How to improve performance at all levels in the broiler chain?

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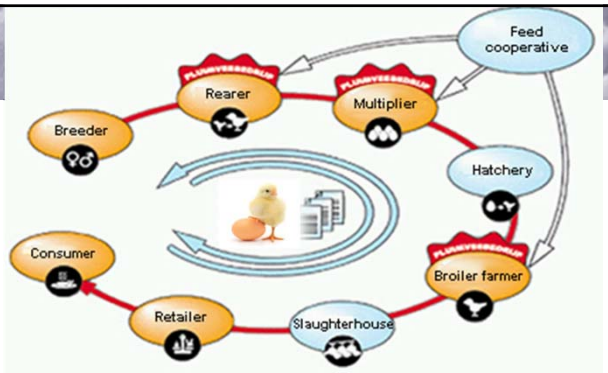
Colombia mevea



Healthy Chicken in Healthy Chicken Chains

1. Good farming and management practice at all levels
2. Open information exchange
3. Upstream Quality Investments
4. Right incentives
5. Return on investments

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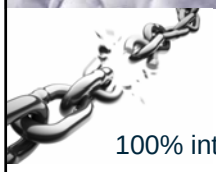

100% integrated broiler meat chain with top-down control

- Central management and planning: quick introduction of new concepts is possible
- Identical farm management
- Farmers do as told; creativity at low level
- Constant and average results; little variation between farms

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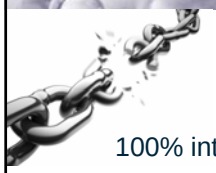

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Independent farmers per chain (Dutch situation)

- Optimisation of own company results
- Specialised and innovative farmers
- Good and poor production farms; more variation between farms

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In both cases, all sectors depend on each other for good results

Many factors influence the down stream technical and financial results

Upstream quality improvements can be lost due to down stream failures

- Breeder rearing and production management, hatching egg quality, storage quality and incubation process affect chick numbers, chick quality and technical performance
- Additional, cumulative effects!

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Large effect of broiler breeder management on offspring performance

