What are the challenges that faces the egg in the next decade?

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The chicken egg

A Basic ingredient for human food

- ✓ Cheap
- ✓ Well balanced
- ✓ High nutritional value
- ✓ No religious prohibition
- ✓ Used in a lot of cuisinary preparations

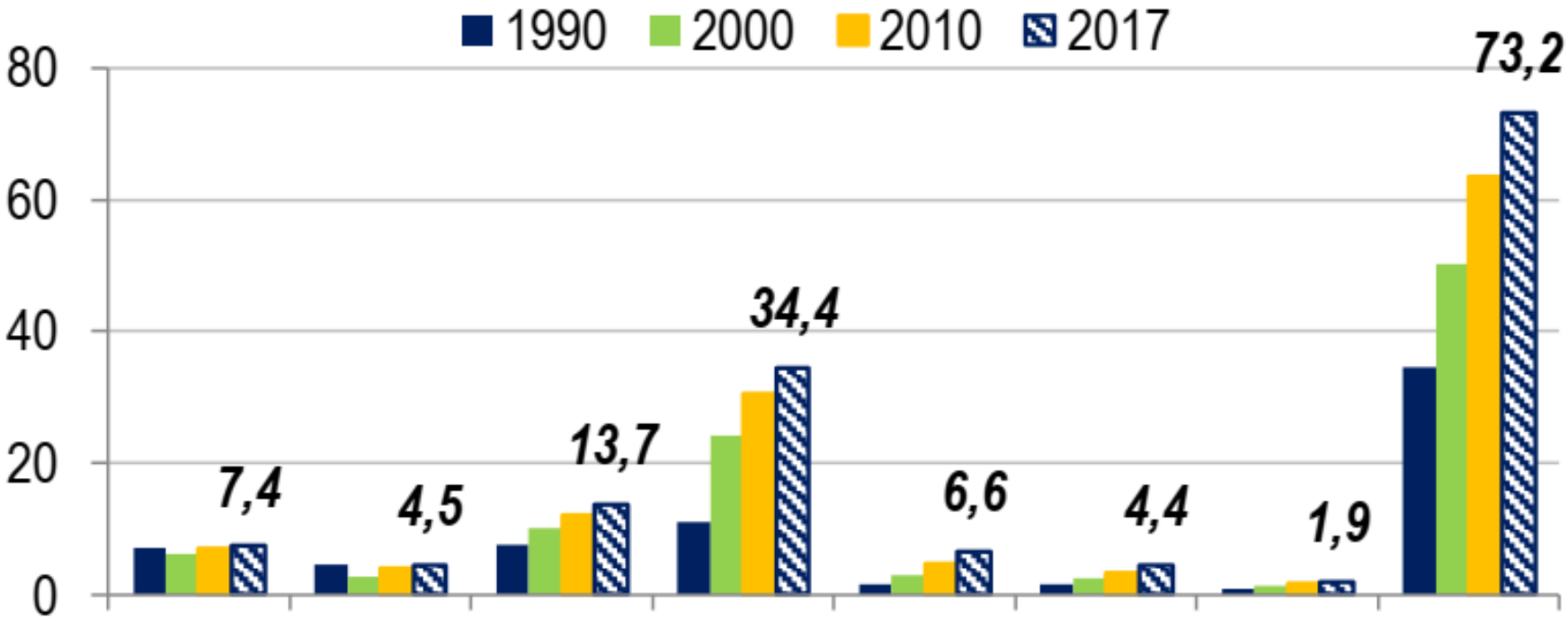
CHANGES IN CONSUMMER EXPECTATION

ETHICAL ISSUES

History of egg production

- Before the war: Domesticated chickens => mostly self-consumption
- After the war: need to meet the demand (in quantity) and to control the sanitary conditions (in quality: zero risk) => confinement and breeding in cages.
- 80 90s => "productive egg".

73 MT of eggs are produced each year in the word
> 1400 billion eggs per year



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History of egg production

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- 80 90s => "productive egg".
- Since the end of the 90s: **new consumer demands: strong awareness of citizens on agricultural production systems in general and animal production in particular, including poultry and eggs diversification of farming methods**
- The current European production models are the result of this social demand Welfare Directive for laying hens (1999/74/EC).
- This regulation is also the result of scientific research to satisfy the 5 freedoms of animal welfare: no hunger, no thirst, free of movement, no fear/distress, while allowing the expression of natural behaviour.

