



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

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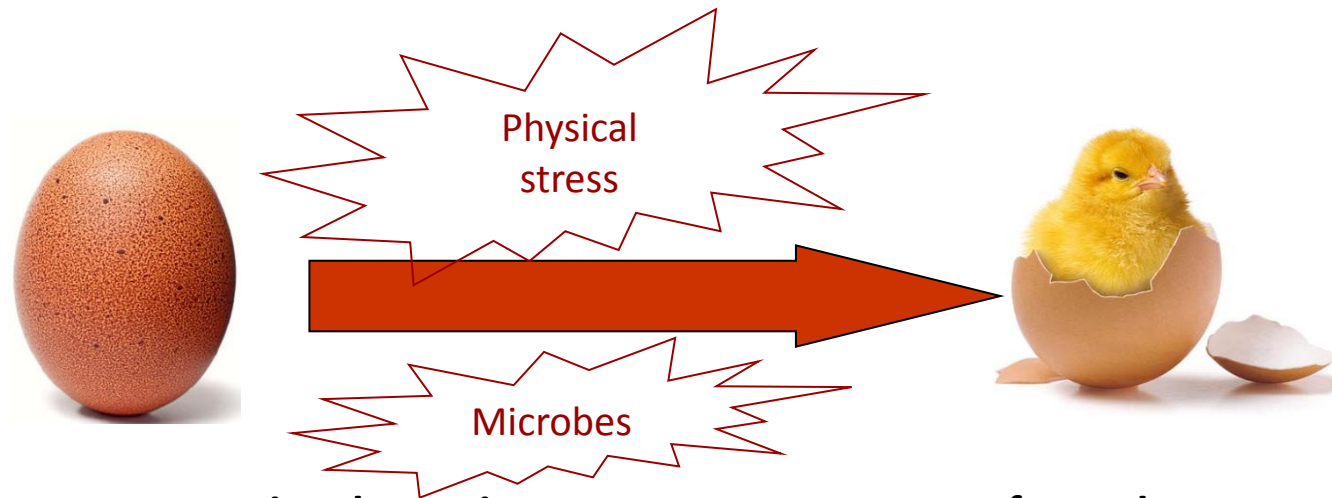
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# The chicken egg

**A Basic ingredient for human food**  
**The egg, an isolated chamber for embryo development**



**Must contains the entire components necessary for embryo**

- Well-balanced nutritious ingredients
- Lot of compound (> 1000) with a broad range of biological activities
- Protective systems (natural defenses)

Physical defense (Mainly shell)

Chemical defense (Proteins with antimicrobial activities)

# The chicken egg

A Basic ingredient for human food

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

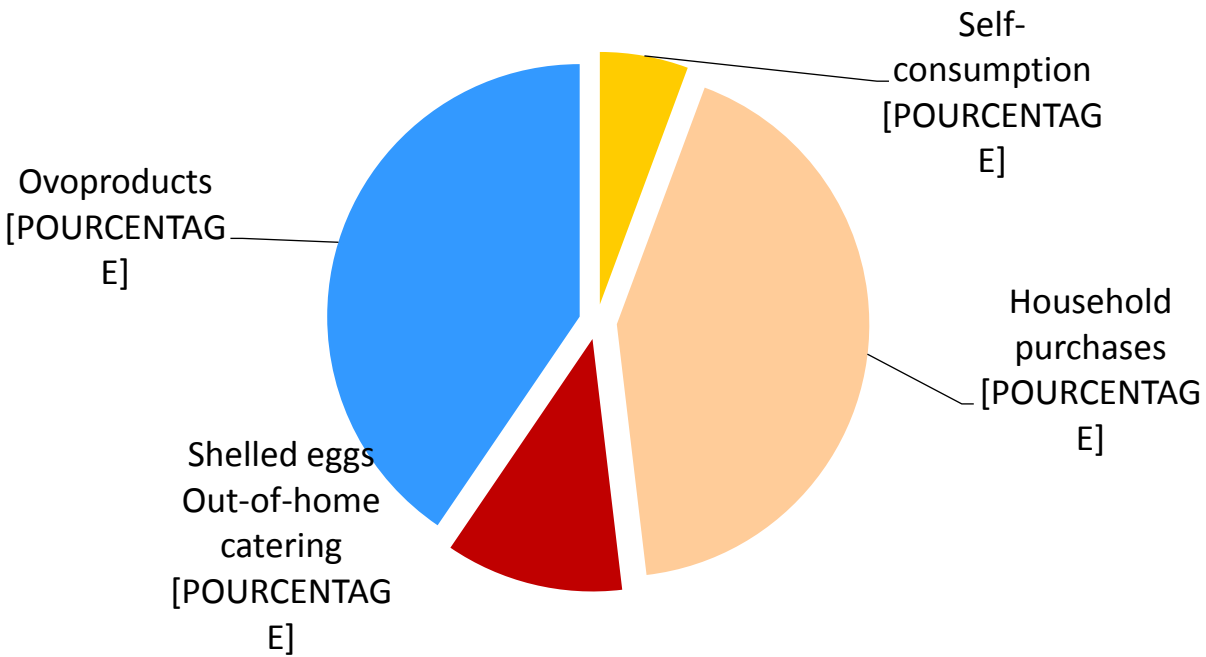


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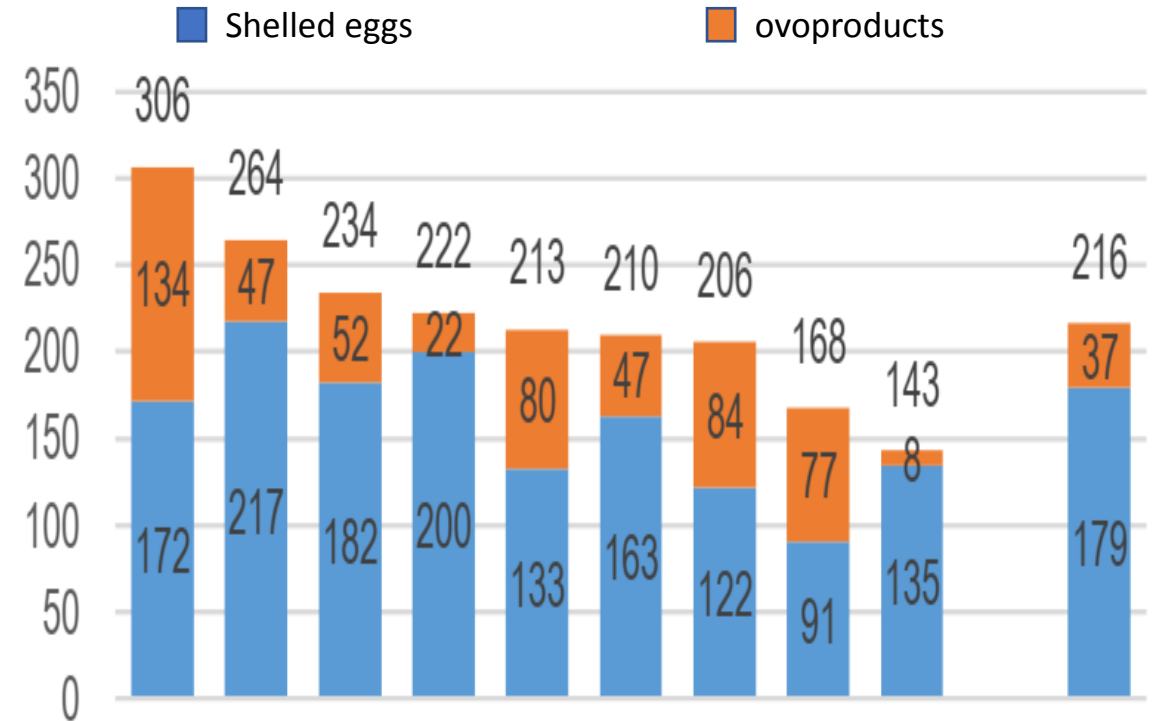


