D - CT started (volumes instead of areas)

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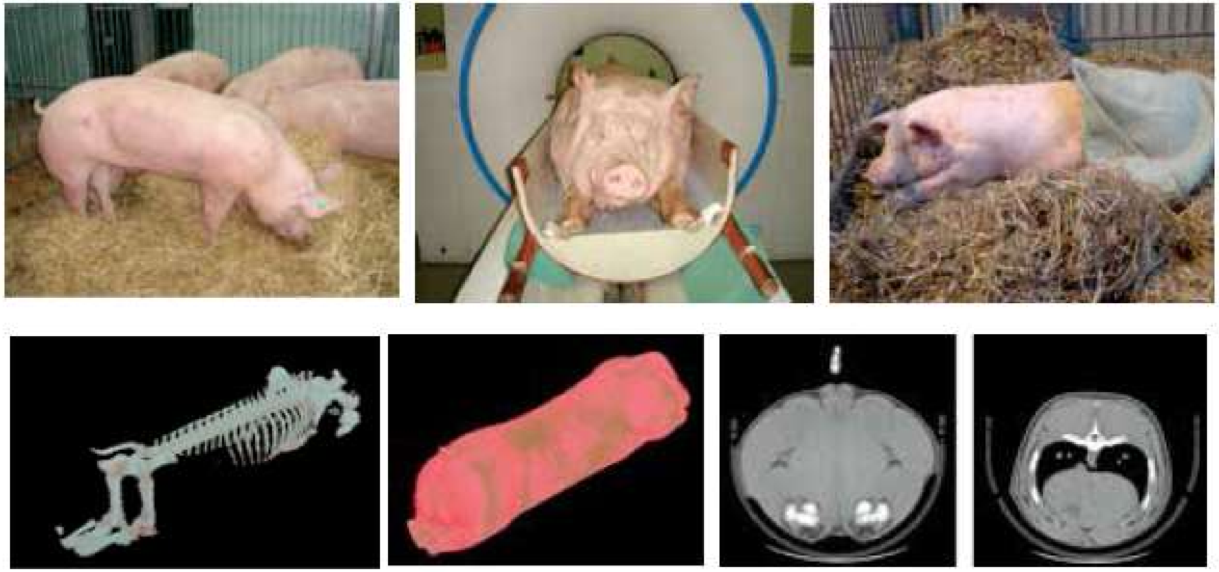
Use of computed tomography (CT) in a longitudinal body composition study in pigs fed different diets

N. Lambe[1], J.D. Wood[2], K.A. McLean[1], G.A. Walling[3], H. Whitney[4], S. Jagger[5], P. Fullarton[6], G. Cesaro[7], C.A. Maltin[8], J. Bayntun[2] , C.A. Glasbey[9] and L. Bünger[1]

Figure 1. Application of CT scanning in pigs (experimental pigs before scanning; the CT scanner at SRUC (Siemens, SOMATOM Esprit); anaesthetized pig in CT scanner, examples for cross sectional images of which for example from this pig 155 were taken; 3D reconstruction of the carcass relevant parts of the pig using all 155 images, changing the threshold makes the skeleton visible, the pig wakening up from anaesthesia).



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Usage of Computed Tomography in the selection of two Hungarian rabbit breeds

Zs. Matics, Zs. Szendrő, I. Nagy, Zs. Gerencsér, T. Donkó

Figure 1. CT examination of rabbits for selection.