Egg production system in Europe

Welfare Directive for laying hens (1999/74/EC)

Rules for rearing of hens

Enriched cages

Code 3: Cage fitted with new standards

Alternative systems

Barn or aviary systems
Indoor or Outdoor

Code 2: Raised on the ground or in an aviary without outside access

Code 1: Aviary or ground + outdoor access

Code 0: Aviary or ground + outdoor access + Organic production

The first (Only ?) food ingredient with MANDATORY labelling according to ethical production methods

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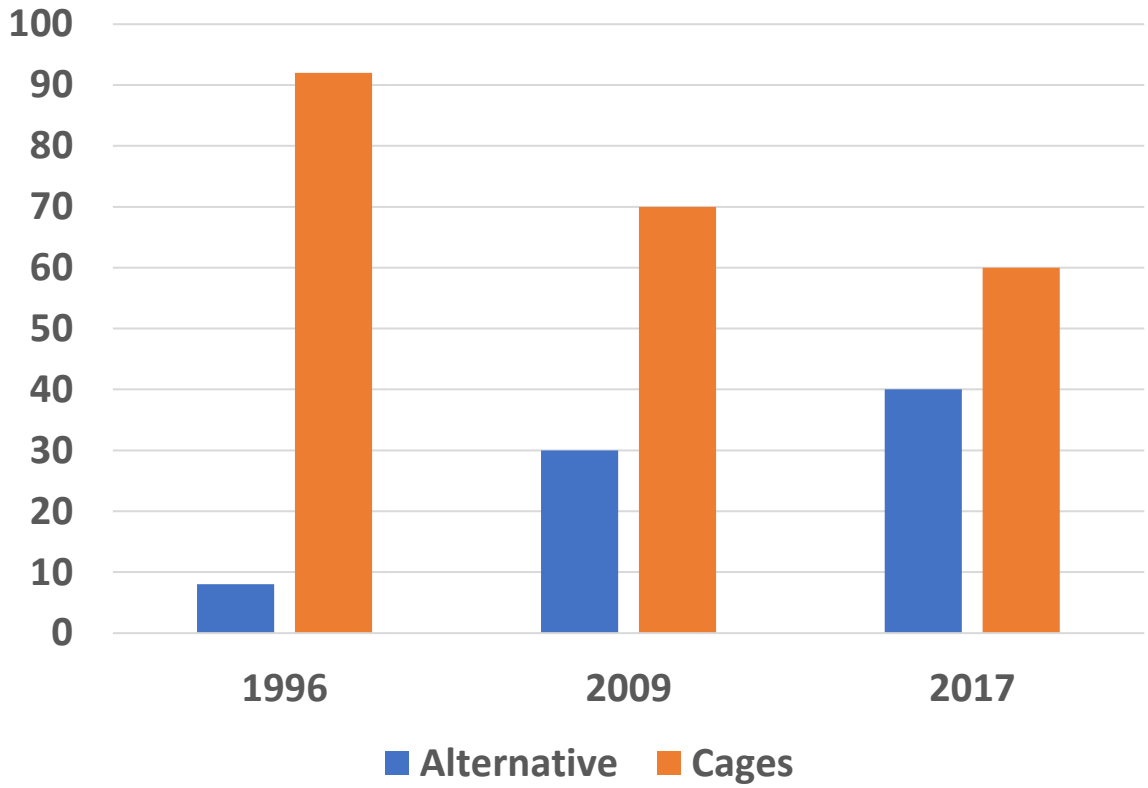
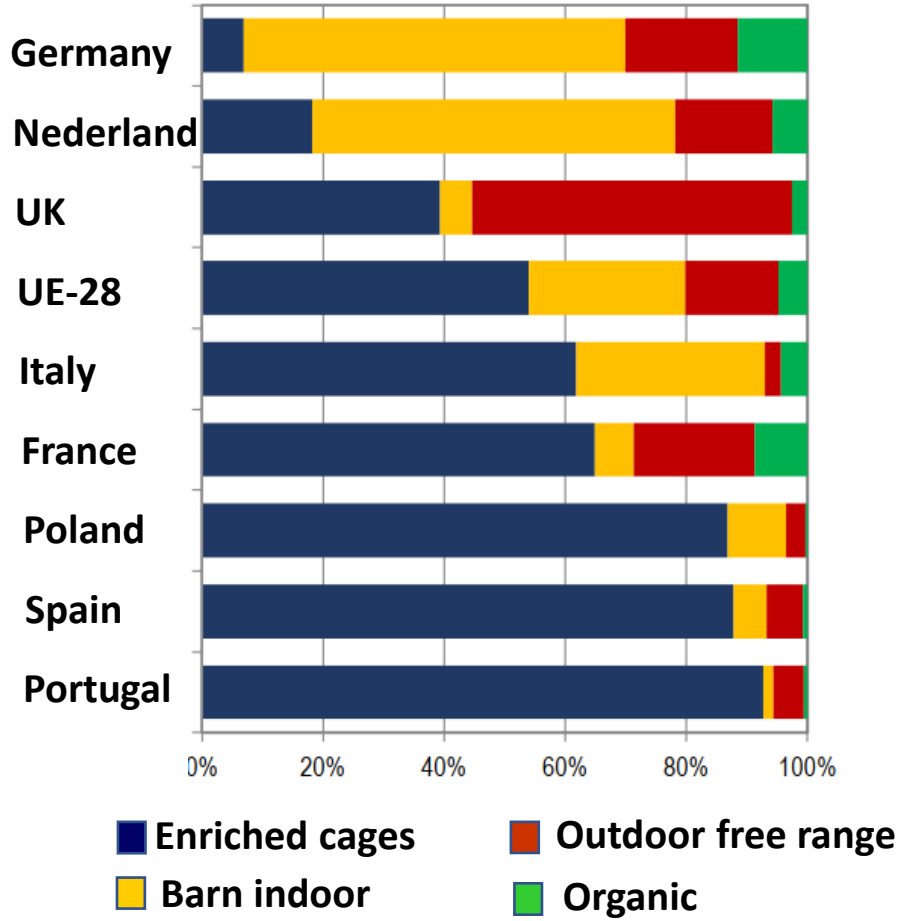
Evolution of egg production systems in UE

Evolution of the proportion of eggs in alternative systems



Distribution of laying hen numbers by production system in Europe (2017)



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And Now ?
Eggs in the next decade ?