# Distribution of total French consumption

## Distribution of the French Consumption

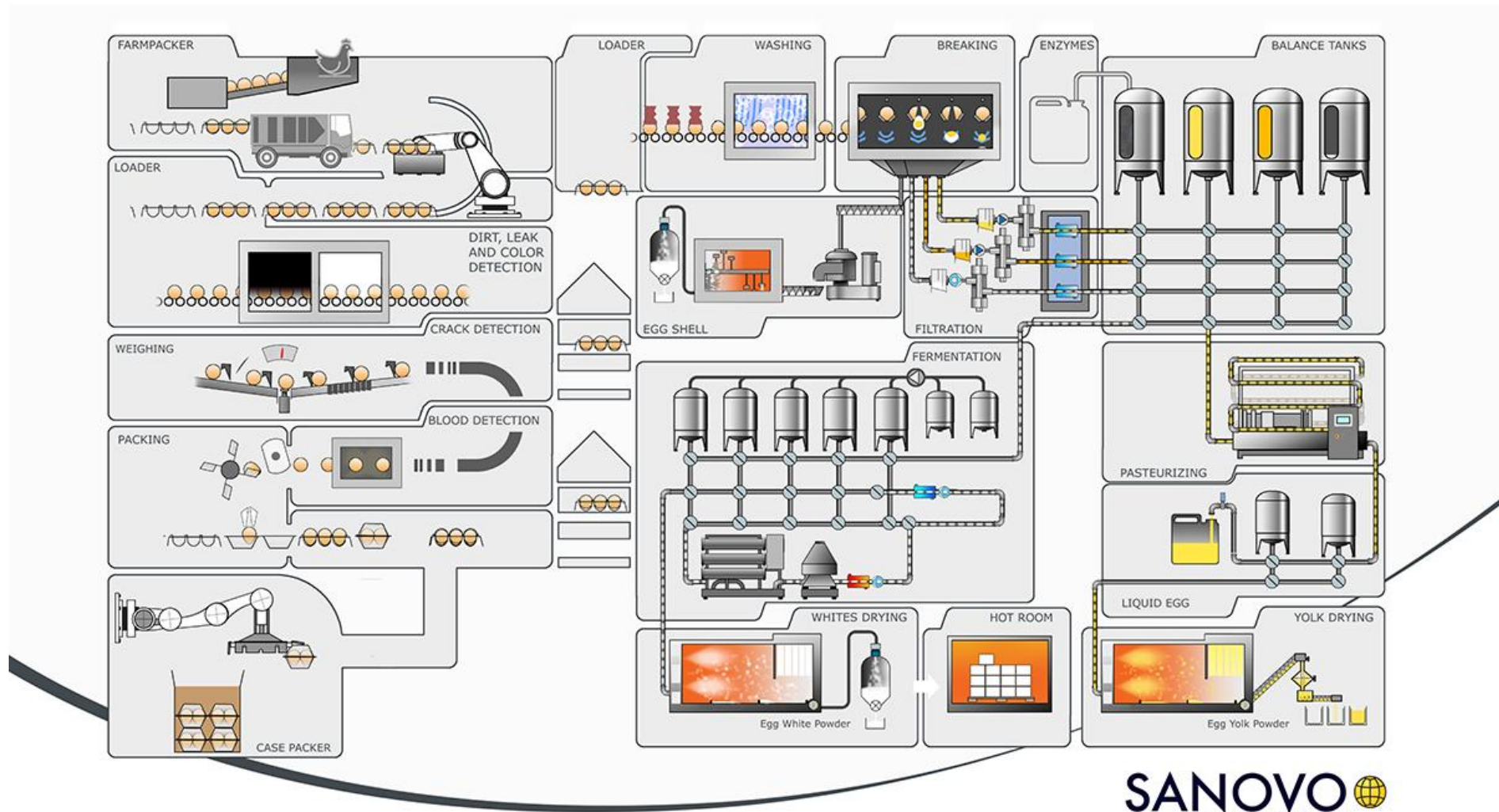


## Annual egg consumption in EC Countries



ITAVI d'après SSP, Kantar et Douanes

# The ovoproducts



shell eggs marketing

flow diagram for obtaining egg products

# Egg as nutritional ingredient for humans

## Nutritional characteristics for 2 eggs (100 g)

- **Calories : 155**

- **Total proteins: 12,3 g**

High quality biological value (reference WHO 100/ Cow milk 86)

- **Total lipids: 11,9 g**

- phospholipids rich: 31 % (soit 3,4 g)

- majority of unsaturated fatty acids

- cholesterol : 0,42 g (1,2 g / 100 g de jaune)

- High digestibility value : 98% Triglycerids, 90% Phospholipids

- **Vitamins rich:**

- A,D,E, B1, B6, B12, biotine (jaune), B2, folic acid, niacine (white)

- **Minerals:** phosphorus, iron and sulfur

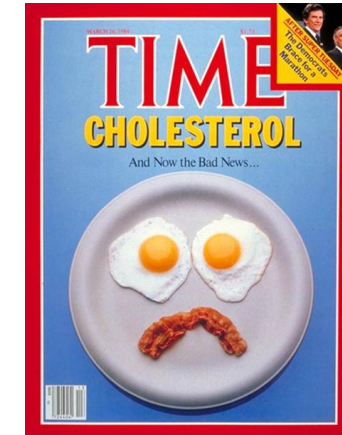
# The egg composition is well adapted for human consumption

## ➤ Egg as a food

- A bad reputation for table eggs

Why this bad reputation ?

- 1968, the american heart association mentioned that no more 3 eggs per a week must be ingested → suspected association between dietary and blood cholesterol
- 1984, March 26th, time magazine's front page is devastating to the egg's reputation
- Since 1995, the recommendations have changed following the results obtained in vitro and in vivo
- **Dietary cholesterol is not associated with blood cholesterol, but with dietary intake of saturated fatty acids** (Myristic acid (14:0) and palmitic acid (16:0))



# The egg composition is well adapted for human consumption

## ➤ Egg as a food

### • Nutritional characteristics of eggs

- Dietary intake of linoleic acid (C18:2 n-6) lowers blood cholesterol and alpha-linoleic acid (C18:3 n-3) reduces the risk of cardiovascular disease
- In eggs, saturated fatty acids including myristic acid (14:0) are low and unsaturated fatty acids including linoleic acid are high (1.38 g/100g).