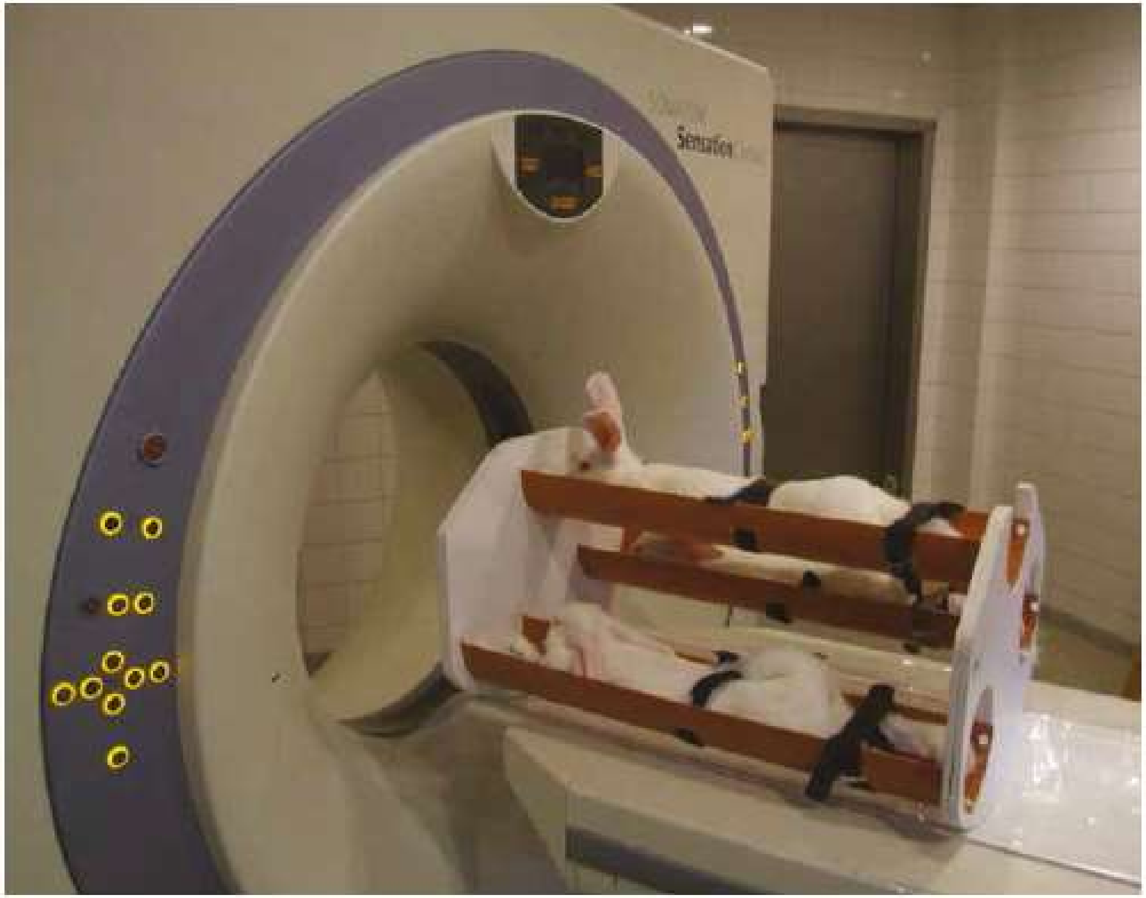
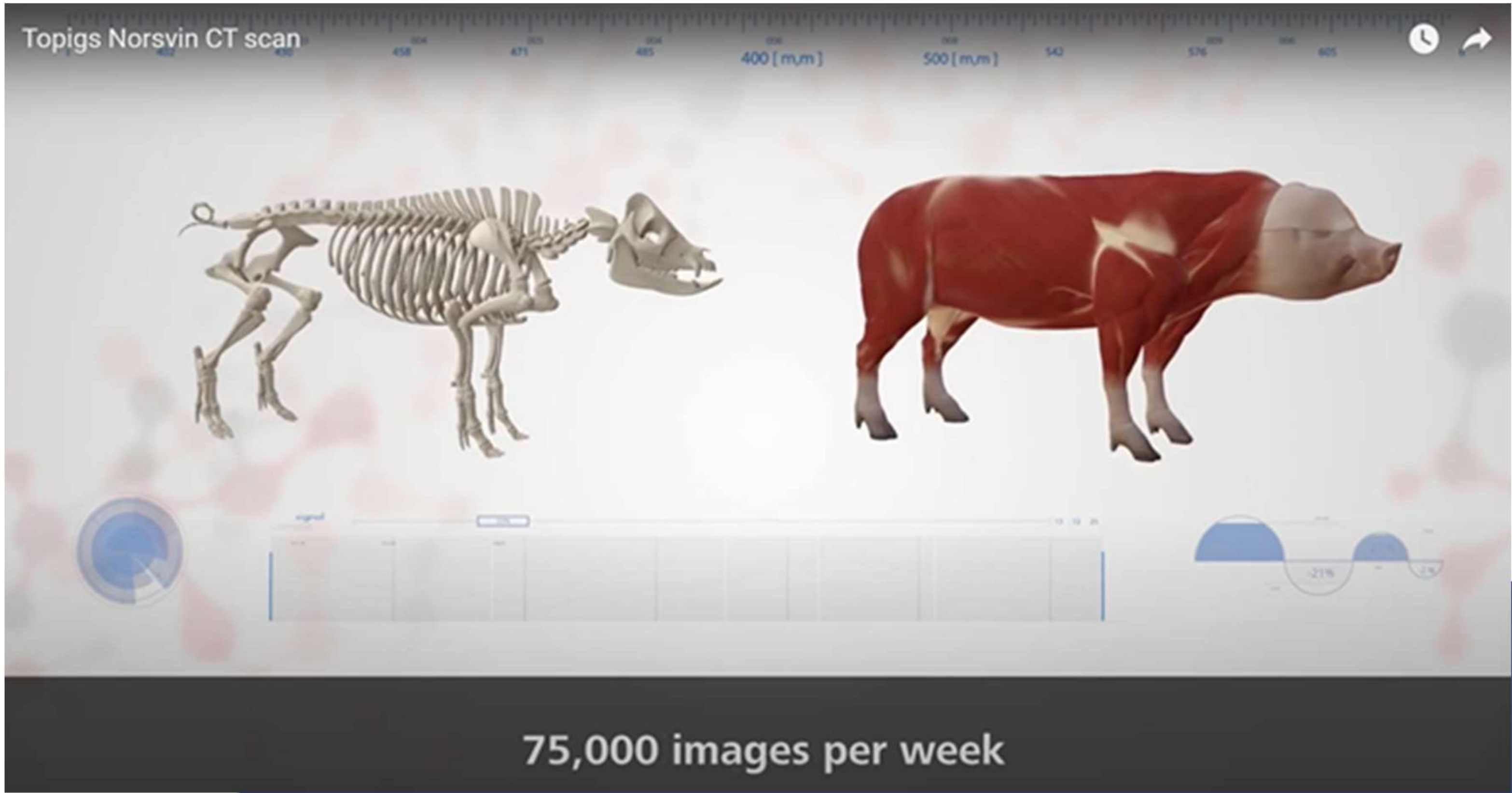

Sensation

Figure 1. Multi-object CT scanning (e.g. Clelland *et al.* 2013; here Tilapia at SRUC's CT unit; collaboration with Stirling University, Khalfan Mohamed Abdullah Al-Rashdi).

Computed tomography (CT)



Topigs Norsvin CT scan

Computed tomography (CT)

FRANCE

MOBILE CT SCANNERS

IFIP – Institut du porc

Mathieu Monziols +33 2 99 60 98 47
mathieu.monziols@ifip.asso.fr

La Motte au Vicomte
BP 35104
35651 Le Rheu Cedex
France

IFIP facilities at Romillé

CT within a trailer

FAIM, 2015

Computed tomography (CT)

Fixed CT scanners

France
Germany
Greece
Hungary
Norway
Portugal
Spain
United Kingdom

PORTUGAL

FIXED CT SCANNERS

Universidade de Trás-os-Montes e Alto Douro - UTAD

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CT GE Brivo 325 scanning a shoulder cut

Scanning a kid carcass

Monitor receiving images of the shoulder cut

Device: CT scanner GE Brivo 325
Year of manufacture: 2014
Characteristics of device: 2 slice CT scanner.
Max volume scanned: 0.5 x 0.5 x 1.5 m

Main applications for which it is used in the institution:
In vivo body composition, carcass composition and meat quality: pig, sheep, goat and poultry
Diagnostic use for veterinary medicine

FAIM, 2015

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Comparison of density and volume measurements from a range of different Computed Tomography scanners across Europe