Eggs and layers, the future

The future of cages systems

Year of the announced cessation of marketing of furnished caged eggs by retailers in France

Aldi	Auchan	Carrefour	Casino
2025	2022	2020	2020

Cora	Leclerc	Lidl	U
2020	2020	2020	2020

A strong questioning of animal and layer farming

Reduce the number of animals

Alternative to the culling of one day old male chicks from layer lines

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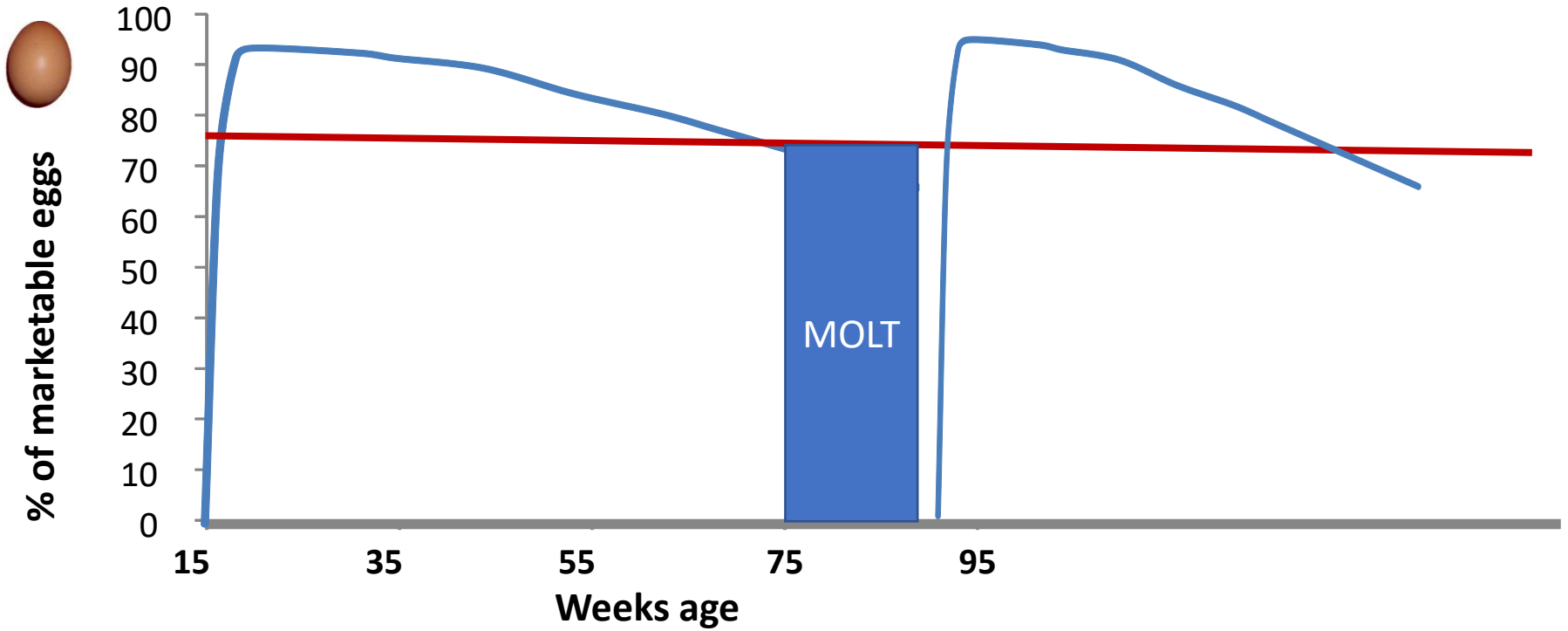
Reduce the number of layers

✓ **Use of molt cycles**



75 % of marketable eggs is the beneficial limit

Second and third laying cycles are possible after molting of the layer

→ Need to induce artificial molt with water and feeding privation not allowed in EU