Name	Average Content (g/100g)
FA saturated	2.64
FA 4:0	<0.05
FA 6:0	<0.05
FA 8:0	<0.05
FA 10:0	<0.05
FA 12:0	<0.05
FA 14:0	0.024
FA 16:0	1.96
FA 18:0	0.65
FA monounsaturated	3.66
FA 18:1 n-9 cis	3.51
FA polyunsaturated	1.65
FA 18:2 9c,12c (n-6)	1.38
FA 18:3 9c,12c,15c (n-3)	0.061
FA 20:4 5c,8c,11c,14c (n-6)	0.12
FA 20:5 5c,8c,11c,14c,17c (n-3) EPA	0
FA 22:6 4c,7c,10c,13c,16c,19c (n-3) DHA	0.09
Cholesterol	0.398

Réhault-Godbert et al 2019; Nys et al., 2018; Griffin 2011, Miranda et al., 2015; Hayes et al., =1992; Pronczuk et al., 1994



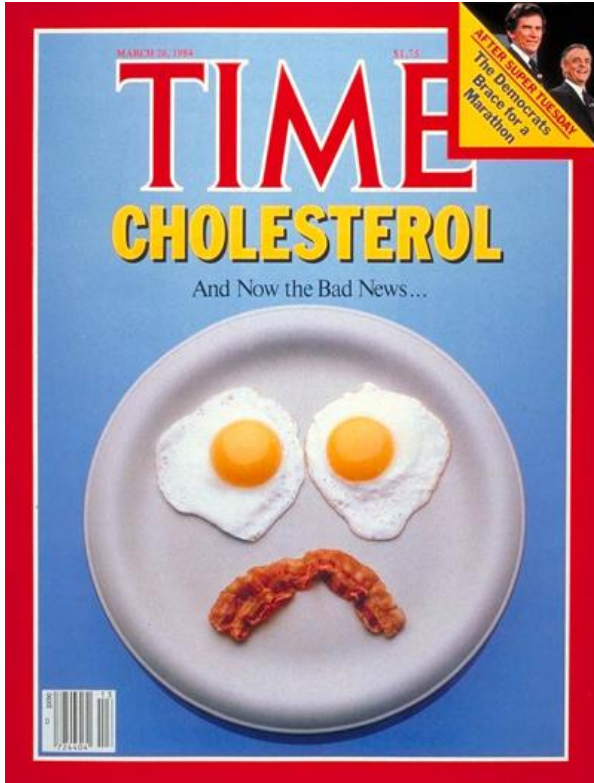
# Egg as nutritional ingredient for humans

## Egg and Cholesterol

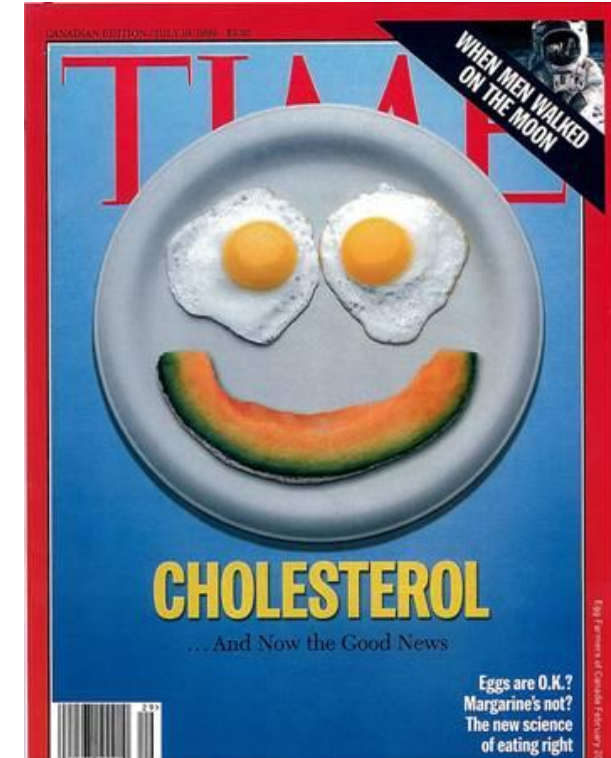
Can we eat eggs every day?

**Yes**, studies have shown that if cholesterol levels are normal, you can eat many eggs a day without affecting cholesterol levels.

If your cholesterol level is high, you should reduce your intake to 4 per week by cutting down on other sources of animal protein and fats.