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5. CECAV, Universidade de Trás-os-Montes e Alto Douro – UTAD, Vila Real, Portugal
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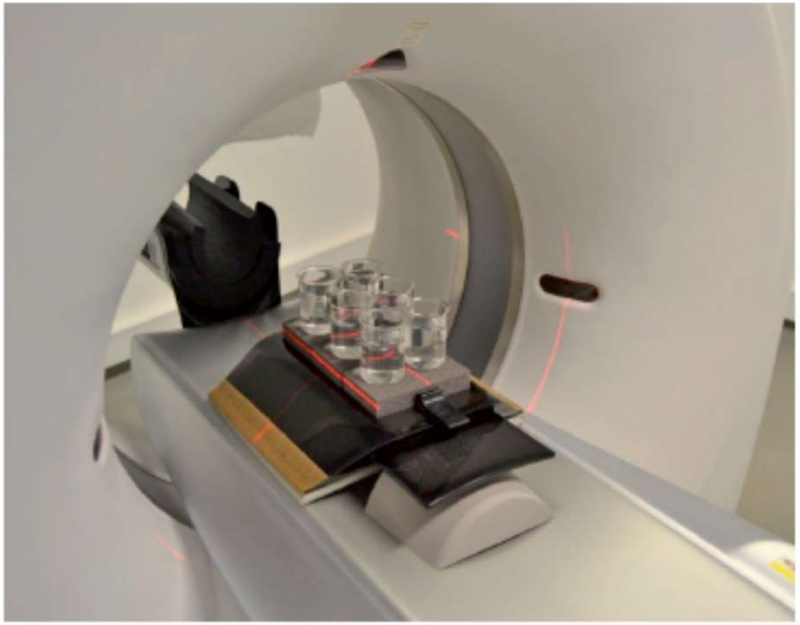


Figure 1. Dilutions samples scanned in UTAD institute (Portugal)

Figure 2. Water bottle scanned in IRTA institute (Spain).

Potassium dihydrogen phosphate KH_2PO_4 dilutions

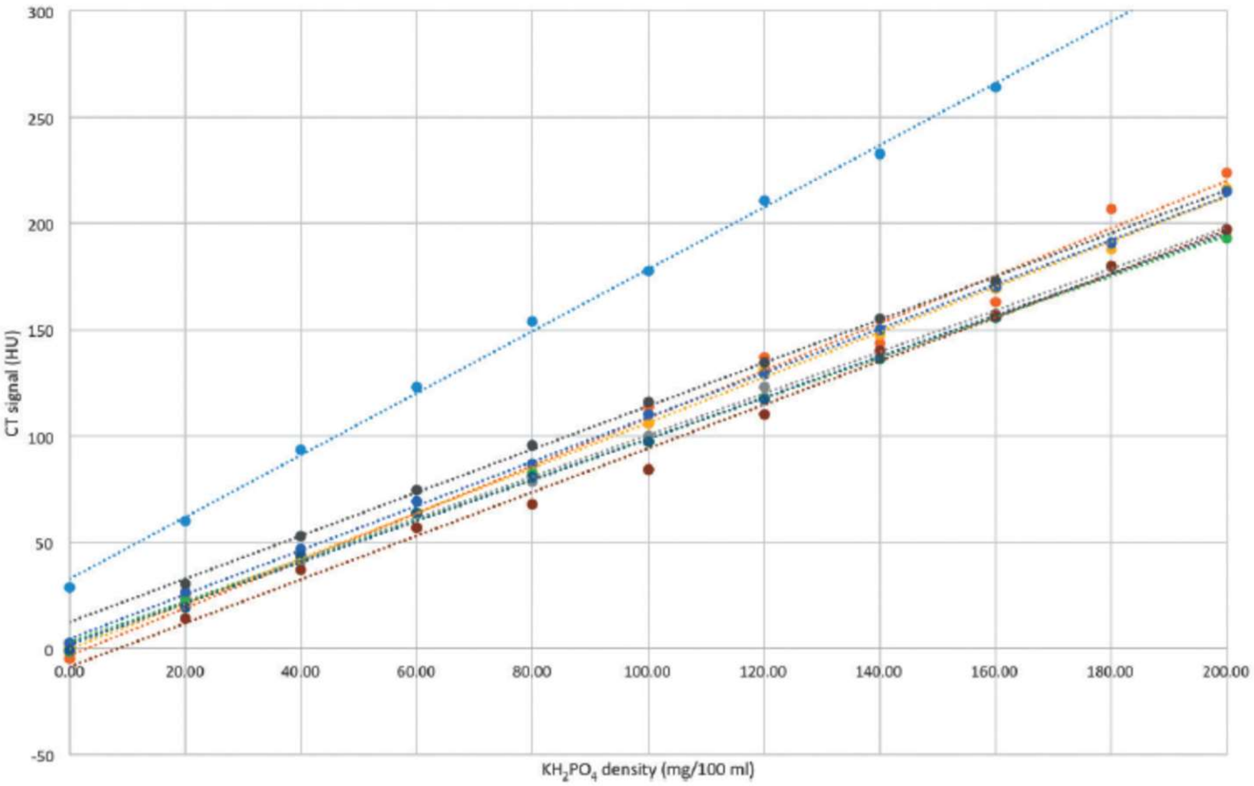
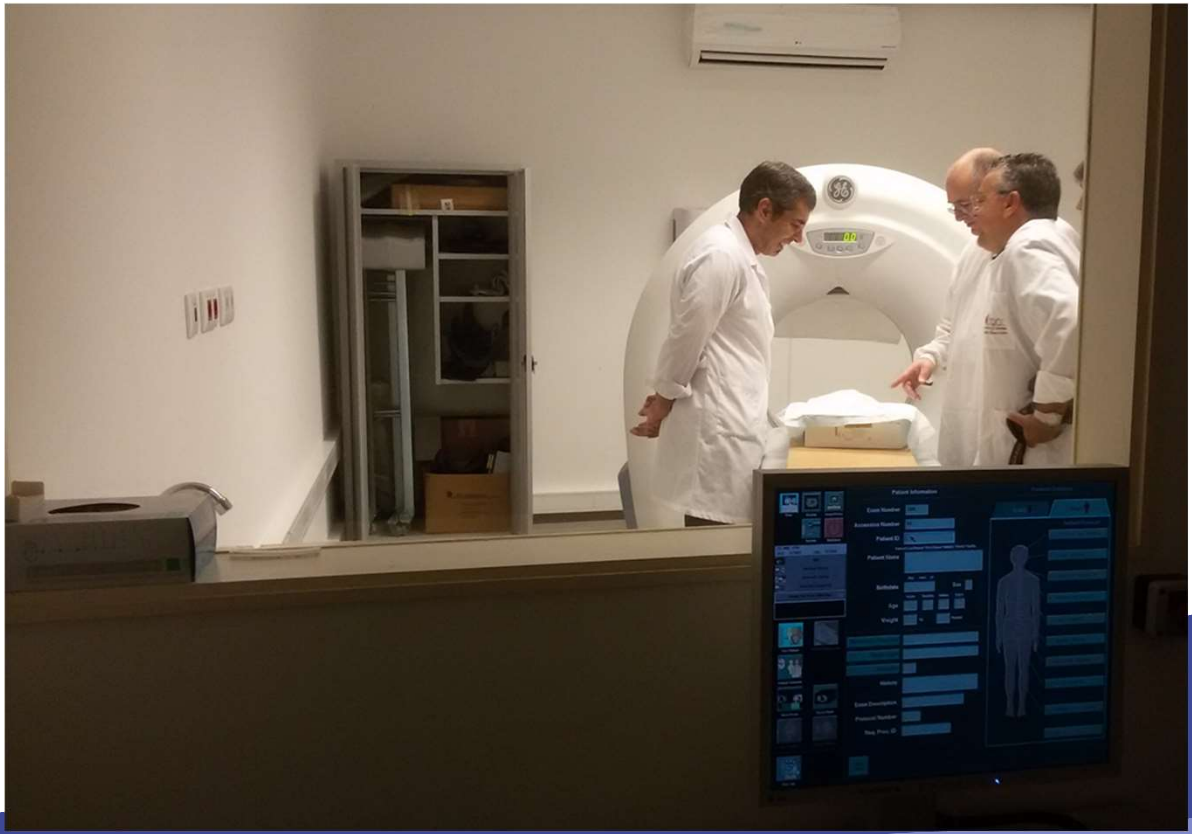