- Zoötechnial factors
- Veterinary factors

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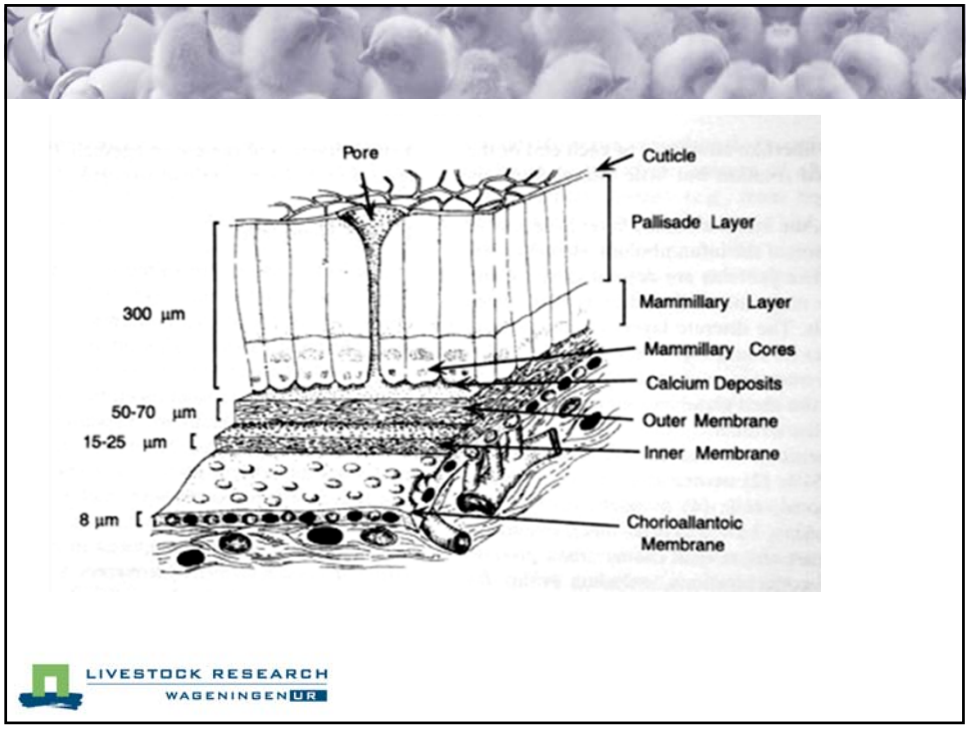
Pore
Cuticle
Palisade Layer
Mammillary Layer
300 µm
Mammillary Cores
Calcium Deposits
50-70 µm
Outer Membrane
15-25 µm
Inner Membrane
8 µm
Chorioallantoic Membrane
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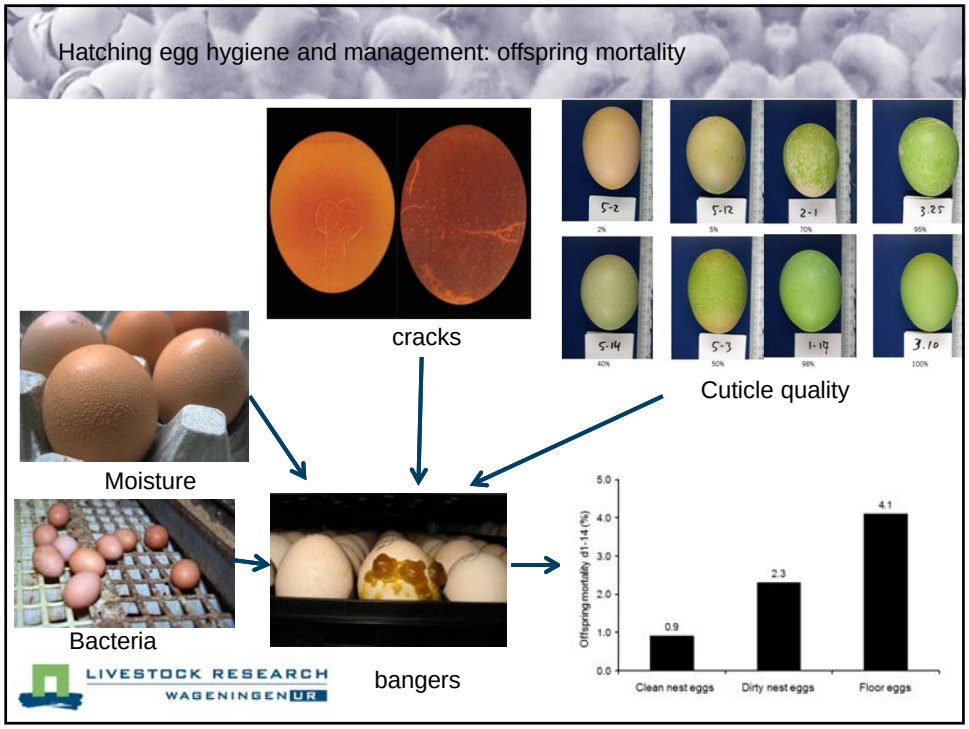
Hatching egg hygiene and management: offspring mortality
cracks
Cuticle quality
Moisture
Bacteria
bangers
Offspring mortality d1-14 (%)
0.9
2.3
4.1
Clean nest eggs
Dirty nest eggs
Floor eggs
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Most effective bacterial penetration across the eggshell:

- Temperature gradient / egg content shrinks by cooling
- Moisture (manure / washing / condensation)
- First minute after lay when the cuticle is still soft
- No cuticle
- Cracks!

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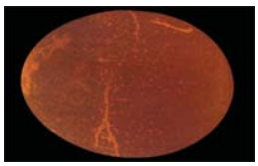
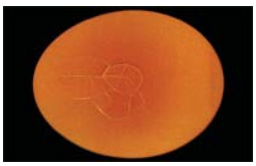
Table 4. Effect of eggshell crack type on infertility, embryo mortality, and contamination.

Treatment	Infertility (%)	Embryo mortality					
		1-8 days (%)	9-17 days (%)	18-19 days (%)	20-21 days (%)	Total embryo mortality (%)	Contamination (%)
Normal	2.22[c]	10.55[c]	0.55[b]	0.55[b]	1.66	13.32[c]	2.77[c]
Star cracks	10.55[b]	23.32[b]	9.44[a]	2.77[ab]	1.1	36.65[b]	6.66[b]
Hairline cracks	16.66[a]	33.88[a]	8.32[a]	5.55[a]	3.32	51.09[a]	10.55[a]
SEM	1.88	2.93	1.68	1.28	0.81	3.14	1.242
P-value	0.0006	0.0004	0.0055	0.0522	0.177	0.0001	0.003

[a-c]: Means within a column without a common superscript differ significantly ($P \leq 0.05$).