26 mars 1984



19 juillet 1999

# Table Egg production

# Hystory 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".

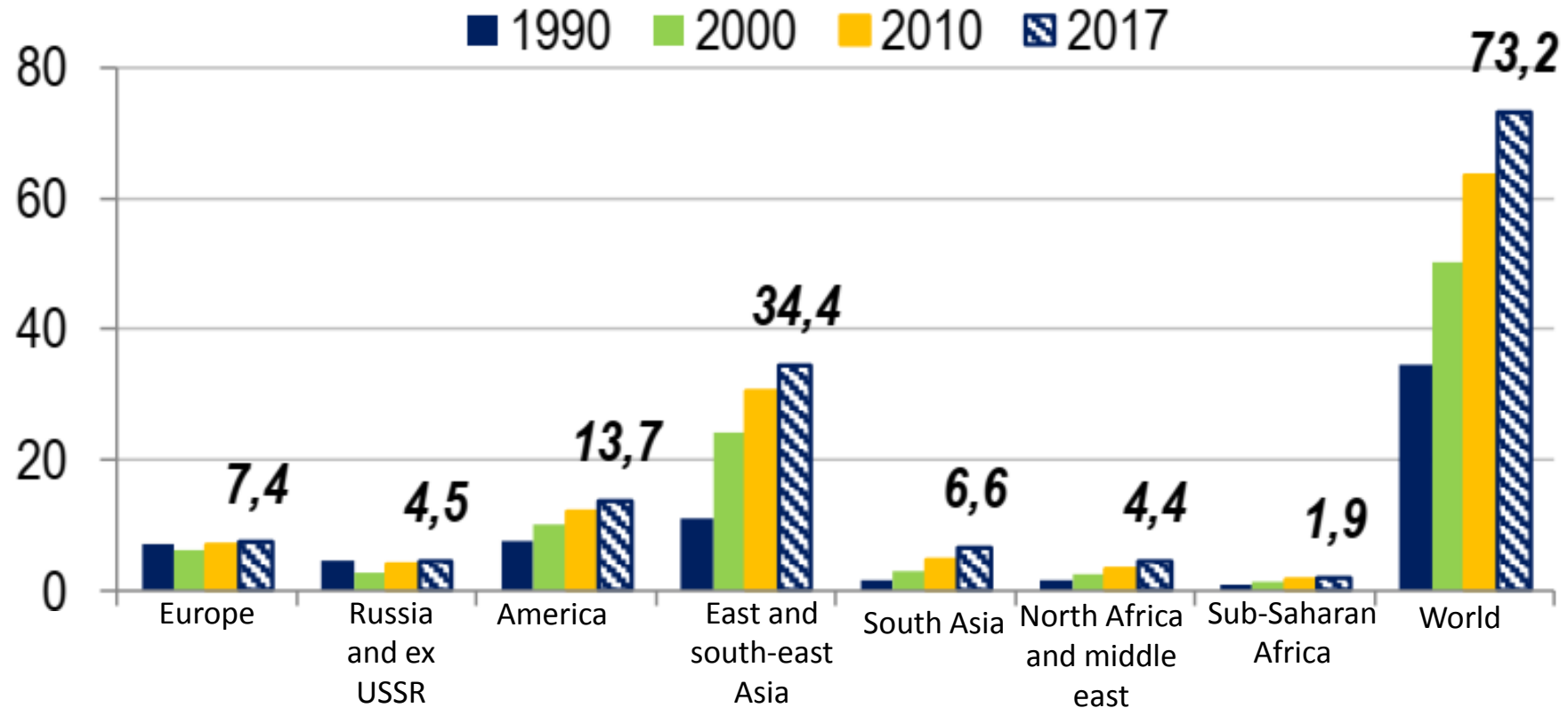
# Eggs and chicken strains



## Table eggs

A basic ingredient for human consumption

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



# Hystory 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.

# Eggs and layers

## Health, economic and ethical issues



### **Table eggs**

14,7 billions eggs per year in France  
>1400 Billions eggs in the world

A basic ingredient for human consumption

- ✓ Risks of toxi-infections for the consumer (Salmonellosis)
- ✓ Economic losses (about 8%): downgraded eggs linked to degraded egg qualities (dirty, cracked or broken shells, poor internal qualities leading to problems of white/yolk separation)



### **Hatchery eggs**

1,1 billion eggs per year in France

Close and self sufficient chamber to allow the development of the chicken

- ✓ 10% clear eggs (absence of fertilization, embryonic mortality)
- ✓ Elimination of male chicks from the laying strain (early in ovo sexing)

# Egg production system in Europe

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

### Rules for rearing of hens

Enriched cages

Alternative systems

Code 3: **Cage fitted with new standards**

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**



# Egg production system in Europe

Code 3: Cage fitted with new standards



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



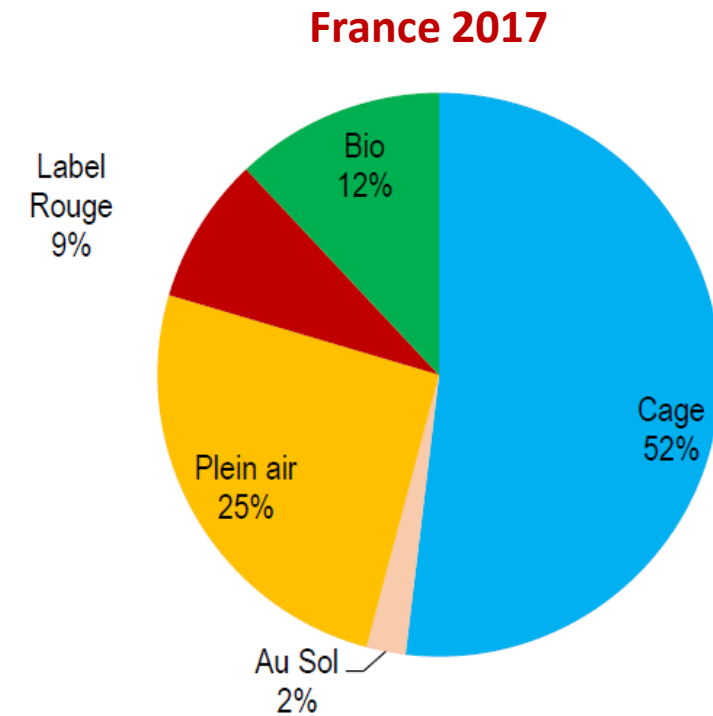
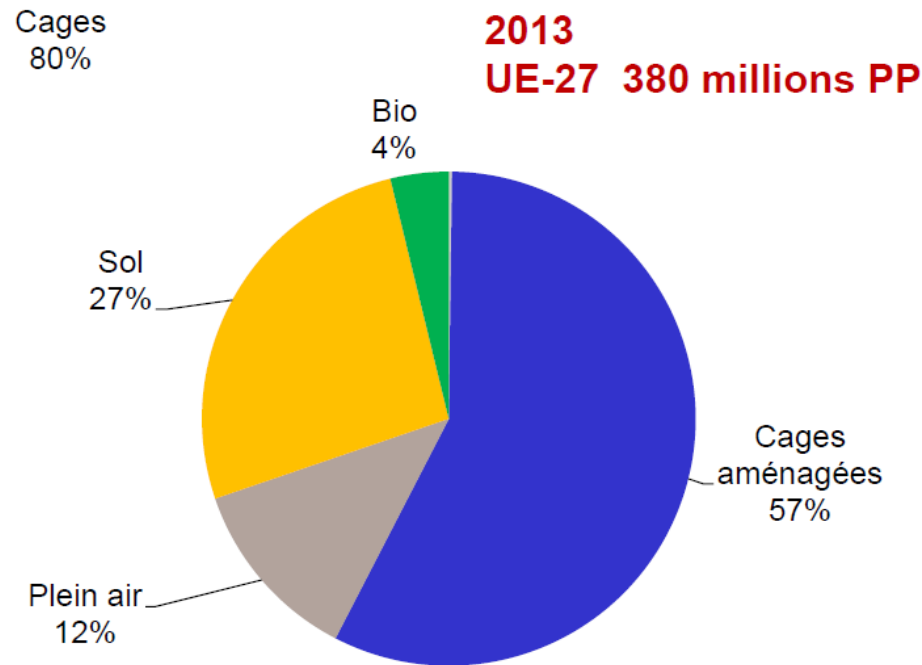
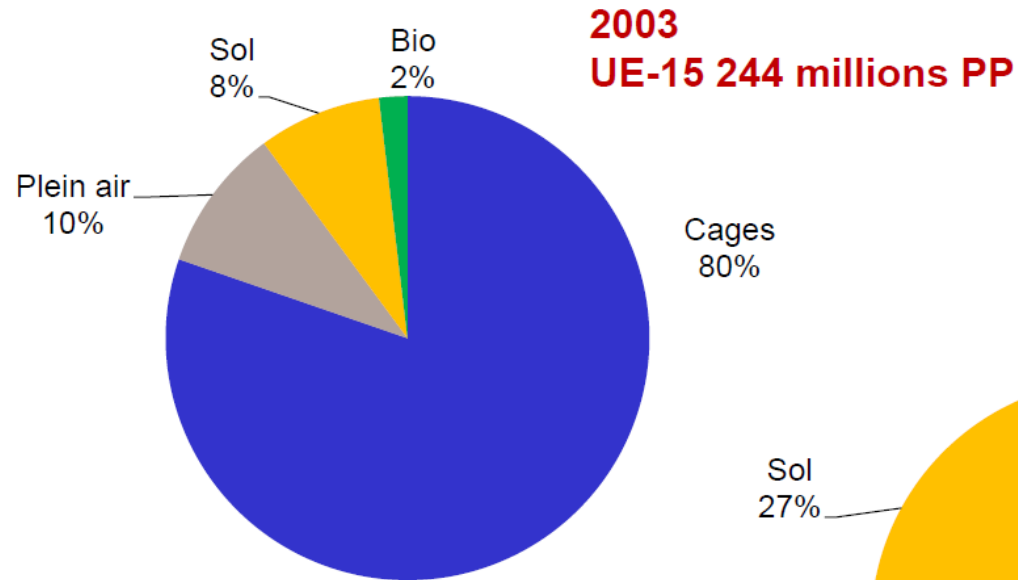
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Code 1: Aviary or ground + outdoor access + Organic production (code 0)