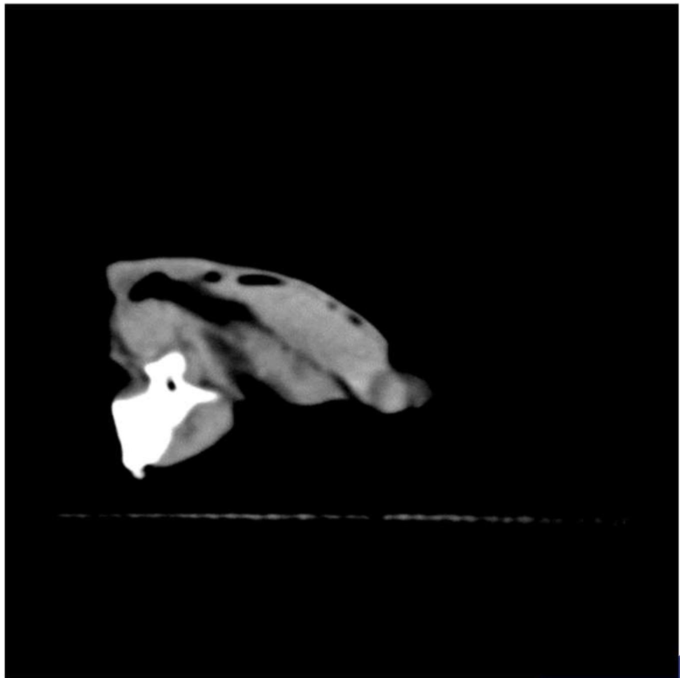
Figure 3. Density measurement relationship between CTs and dilution references.

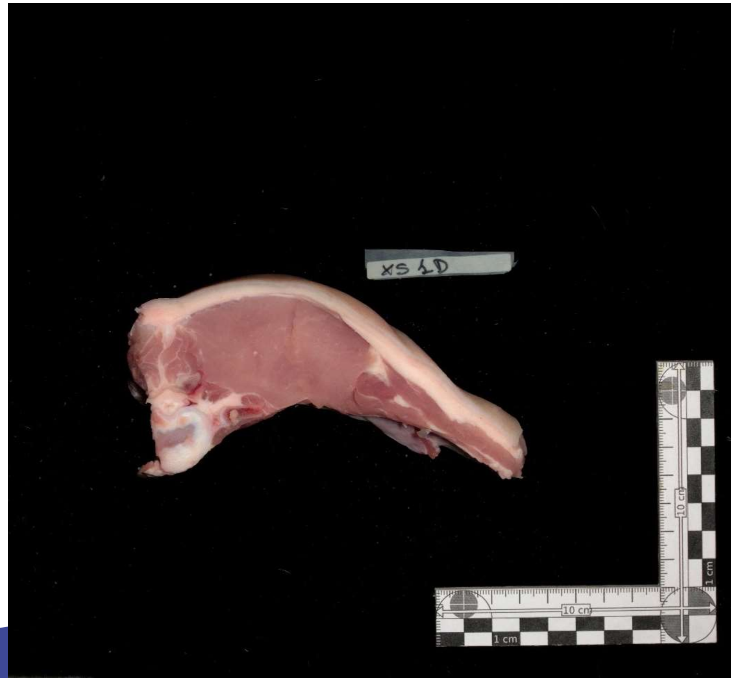
Computed tomography (CT)