Research is needed to induce moulting while respecting animal welfare

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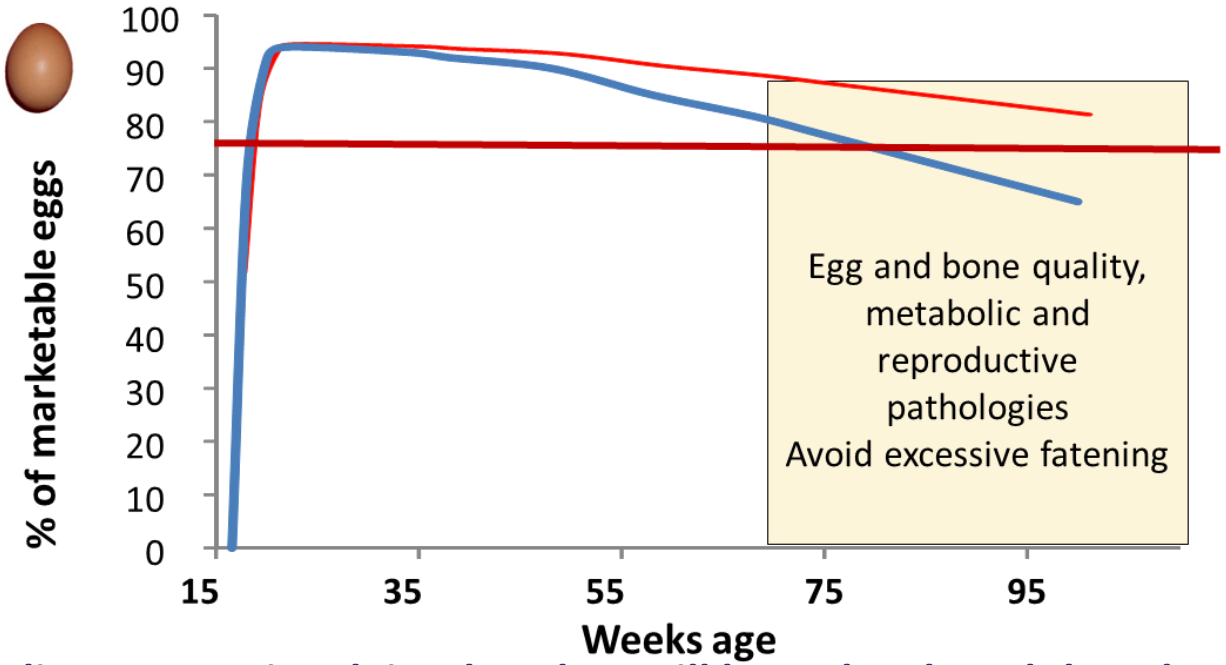
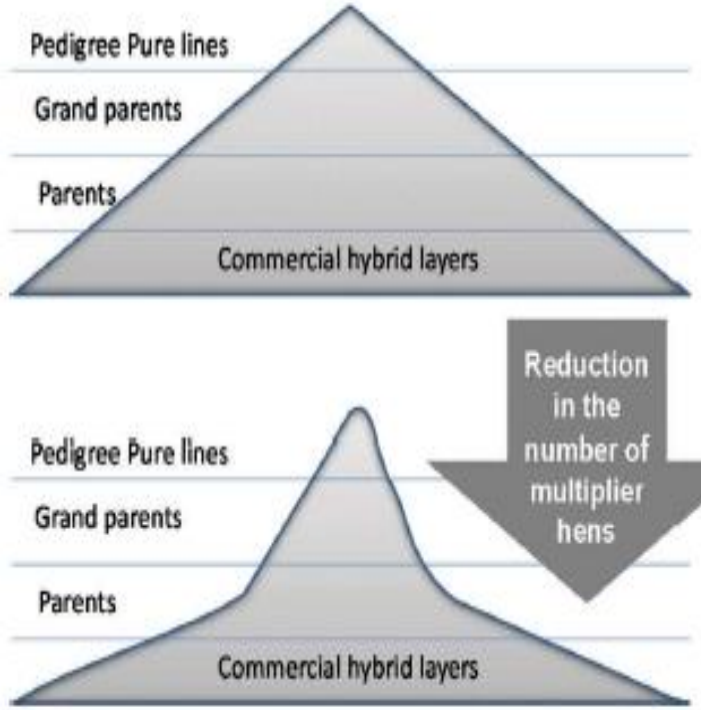
Reduce the number of layers

✓ **Increasing persistency of laying hens**



75 % of marketable eggs is the beneficial limit



Breeding companies claim that they will have developed the « long life » layer, which will be capable of producing 500 eggs in a production cycle lasting 100 weeks by 2020 (Van Sambeek, 2010)

Bain et al., 2016 estimated « than even 25 more eggs per hen could potentially reduce the UK flock, including breeding hens by 2,5 millions birds per annum. »

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Alternative to the culling of male day-old chicks of layer lines

The specialized chicken lines

Layer hens

(340 eggs per year)

Meat is not marketable

Broiler Production

(<150 eggs per year)

Non marketable low quality eggs

6 billions of males are killed every year in the world

Ethical and societal concern

Alternative to the culling of male day-old chicks of layer lines

A very strong demand on the sector

Citizens are increasingly interested in the issue of animal care and welfare

An animal is NOT a waste product

Male chicks are crushed alive by the egg industry

Would you be willing to put a live chick in a grinder?