# Evolution of egg production systems in UE

## Evolution of egg production systems in Europe



Source Commission européenne



**And Now ?**  
**Egg in the next decade ?**

# 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**

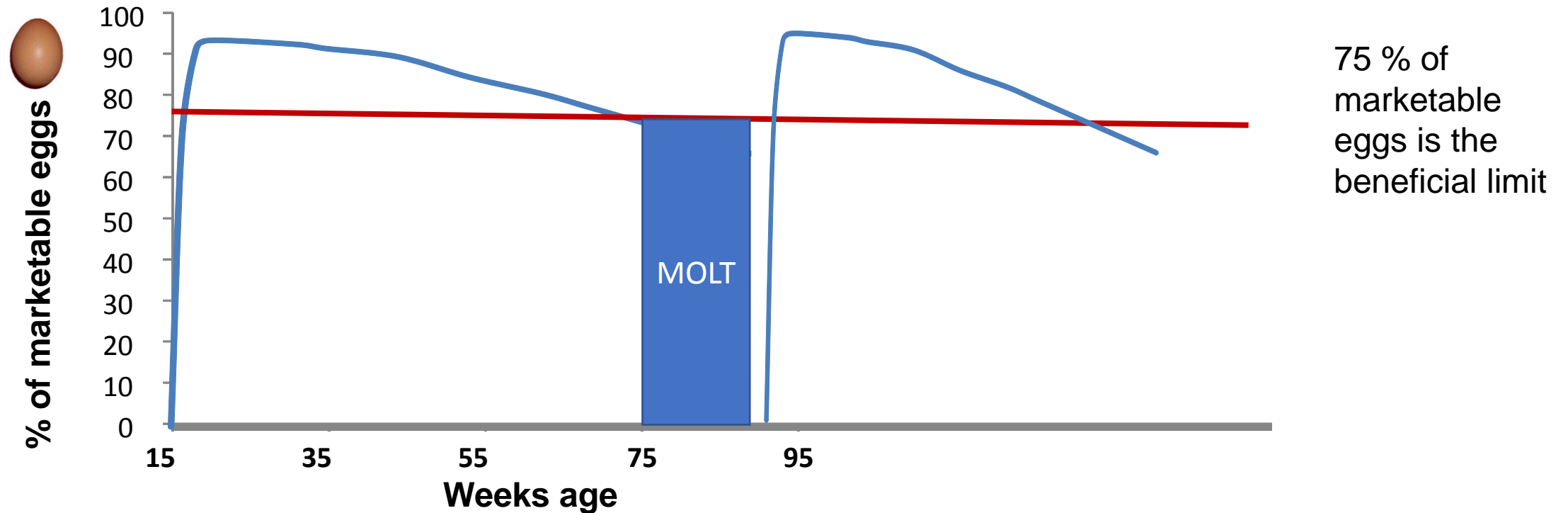


**Ethical and societal concern**

## Alternatives ?

# 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

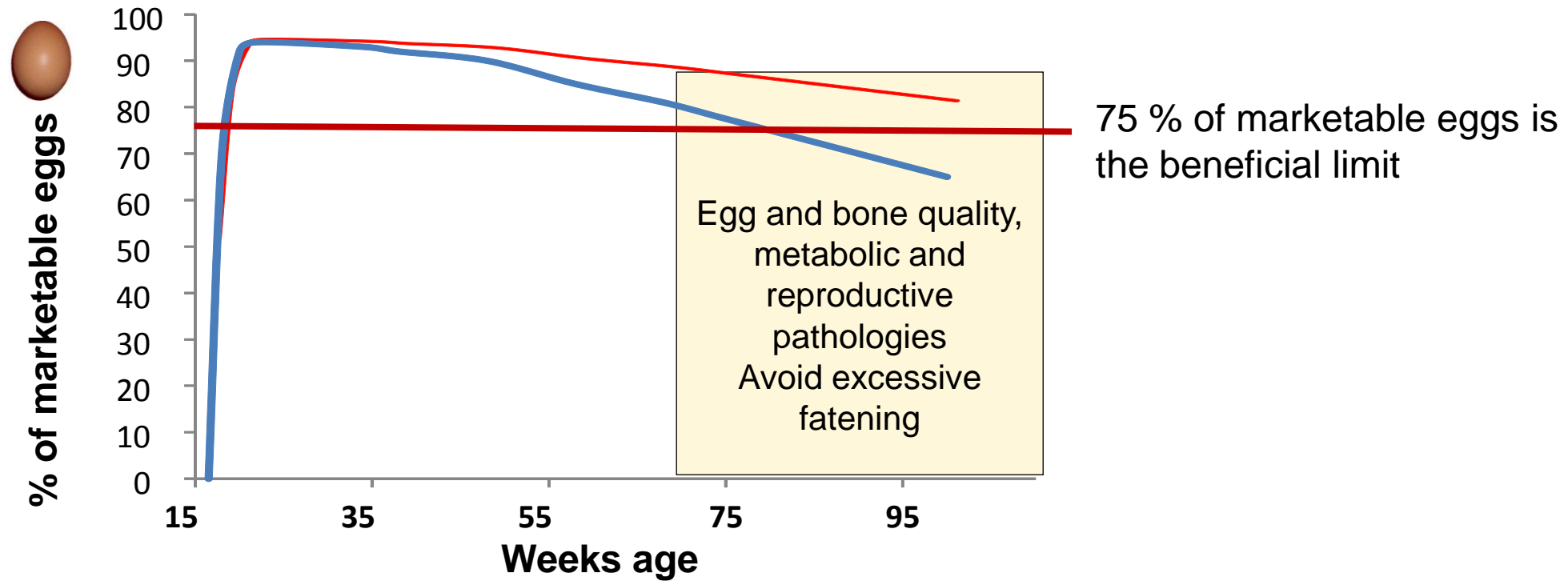
→ Need to induce artificial molt with water and feeding privation not allowed in