UTAD, 2018

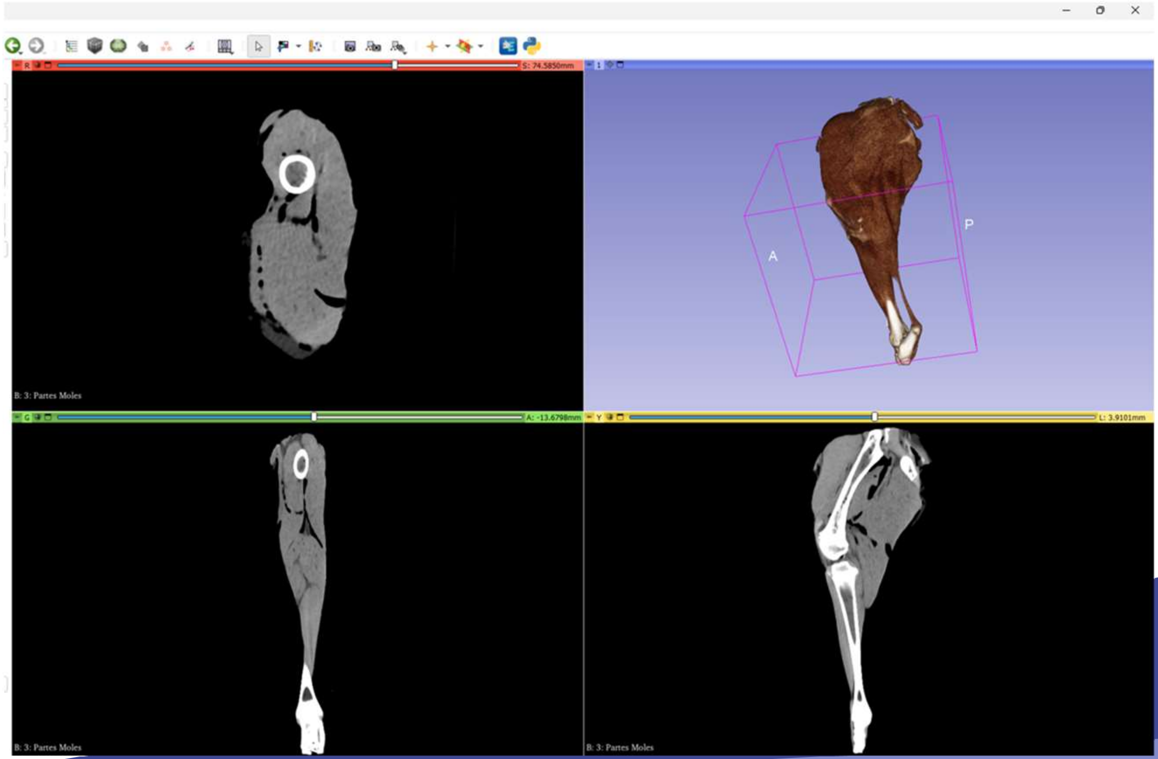
Computed tomography (CT): Bísaro loin

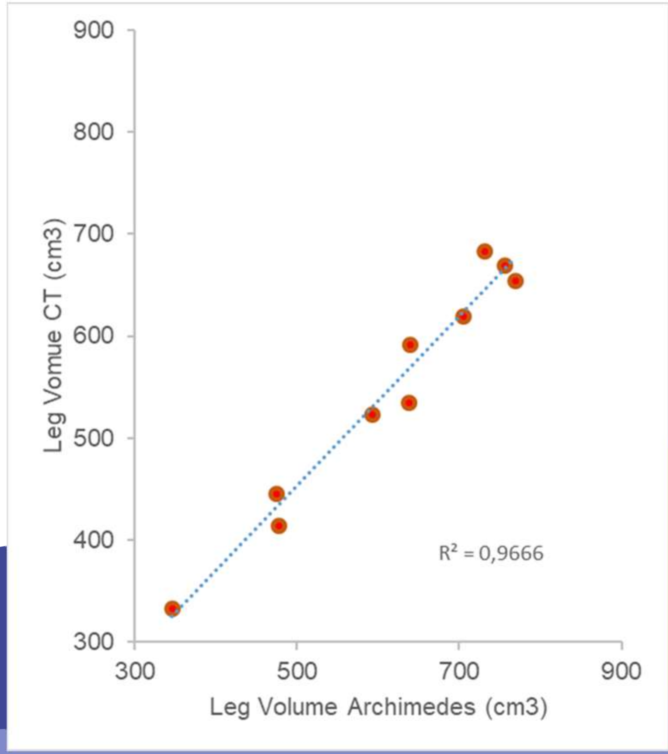




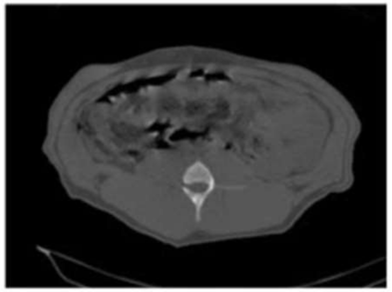
CT using a GE Revolution ACT CT scanner (GE HealthCare Technologies Inc., Chicago, IL, USA) with a slice width of 1 mm.

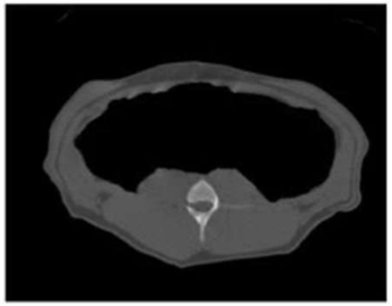
The leg volume was calculated from the DICOM images produced by CT scanning using the 3D Slicer (v.5.2.1 for Windows) software and Quantitative Reporting extension

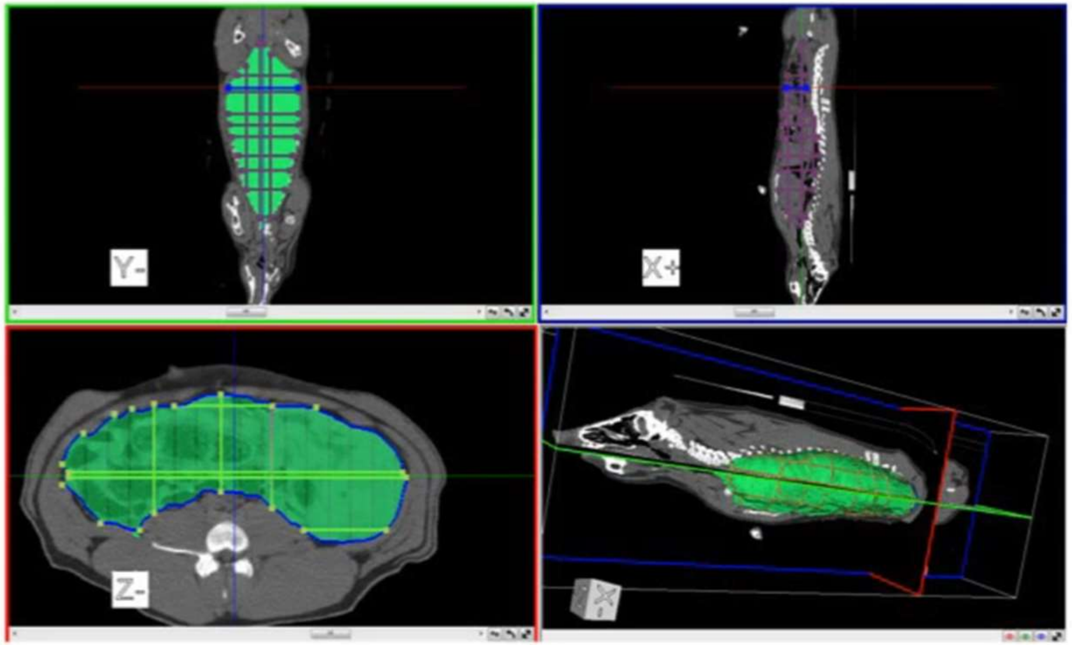




- On sépare les viscères sur les images pour recréer une carcasse « virtuelle »