However, this is what the industry does to make you eat eggs

Courtesy of Maxime Quentin

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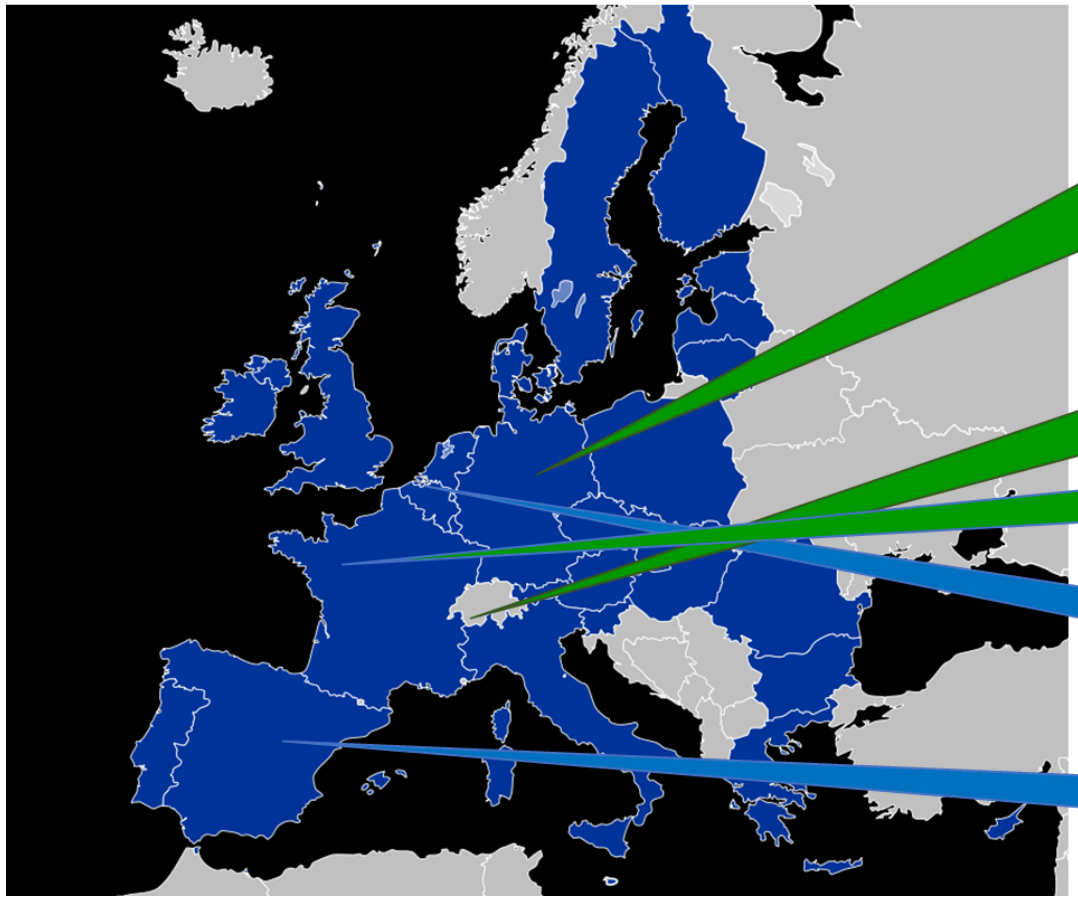
Alternative to the culling of male day-old chicks of layer lines

Some political decisions

2020, January 13th at Berlin, Announcement of a bilateral decision between France and Germany banning the slaughter of male chicks from laying lines before the end of 2021

Alternative to the culling of male day-old chicks of layer lines

An European issue?



German law prohibits the culling of male chicks as of January 1, 2022. Sexing technique < 6 days from January 1, 2024

Switzerland has banned the crushing of male chicks as of January 1, 2020. Disposal with CO^2 is tolerated/ 50% of Swiss male chicks are recycled (animal feed, Zoo)

France: Law passed in February 2022.

The Netherlands: committed to stop the elimination of male chicks by the end of 2021.

Spain: committed to stop the elimination of male chicks

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The following declared that they would follow the French-German position: Luxembourg, Finland, Cyprus, Ireland, Spain, Belgium, Netherlands, Greece, Slovakia, Portugal

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Alternative to the culling of male day-old chicks of layer lines

Dual purpose chickens

Layers strain
(340 eggs per year)
Meat is not marketable

Broiler strains
(<150 eggs per year)
Non marketable low quality eggs

Crossbreed

Females are reared for egg production

→ Low number of eggs
Quality ?

Unfavorable environmental impact

Males are reared for meat production

→ Low meat yield
Different meat texture (consumer education)

Need to evaluate the productivity, the quality, the behaviour of animals in various housing systems and various environmental conditions, health and costs

Alternative to the culling of male day-old chicks of layer lines

In ovo sexing, Identify male eggs for removal before hatching

Postulate: male and female embryos "express" chromosomal, anatomical, physiological and molecular differences (direct indicators/markers) and some of these molecules may diffuse into the egg structures (indirect indicators/markers)

→ Towards a practical and marketable method

- ✓ Must be fast (20 000 to 30 000 eggs per hour)
- ✓ Must be cheap
- ✓ Must be precise (98.5 %)
- ✓ Without detrimental consequences on the hatchability and the viability of the chicken
- ✓ Must be done before **XXX** days of embryonic development to avoid any pain.

→ A frantic race between states, scientists and industry to offer alternative solutions and hit the jackpot.