EU

Research is needed to induce moulting while respecting animal welfare

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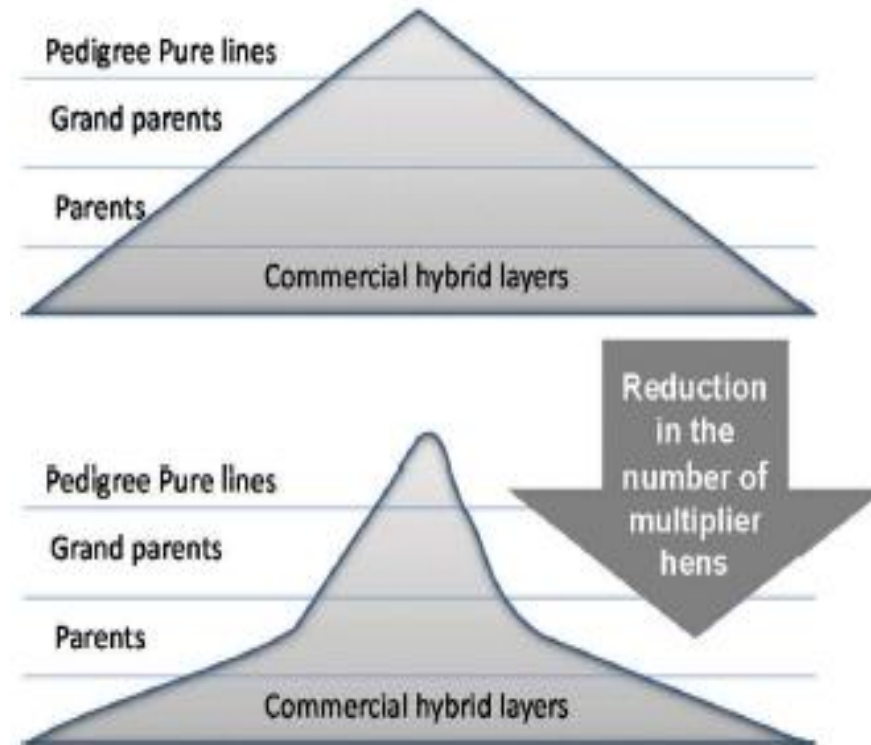
# Increasing persistency of laying hens



# Increasing persistency of laying hens

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. »



# 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 ?



Males are reared for  
meat production

Low meat yield  
Different meat texture (consumer education)



Unfavorable  
environmental impact

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

# 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.**



# How to determine sex in ovo

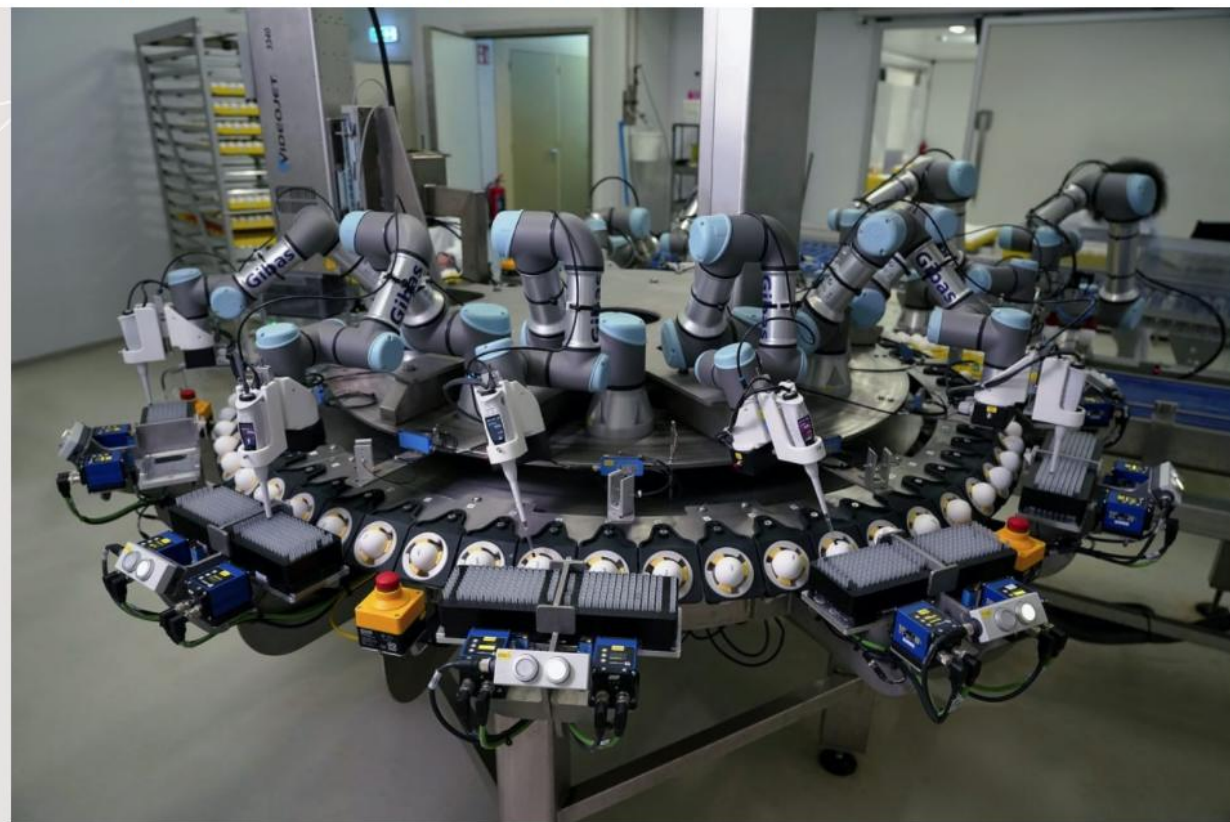
- Destructives and non destructive methods
- Biological approaches
  - Hormonal detection
  - Metabolite marker detection
- Physicochemistry approaches
  - Dimorphic volatile odors between male and females
- Physical and optical approaches
  - FTIR spectroscopy
  - Raman spectroscopy
  - Magnetic resonance imaging
  - Hyperspectral analysis
- Genetic engineering
  - Genome editing

# How to determine sex in ovo



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

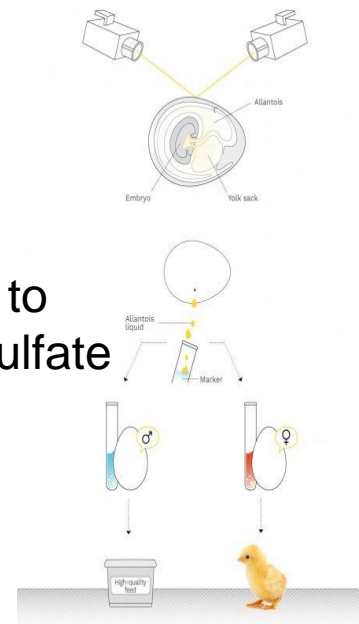
## THE SELEGGT PROCESS



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.