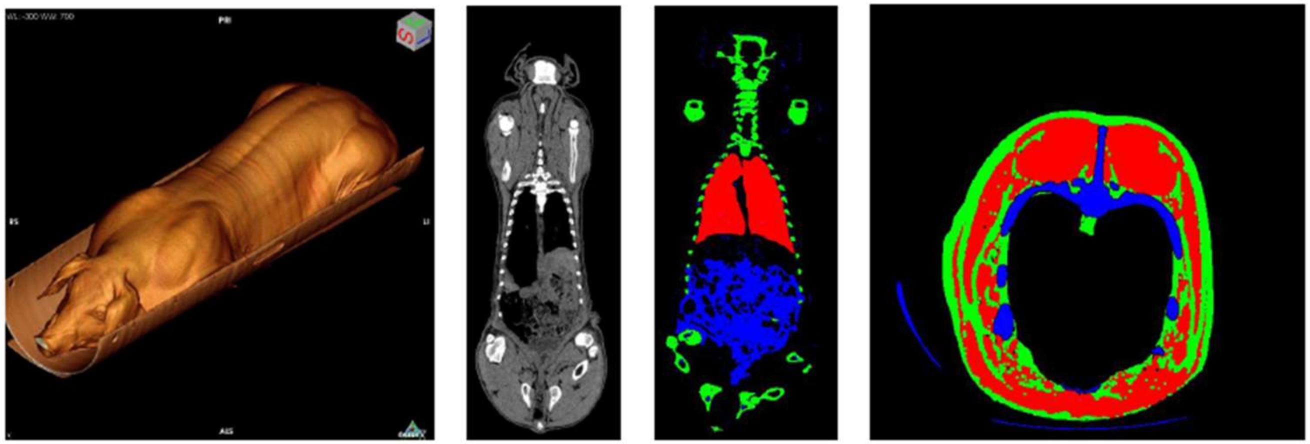




Monziols 2015

Computed tomography (CT)

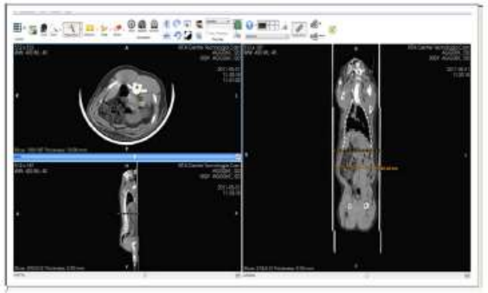
- Carcass lean meat percentage and yield are obtained from CT.
- Fully automatic MATLAB algorithm removing internal organs, classifying pixels and estimating tissue weights. Stepwise process of segmentation.
- Virtual copy of the animal stored in database.



Kongsro, 2012

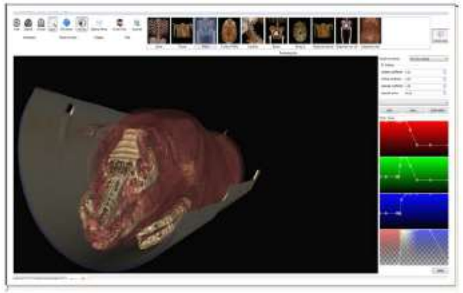
VisualPork modules

2D Viewer



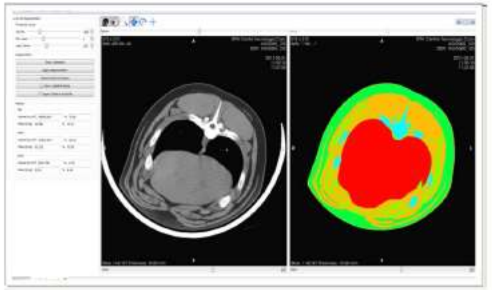
This module integrates basic slice visualization with editing tools such as zoom, pan, scroll, and window level. It also has measurement tools to compute distances, angles and define multiple ROI types.

3D Viewer



This module provides 3D renderings of volume data sets. These are obtained using predefined colour and opacity functions, which can be easily modified by the user.

Segmentation



This module allows the user to quantify the volume of fat, lean, bone, and internal organs of the pork by using image processing techniques. The final labelled volume and the numerical data (in terms of volume and mass of each class) can be exported to standard file formats.