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How to determine sex in ovo

- Destructives and non destructive methods

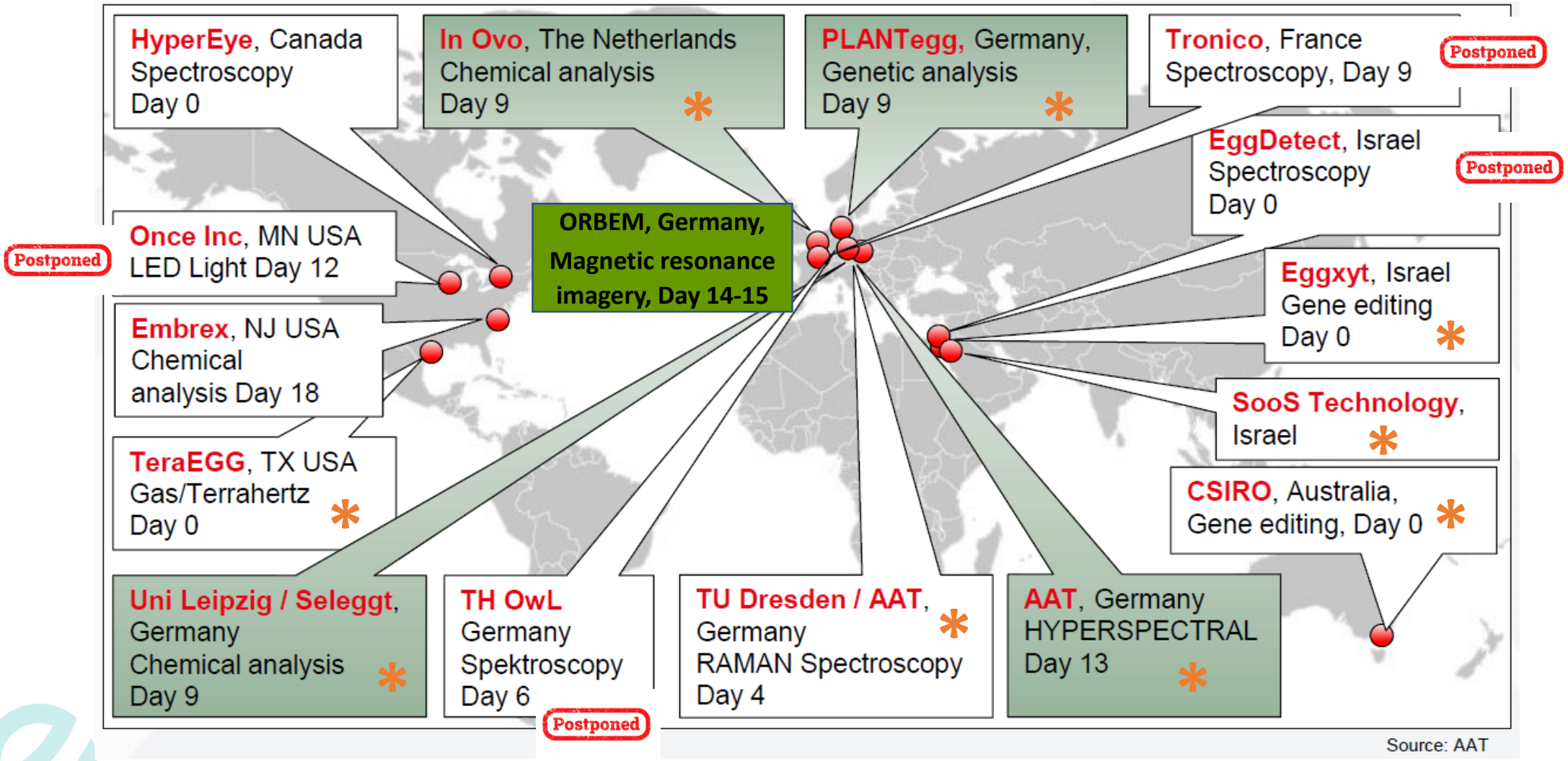
- Biological approaches
  - Hormonal detection
  - Metabolite marker detection

- Physicochemistry approaches
  - Dimorphic volatile odors between male and females

- Physical and optical approaches
  - FTIR spectroscopy
  - Raman spectroscopy
  - Magnetic resonance imaging
  - Hyperspectral analysis

- Genetic engineering
  - Genome editing

Alternative to the culling of male day-old chicks of layer lines



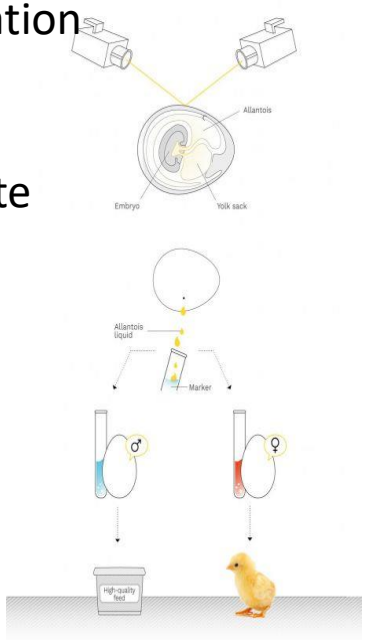
How to determine sex in ovo

SELEGGT – Hormonal testing (http://www.seleggt.com/) (Allemagne)

THE SELEGGT PROCESS

The SELEGGT process is a way to prevent chick culling. The scientific approach of endocrinological (hormone-based) gender identification in the hatching egg has been automated in the SELEGGT process and is already in use today.

