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Bologna (The town)
A MULTIDISCIPLINARY RESEARCH UNIVERSITY

About 90,000 students

2,847 teaching staff
734 professors
829 associate professors
1,284 researchers

20 %
Scientific Area

15 %
Social Sciences Area

10 %
Technology Area

5 %
Medical Area

Humanities Area
ALMA MATER STUDIORUM – University of Bologna (Multi Campus University)
ALMA MATER STUDIORUM – University of Bologna (Multi Campus University)
Dipartimento di Scienze e Tecnologie Agro-Alimentari

L'organizzazione, le persone, l'amministrazione e le strutture che compongono il Dipartimento di Scienze e Tecnologie Agro-Alimentari (DISTAL)

In evidenza

Ambiti di ricerca
Le 7 aree tematiche principali dell'attività di ricerca del DISTAL.

Link esterni di interesse
Genetic factors affecting dry-cured ham quality traits – the case of Italian heavy pigs

Luca Fontanesi

Department of Agricultural and Food Sciences (DISTAL)
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Bologna, Italy
### Italian PDO products from pig meat

<table>
<thead>
<tr>
<th>Code</th>
<th>Product Description</th>
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<tr>
<td>IT/PDO/0105/02118</td>
<td>Crudo di Cuneo</td>
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2 billion of euro per year
Italian heavy pig breeds

- Italian Large White
- Italian Duroc
- Italian Landrace
Selection programs in heavy pigs are complicated as they should satisfy expectation of

- Farmers
- Slaughterhouses
- Seasoning operators
Selection programs in heavy pigs are complicated as they should satisfy expectation of

- Farmers
- Slaughterhouses
- Seasoning operators
- Performances
- Carcass quality
- Meat quality
- Consumers
Candidate boar in the farm

Performance tested pigs at the genetic station

3 full sibs (1 castrated male and 2 females)
Candidate boar in the farm

Performance tested pigs at the genetic station

3 full sibs (1 castrated male and 2 females)

At the genetic station

Average daily gain (g)
Feed conversion rate
Candidate boar in the farm

Performance tested pigs at the genetic station

3 full sibs (1 castrated male and 2 females)

At the genetic station

- Average daily gain (g)
- Feed conversion rate

At slaughterhouse (155 kg)

- Back fat thickness (mm)
- Lean cuts (neck and loin) weight (kg)
- Ham weight (kg)
- Visible intermuscular fat
Candidate boar in the farm

Performance tested pigs at the genetic station

3 full sibs (1 castrated male and 2 females)

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Average daily gain (g)
Feed conversion rate

At slaughterhouse (155 kg)

Back fat thickness (mm)
Lean cuts (neck and loin) weight (kg)
Ham weight (kg)
Visible intermuscular fat

At the seasoning plant

Ham weight loss at first salting (g)
Candidate boar in the farm

Performance tested pigs at the genetic station

3 full sibs (1 castrated male and 2 females)

Average daily gain (g)
Feed conversion rate

At the genetic station

EBV: BLUP-Animal Model Multitrait

At slaughterhouse (155 kg)

Back fat thickness (mm)
Lean cuts (neck and loin) weight (kg)
Ham weight (kg)
Visible intermuscular fat

At the seasoning plant

Ham weight loss at first salting (g)
Breeding program for dry cured ham quality traits

Fat coverage

Intermuscular fat

Ham weight loss at first salting
Italian Large White: genetic trends

Average Daily Gain

Lean cuts

Ham weight loss at first salting

Feed gain ratio

Ham weight

Back fat thickness
Italian Duroc: genetic trend for VIF

Visible Intermuscular Fat
Heritability (diagonal) and genetic correlations between traits

<table>
<thead>
<tr>
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<th>ADG</th>
<th>BFT</th>
<th>LC</th>
<th>HWLFS</th>
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<td>-0.66</td>
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ADG = Average Daily Gain
BFT = Back Fat Thickness
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VIF = Visible Intermuscular Fat
Heritability (diagonal) and genetic correlations between traits

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ADG = Average Daily Gain
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Animal resources

~20,000 performance tested Italian Large White

~10,000 performance tested Italian Duroc

~7,000 performance tested Italian Landrace

~1,000-1900 pigs
~300 phenotypes

~400-500 pigs
~250 phenotypes
Phenotype space

Genome space

Genome Wide Association Studies

PorcineSNP60 BeadChip
Genome Wide Association Studies

H WLFS and VIF

PorcineSNP60 BeadChip

Genome space
Genome Wide Association Study for HWLFS

- log10 (P nominal value)

Chromosomes

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

SLC35D2/ HSD17B3
CCND2
UBL3

P Bonferroni <0.10
P nominal value < 5.0E-05
P nominal value < 5.0E-04
## Results of the gene enrichment analyses

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<tr>
<th>Term/item</th>
<th>P-value(^1)</th>
<th>Adjusted P-value(^2)</th>
<th>Overlap(^3)</th>
<th>Genes</th>
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<td>protein tyrosine phosphatase activity (GO:0004725)</td>
<td>0.00035</td>
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<td>EYA4, DUSP8, CDC14B</td>
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<tr>
<td>protein tyrosine/serine/threonine phosphatase activity (GO:0008138)</td>
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<td>phosphoprotein phosphatase activity (GO:0004721)</td>
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<td>neuron recognition (GO:0008038)</td>
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<td>peptidyl-tyrosine dephosphorylation (GO:0035335)</td>
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<td>CCND2, EP300, CDC14B</td>
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</tbody>
</table>

1 P nominal value
2 Bonferroni adjusted P-value
3 No. of genes included
Visible intermuscular fat (VIF)

Yes

No
m. semitendinosus

m. semimembranosus

m. biceps femoris

m. gastrocnemius
Genome Wide Association Study for VIF

- log10 (P nominal value)