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Computed tomography (CT

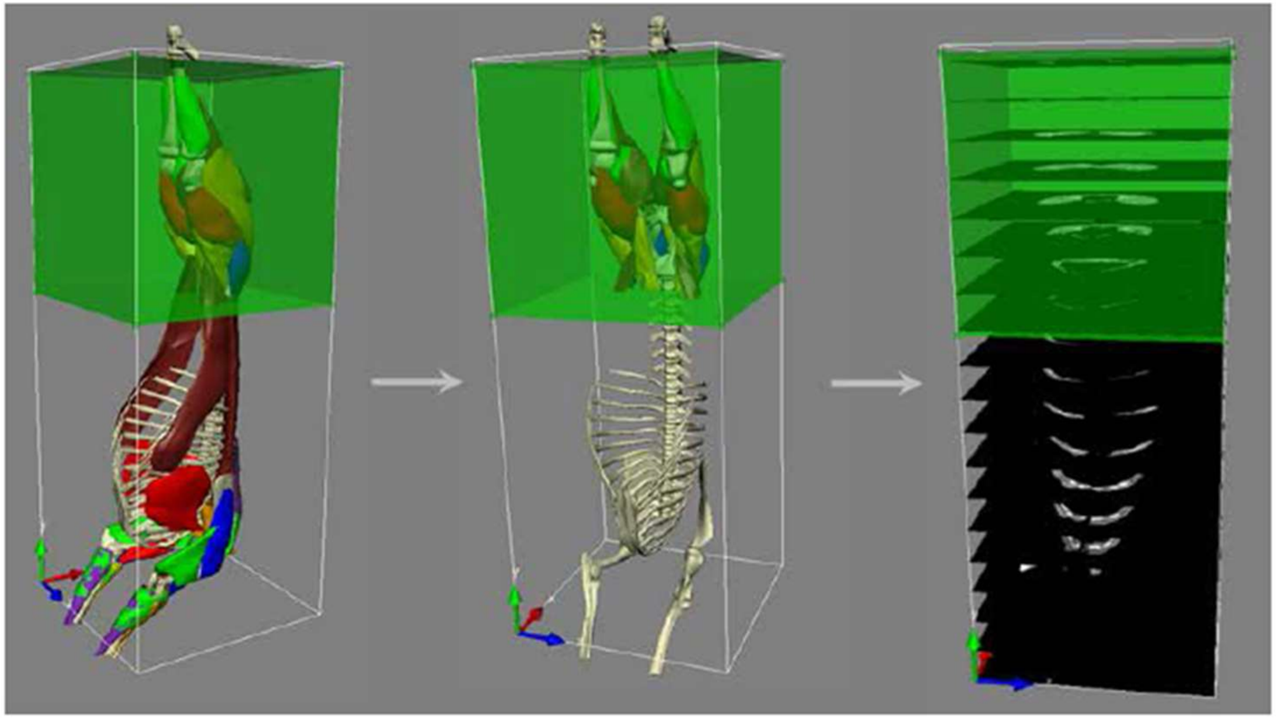

Figure 1: Virtual resection planning on the musculo-skeleton model. The virtual cutting scheme is mapped onto a 3D CT image

Ho, 2013

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Contents lists available at ScienceDirect

Computers and Electronics in Agriculture

journal homepage: www.elsevier.com/locate/compag

Original papers

Building an *in vivo* anatomical atlas to close the phenomic gap in animal breeding

Lars Erik Gangsei [a,c,*], Jørgen Kongsro [b], Kristin Olstad [d], Eli Grindflek [b], Solve Sæbø [c]

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[c] *Norwegian University of Life Sciences, Department of Chemistry, Biotechnology and Food Science, Ås, P.O. Box 5003, N-1432 Ås, Norway*
[d] *Norwegian University of Life Sciences, Department of Companion Animal Clinical Sciences, Equine Section, Oslo, P.O. Box 8146 Dep, N-0033 Oslo, Norway*

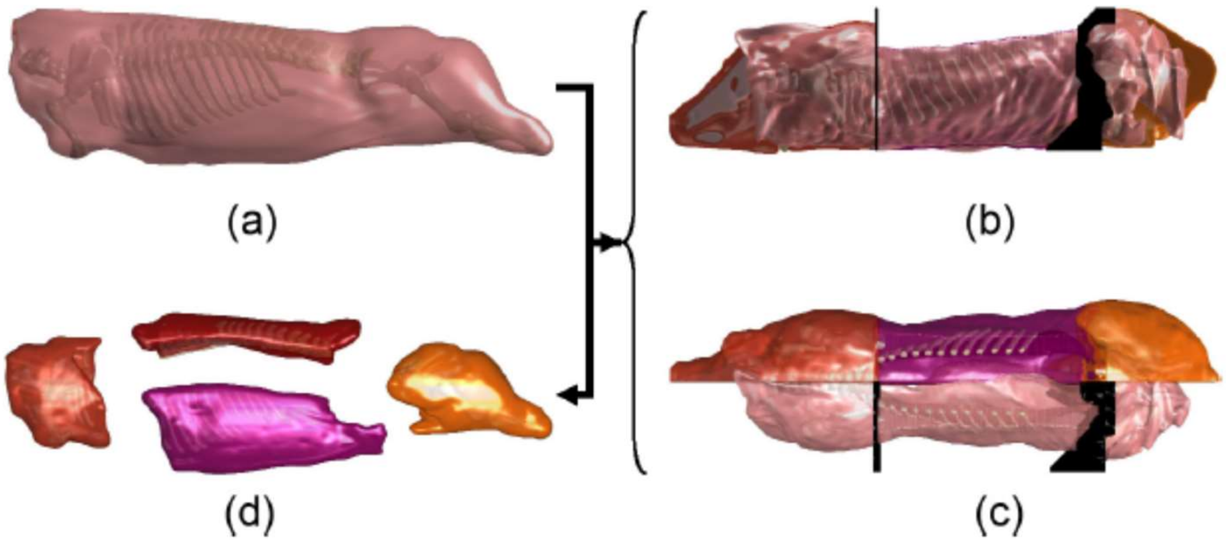

Fig. 4. Atlas segmentation applied to a carcass (left half). (a) An untransformed carcass. (b and c) The carcass (left hand side) registered (transformed) to the atlas (right hand side). The loin cut is removed to increase visibility. The other cuts are illustrated as black surfaces. (d) The final segmentation for the carcass in its four major cuts.

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Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Review

A review of computed tomography and manual dissection for calibration of devices for pig carcass classification - Evaluation of uncertainty

Eli V. Olsen *, Lars Bager Christensen, Dennis Brandborg Nielsen

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Mesure de composition corporelle sur carcasse et pièces

ifip institut du porc

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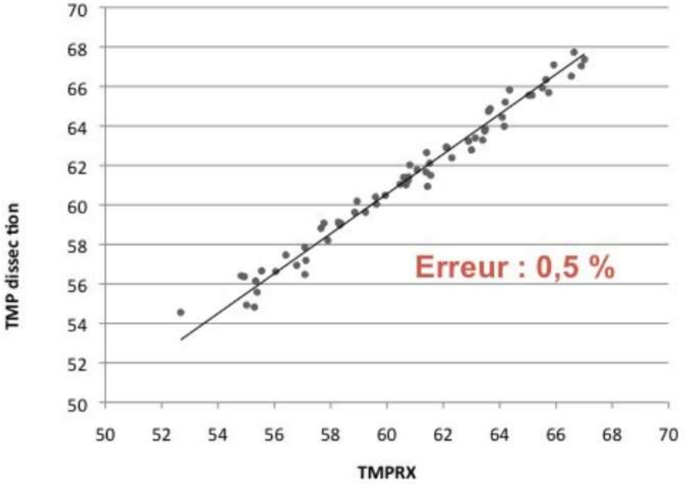
- L'analyse d'image permet de quantifier le tissu
  - Comparaison avec une dissection
  - Ex : TMP : teneur en muscle des 4 pièces (63 animaux)