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Khabisi et al., 2012

Table 1 Comparison of the microflora on the surface of the egg and within spoiled eggs (Mayes and Takeballi, 1983).

Type of organism	Frequency of occurrence[a]	
	On the shell	In rotten eggs
Micrococcus	+++	+
Achromobacter	++	+
Aerobacter	++	-
Alcaligenes	++	+++
Arthrobacter	++	+
Bacillus	++	+
Cytophaga	++	+
Escherichia	++	+++
Flavobacterium	++	+
Pseudomonas	++	+++
Staphylococcus	++	-
Aeromonas	+	++
Proteus	+	+++
Sarcina	+	-
Serratia	+	-
Streptococcus	+	+

[a] The more plus signs, the more frequent the occurrence

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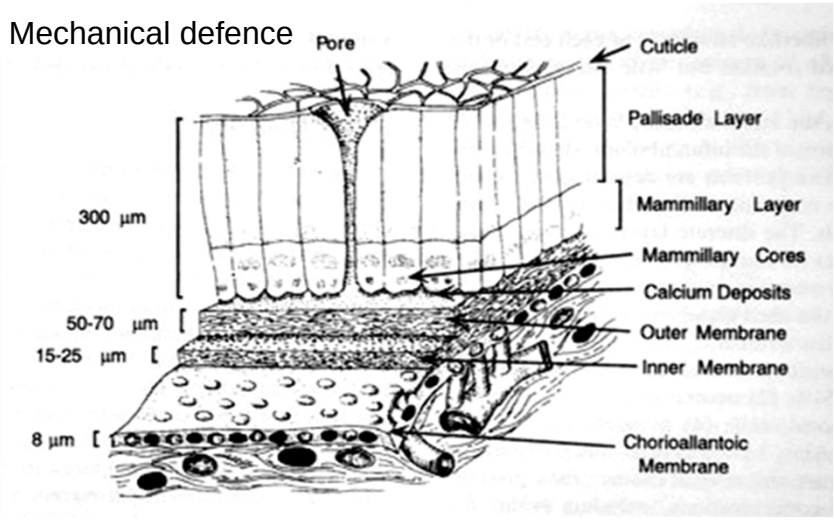
Mechanical defence



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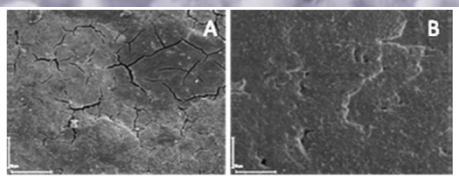
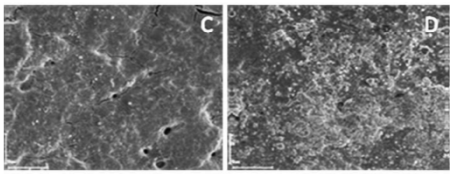
Good cuticle coverage:
cracked mud



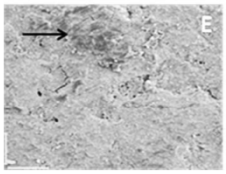
No cuticle

Poor cuticle coverage:
pores visible



Surface debris

Mechanical abrasion
(use of sand paper)



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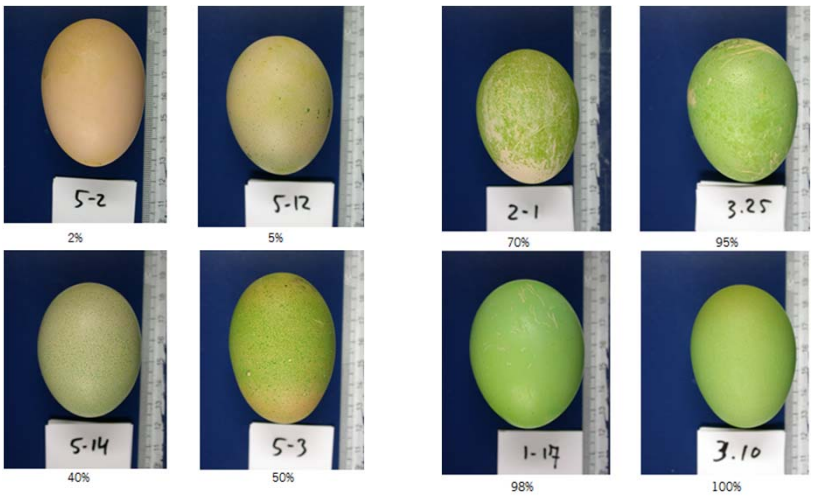
Leleu et al., 2011
Effects of washing / sanitation?