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- ✓ 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%
- ✓ Prototype développé
- ✓ Almost 100 000 eggs already hatched
- ✓ Price 1-3 cents per egg, 7 Euros per pullet
- ✓ Low throughput of approximately 1 to 3000 eggs/hour

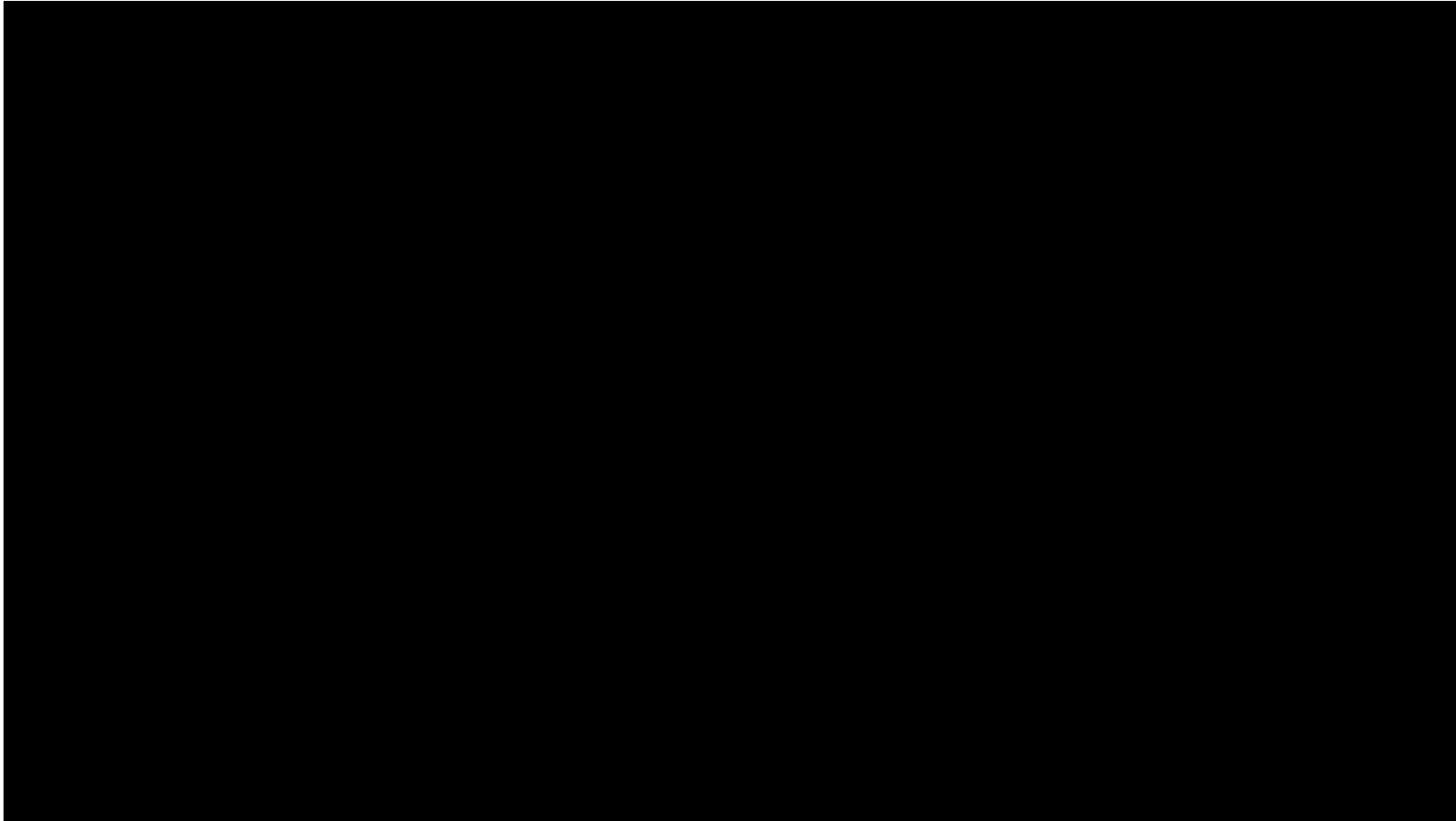
# Comment déterminer le sexe *in ovo*



*In ovo – Biomarker detection* (<https://inovo.nl/solutions/in-ovo-egg-sexing/>) (Netherlands)

- ✓ H NRM spectroscopy
- ✓ Fast 2 sec/oeuf

- ✓ Marketing
- ✓ Low throughput (1500 eggs/hours)