Chromosomes

1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16  17  18

GRIK2  MYBPC1  PTK9/CUL7/CUL9  ETS1

P<5.0E-05  P<5.0E-04
QTL region 1 (74.9-81.7 Mbp)

QTL region 2 (84.4-86.2 Mbp)
Genome Wide Association Studies

**HWLFS**

- ENSSSCG00000027499
- TMEM156
- ENSSSCG00000021850

- $P < 5.0 \times 10^{-05}$
- $P < 5.0 \times 10^{-04}$

**VIF**

- VDAC1
- MOCS1
- GPC6
- ATRN

- $P < 5.0 \times 10^{-05}$
- $P < 5.0 \times 10^{-04}$
HWLFS

-CCND2
-SCC3502/HS01783
-UBL3

VIF

-GRIK2
-MYBPC1
-PTK9/CUL7/CUL9
-ETS1

ALMA MATER STUDIORUM - UNIVERSITÀ DI BOLOGNA
IL PRESENTE MATERIALE È RISERVATO AL PERSONALE DELL'UNIVERSITÀ DI BOLOGNA E NON PUò ESSERE UTILIZZATO AI TERMI DI LEGGE DA ALTRE PERSONE O PER FINI NON ISTITUZIONALI
Genome Wide Association Studies

Phenotype space

PorcineSNP60 BeadChip

Genome space
Genome Wide Association Studies

External phenotypes

Internal phenotypes

PorcineSNP60 BeadChip

Genome space
Genome Wide Association Studies

External phenotypes

| PorcineSNP60 BeadChip |

Internal phenotypes

Genome space
Animal resources

- ~20,000 performance tested Italian Large White
- ~10,000 performance tested Italian Duroc
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- ~300 phenotypes
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Animal resources

- ~20,000 performance tested Italian Large White
  - ~1,000-1900 pigs
  - ~300 phenotypes
  - ~200 metabotypes

- ~10,000 performance tested Italian Duroc
  - ~400-500 pigs
  - ~250 phenotypes
  - ~200 metabotypes

- ~7,000 performance tested Italian Landrace
Genome Wide Association Studies

- External phenotypes
- Metabotypes
- Genome space

PorcineSNP60 BeadChip
Metabolomics measures all endogenous metabolites of a tissue or body fluid under given conditions.

From Junot et al. 2014
<table>
<thead>
<tr>
<th>Metabolite classes</th>
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<th>Biological relevance (selected examples)</th>
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<td>Acylcarnitines</td>
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<td>Energy metabolism, fatty acid transport and mitochondrial fatty acid oxidation, ketosis, oxidative stress, mitochondrial membrane damage (apoptosis)</td>
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<td>Amino acids</td>
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<td>Amino acid metabolism, urea cycle, activity of gluconeogenesis and glycolysis, insulin sensitivity/resistance, neurotransmitter metabolism, oxidative stress</td>
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<tr>
<td>Biogenic amines</td>
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<td>Neurological disorders, cell proliferation, cell cycle progression, DNA stability, oxidative stress</td>
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<td>Hexoses</td>
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<td>Carbohydrate metabolism</td>
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<td>- lysoPhosphatidylcholine acyl – lysoPC a Cx:x</td>
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<td>Degradation of phospholipids (phospholipase activity), membrane damage, signalling cascades, fatty acid profile</td>
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<td>- Phosphatidylcholine diacyl – PC aa Cx:x</td>
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<td>Dyslipidemia, membrane composition and damage, fatty acid profile, activity of desaturases</td>
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<tr>
<td>- Phosphatidylcholine acyl-alkyl – PC ae Cx:x</td>
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<tr>
<td>Sphingolipids</td>
<td>15</td>
<td>Signalling cascades, membrane damage (e.g. neurodegeneration)</td>
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METABOTYPES

Acylcarnitines

Aminoacids

Biogenic Amines

Glycerophospholipids

Sphingolipids
Kynurenine 3-monooxygenase (KMO)
...... to be continued ......
Metabolites that we analysed

Metabolites present in body fluids
Conclusions

a) We have identified genes associated with meat quality traits for dry-cured ham production

b) The future of animal breeding relies on the analysis of as many phenotypes as possible
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Samuele Bovo
Gian Luca Mazzoni
Giuseppina Schiavo
Anisa Ribani
Valerio Joe Utzeri
Antonia Bianca Samoré
Emilio Scotti
Stefania Dall'Olio
Paolo Trevisi
Paolo Bosi

Department of Surgical and Medical Sciences
Endocrinology Unit
Flaminia Fanelli
Marco Mezzullo
Uberto Pagotto

Department of Statistical Sciences
Giuliano Galimberti
Daniela Giovanna Calò

Biocomputing Group
Pier Luigi Martelli
Rita Casadio

Associazione Nazionale Allevatori Suini
Maurizio Gallo

Consiglio per la Ricerca e la sperimentazione in Agricoltura
Luca Buttazzoni

Funded by:
Innovagen project (MiPAAF)
AGER project (Fondazioni Bancarie)
FARB project (University of Bologna)
Schema di Selezione in pratica

Nuclei allevamento: Registrazione dati e Identificazione nidiate

Centro Genetico (Reggio Emilia)

Flusso operativo quindicinale

Stima Valore Genetico (BLUP Animal Model MT):
- Efficienza
- Caratteristiche carcassa
- Qualità carne

Centro FA convenzionato per la distribuzione pianificata seme ai nuclei allevamento

Ritiro gruppi SIB

Analisi DNA per parentela e gene alotano

Tra i fratelli dei gruppi migliori sono scelti I Verri per la FA