Monziols 2015

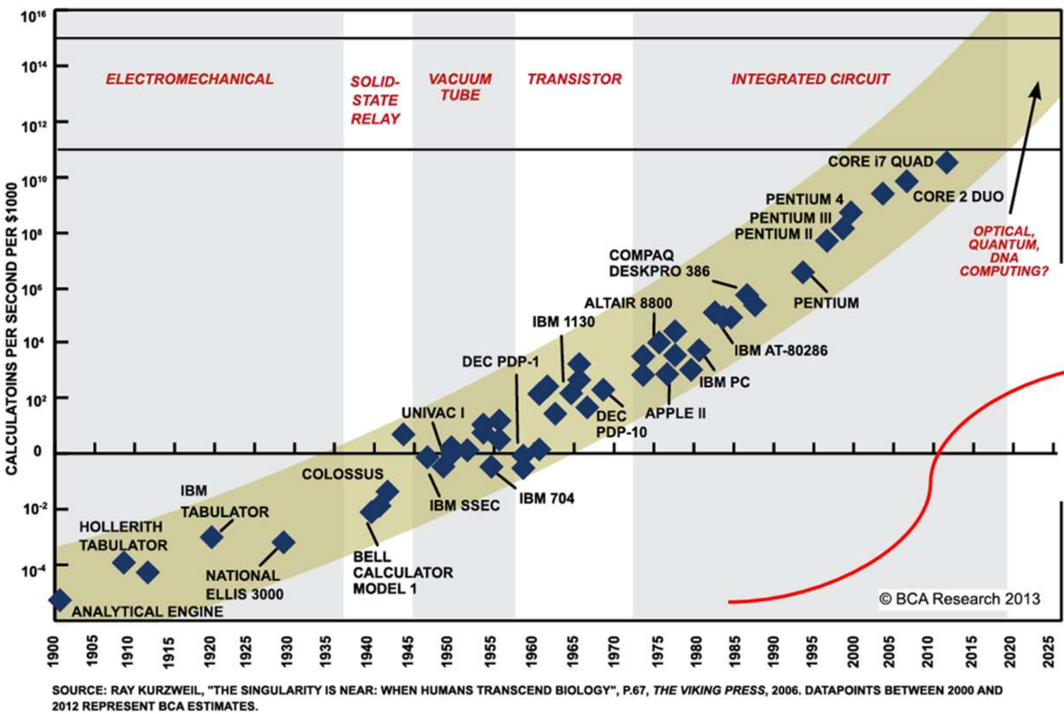
Computed tomography (CT)

Slik ser CT-skanneren for næringsmiddelbruk ut. Modellen vil i prinsippet kunne skanne 600 midtstykker av svin hver time. (Bilde: Teknologisk Institut)

Future

Jorgen Kongsro

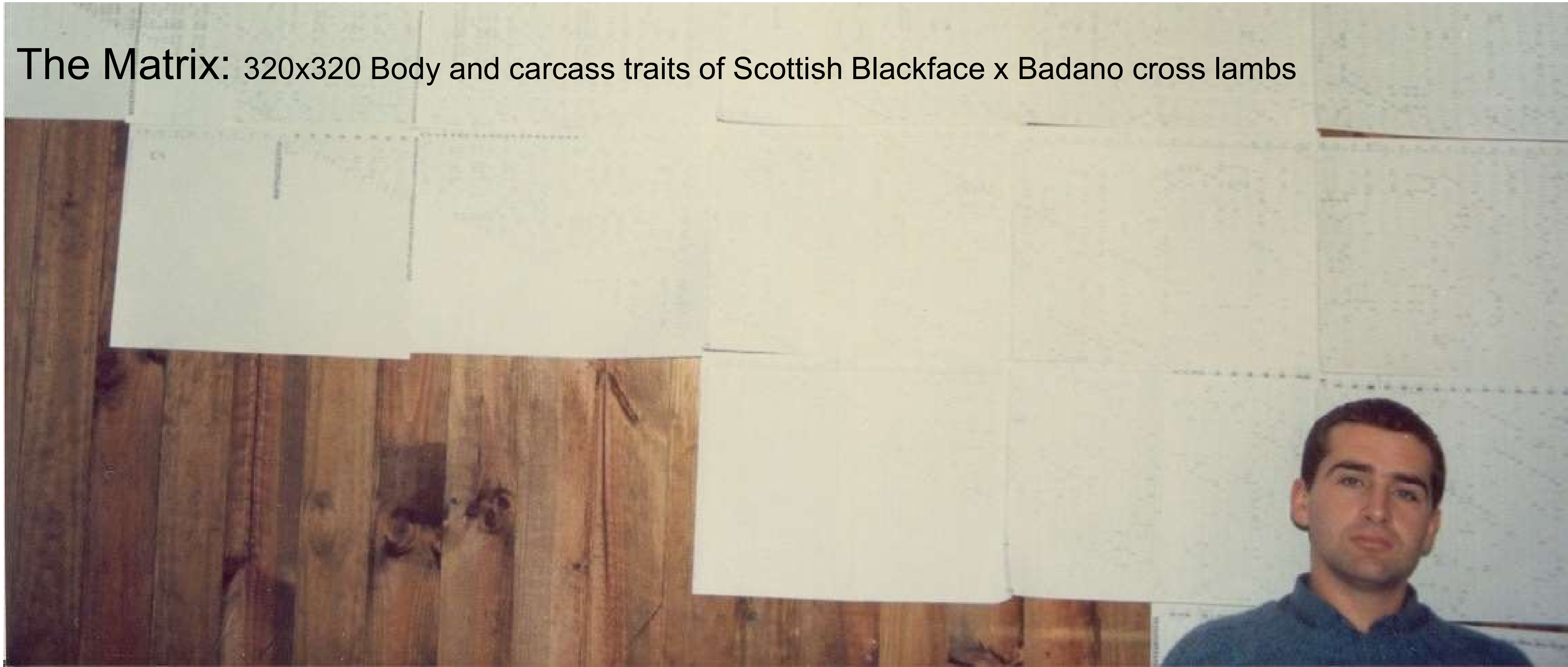
Moore's law. Processing capacity doubles every 18 months



Macintosh 128k

Adapted From Templeton (2016)

March 1986, one week before enlisting in the cavalry arm



The Matrix: 320x320 Body and carcass traits of Scottish Blackface x Badano cross lambs

I was happy making matrices and in a week, I will be crawling in the mud