- ✓ Test performed at 9 days of incubation
- ✓ Small hole 12 mm in the shell
- ✓ Samples used a patented test to measure the level of Estrone sulfate only present in females

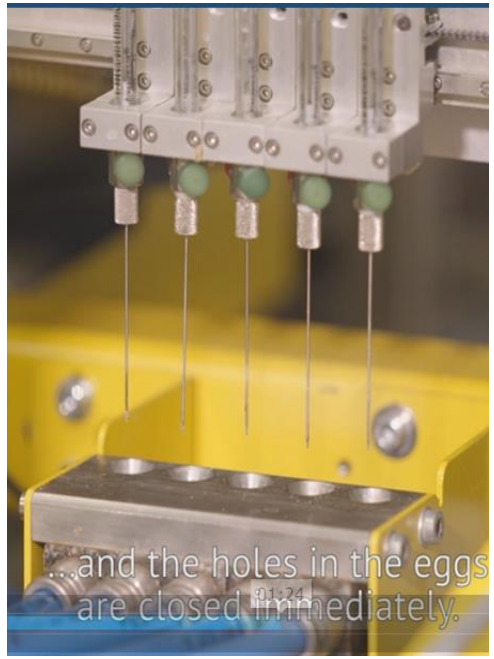


- ✓ Accuracy 97-98%
- ✓ Machine already installed in NL and Fr
- ✓ Price 1-3 cents per egg, 7 Euros per pullet
- ✓ Low throughput of approximately 1 to 3000 eggs/hour

How to determine sex in ovo

In ovo – Biomarker detection (Metabolite in allantoic fluid) (https://inovo.nl/solutions/in-ovo-egg-sexing/) (Netherlands)

- ✓ H NRM spectroscopy at 9 days of incubation
- ✓ Fast 2 sec/egg
- ✓ machine capability 5 millions of female eggs per year
- ✓ Marketing
- ✓ Low throughput (1500 eggs/hours)
- ✓ Errors about 5%



How to determine sex in ovo

PLANTegg
In-Ovo
Détermination Du Sexe

PLANTegg– Gender sex specific PCR detection (https://www.plantegg.de/en/) (Germany)

- ✓ Méthod based on PCR of ADN present in allanatoic fluid At 9 days of incubation
- ✓ 3600 Eggs/hour
- ✓ error rate 0.5 %

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How to determine sex in ovo

Agri Advanced Technologies CHEGGY (https://www.agri-at.com/fr/produits/determination-du-sexe-in-ovo/cheggy/156-cheggy-downloads) (Allemagne)

- ✓ Hyperspectral technic (feather colour)
- ✓ 20 000 eggs/hour
- ✓ 10 millions eggs per year per machine
- ✓ The improvement of image analysis requires an analysis algorithm that learns and must be trained to reduce the error rate

- ✓ Non-invasive method usable at D13
- ✓ Usable ONLY on brown strains
- ✓ Sexing error < 2%.

How to determine sex in ovo

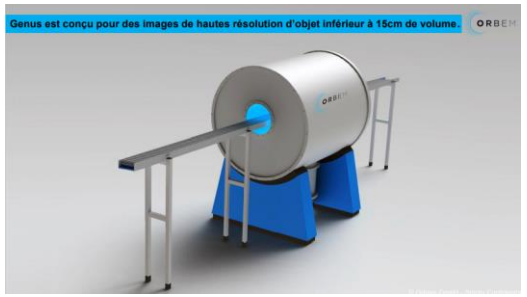
EggXYt – Genetic alteration (https://www.eggxyt.com/) (Israël)

- ✓ Genome editing
- ✓ Feasable the day of lay
- ✓ Fluorescent detection through the shell
- ✓ Transgenic chickens
- ✓ Accuracy 100 %
- ✓ Price ???

Very interesting because sexing before incubation!, But what is the acceptability of a GMO product?