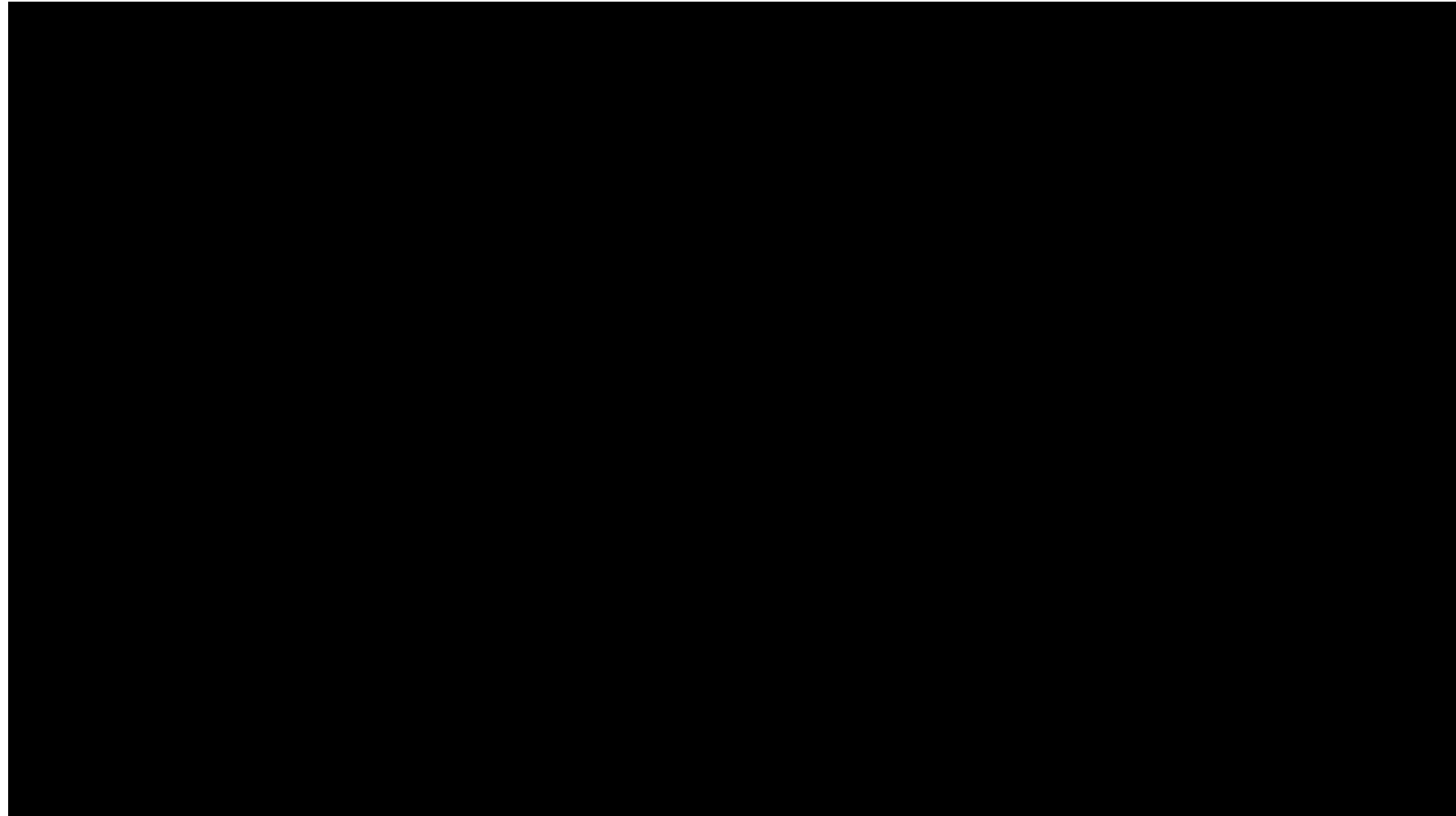


# Comment déterminer le sexe *in ovo*



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

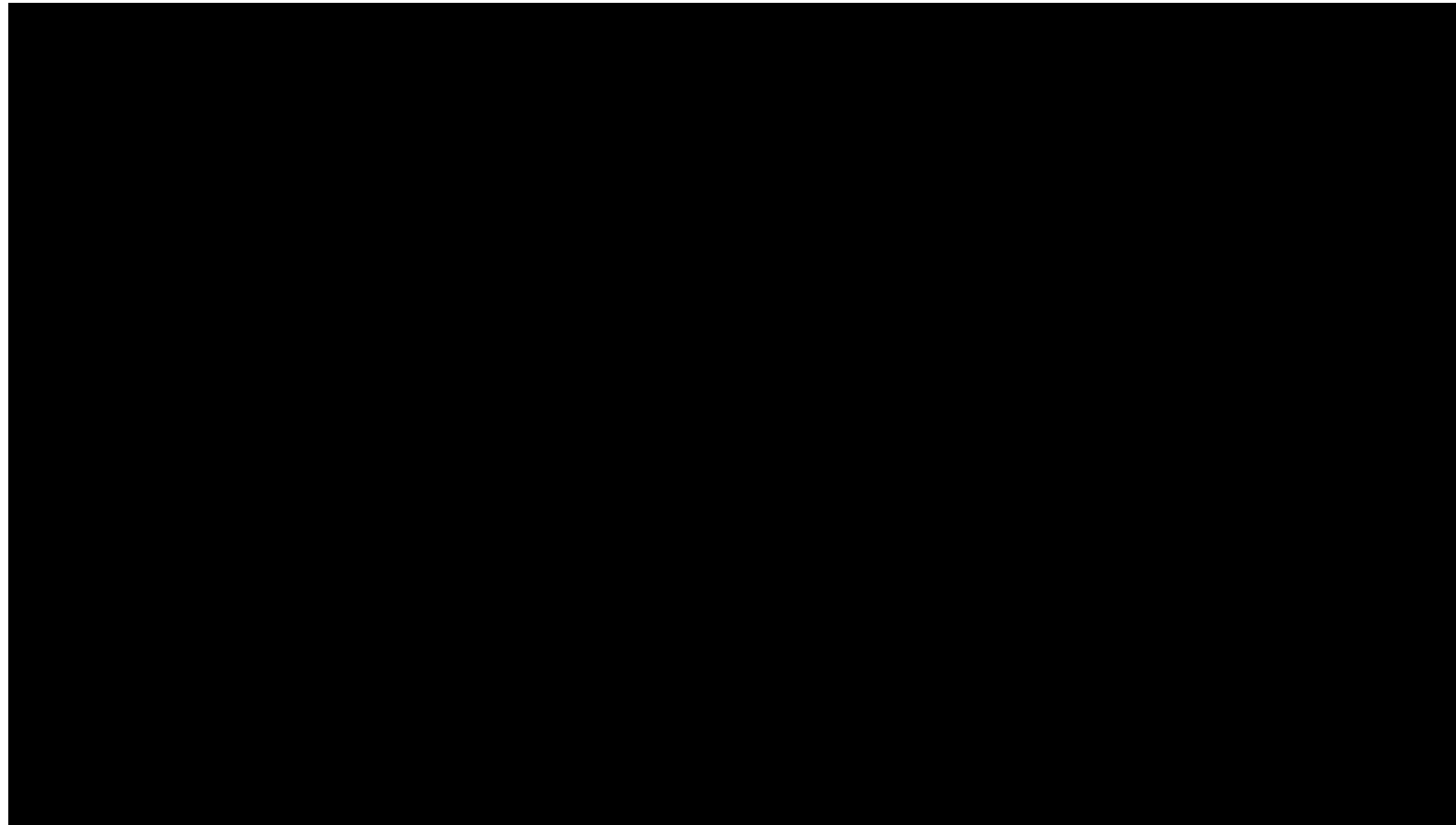
- ✓ Hyperspectral technic (feather colour)
- ✓ 20 000 eggs/hour



# Comment déterminer le sexe *in ovo*

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

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



# How to determine sex in ovo

Principle of the method			Technique	invasiveness / precision / capacity	Marketing
	stade	Structure			
<b>Chromosomic</b>	E9	Allantoïc liquid (200-300 µL)	PCR on cells suspended in allantoic fluid	<b>Invasive</b> , 97-99% <b>3000/h</b>	<b>PLANTegg</b> (Allemagne) En cours (ALDI)
<b>Molecular</b>	E9	Allantoïc liquid	Determination of oestrone sulphate (hormone ♀)	<b>Invasive</b> , 98%, SELEGGT: <b>3600/h</b> In Ovo: <b>1500/h</b>	<b>SELEGGT</b> (Allemagne) <b>In ovo</b> (Pays-Bas): Machine= Ella
<b>Physiological /phénotypical</b>	<b>E13</b>	Whole egg/ luminous flash	hyper-spectral imaging / feather colour	<b>Non invasive</b> , 95%, <b>20 000 /h</b>	<b>Agri Advanced Technologies</b> (Allemagne): Fermiers de Loué  Machine: CHEGGY
<b>Genome editing</b>	E0	Whole egg/ Transillumination	Imaging by fluorescence of a molecule produced by males after editing	Non invasive 100 %	<b>EggXYT</b> (Israël)

# Alternatives? 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 whatever method used, no fast and robust method is fully operational
- A race against time: There is 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