How to determine sex in ovo

And a brand new method: MRI



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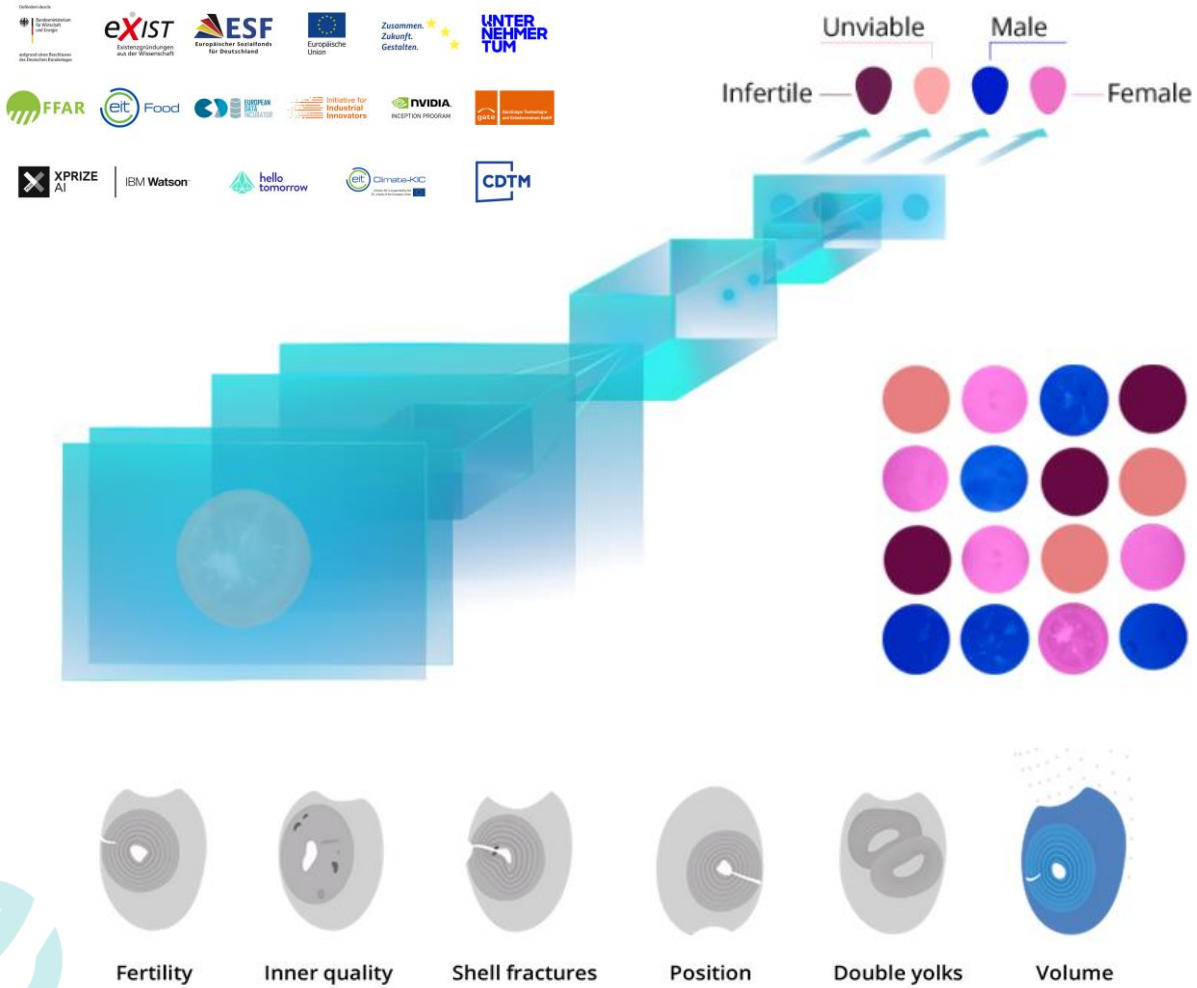

- Magnetic resonance imaging (medical apparatus)
- Non invasive
- Detection of infertile/non-viable
- Gonad detection at D**14-15**
- All genetics

- Under development
- First prototypes available in 2022 ??

Ovo-sexing cost estimate : 1 to 1,3€/layer
e.g. 0.3 à 0.4€ / 100 eggs

How to determine sex in ovo

Principle of the method			Technique	invasiveness / precision / capacity	Marketing
	stage	Structure			
Chromosomic	E9	Allantoïc liquid (200-300 µL)	PCR on cells suspended in allantoic fluid	**Invasive**, 97-99% **3000/h**	**PLANTegg** (Germany) ALDI
Molecular	E9	Allantoïc liquid	Determination of Metabolite	**Invasive**, 98%, In Ovo: **1500/h**	**In ovo** (Nederlands): Ella
Molecular	E9	Allantoïc liquid	Determination of oestrone sulphate (hormone ♀)	**Invasive**, 98%, SELEGGT: **3600/h**	**SELEGGT** (Germany)
Physiological /phénotypical	**E13**	Whole egg/ luminous flash	hyper-spectral imaging / feather colour	**Non invasive**, 95%, **20 000 /h** **Only brown lines**	**Agri Advanced Technologies** (Germany): Fermiers de Loué (LDC group, France) CHEGGY
Physiological /phénotypical	**E14-15**	Whole egg	Magnetic resonnace imagery	**Non invasive**,	**ORBEM** **AI-powered early-stage sexing is still under development and not commercially available.**
Genome editing	E0	Whole egg/ Transilllumination	Imaging by fluorescence of a molecule produced by males after editing	Non invasive 100 %	**EggXYT** (Israël) **Not Marketed**

Take-home messages

Few alternatives to the culling of male day-old chicks of layer lines:

- Increasing of laying period and use of molt cycles to reduce the number of births chickens for renewal
- Developing dual purpose chickens, but not for a mass market
- Strengthening the development of *in ovo* sexing processes

BUT

- Today whathever method used, no fast and robust method is fully operational
- A race against time: There is still an increased need for research and development before considering the industrial scale
- This change will be really challenging for producers with many technical and economical adaptations

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