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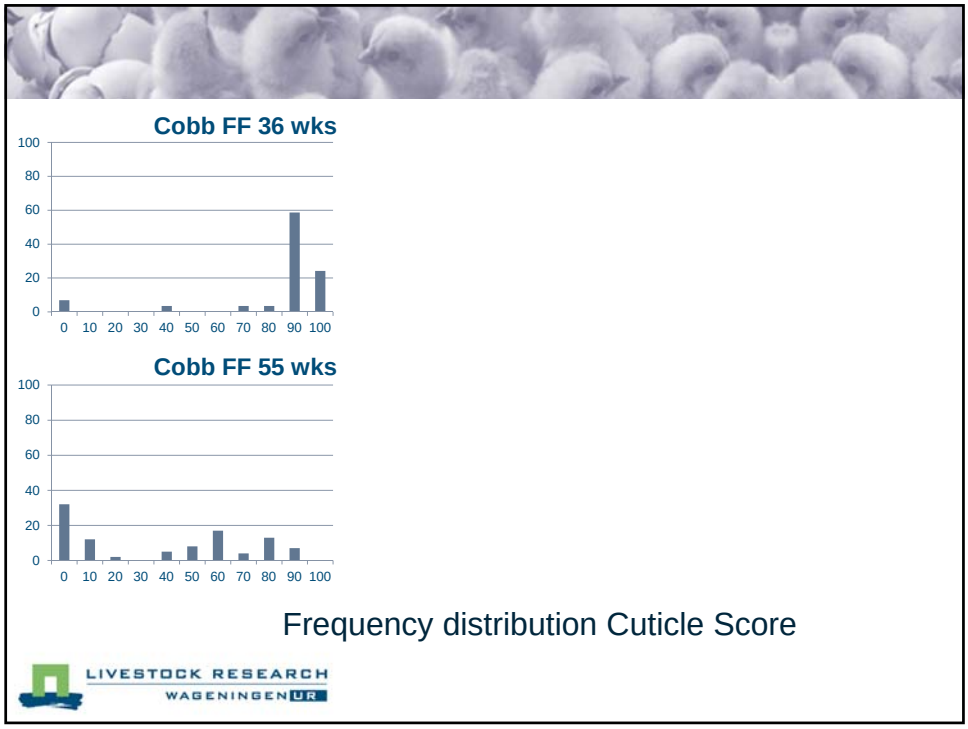
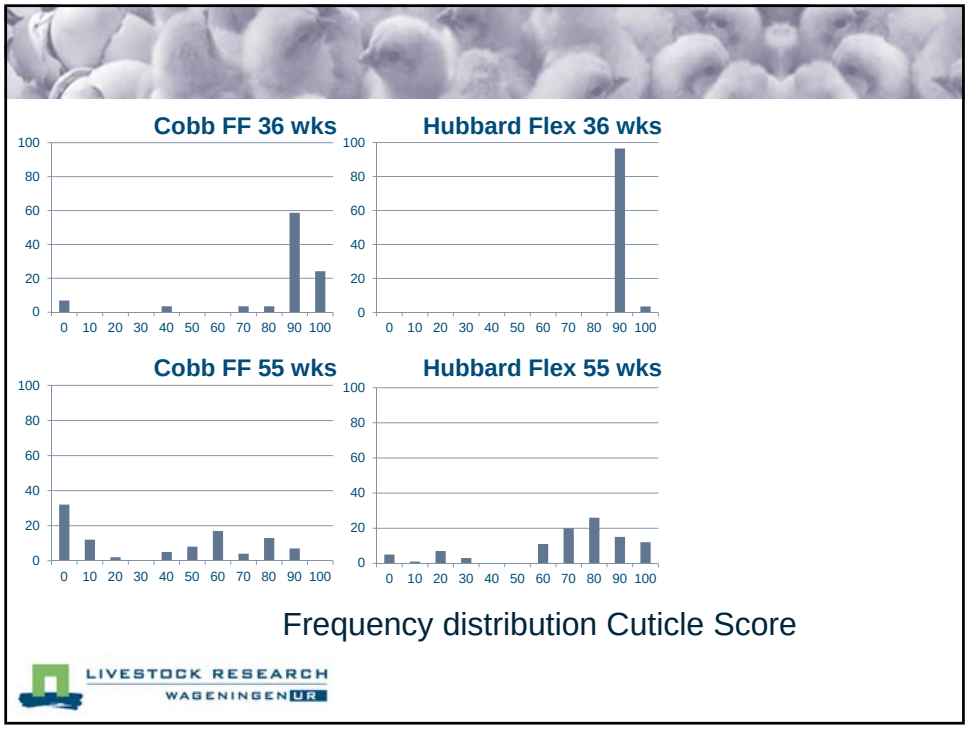
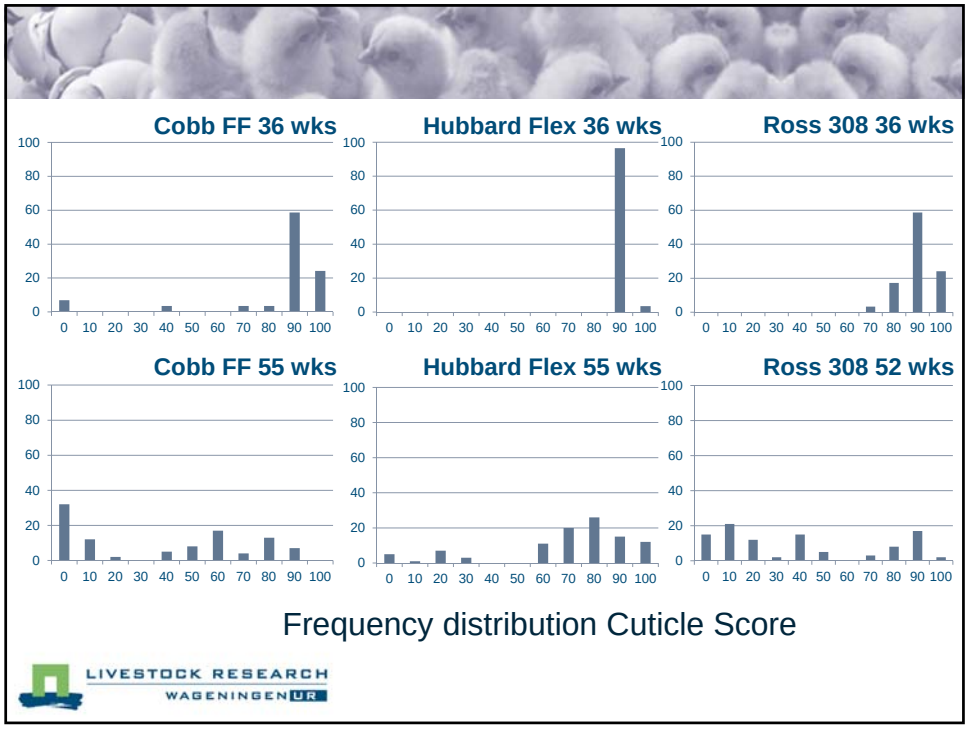
1 minute in aquaous solution of 1% Edicol Pea Green
(Board en Halls, 1973).


Cobb FF 36 wks
100
80
60
40
20
0
0 10 20 30 40 50 60 70 80 90 100
Cobb FF 55 wks
100
80
60
40
20
0
0 10 20 30 40 50 60 70 80 90 100
Frequency distribution Cuticle Score
LIVESTOCK RESEARCH
WAGENINGEN UR


Cobb FF 36 wks
Hubbard Flex 36 wks
Cobb FF 55 wks
Hubbard Flex 55 wks
100
80
60
40
20
0
0 10 20 30 40 50 60 70 80 90 100
Frequency distribution Cuticle Score
LIVESTOCK RESEARCH
WAGENINGEN UR


Cobb FF 36 wks
Hubbard Flex 36 wks
Ross 308 36 wks
Cobb FF 55 wks
Hubbard Flex 55 wks
Ross 308 52 wks
0 10 20 30 40 50 60 70 80 90 100
0 20 40 60 80 100
Frequency distribution Cuticle Score
LIVESTOCK RESEARCH
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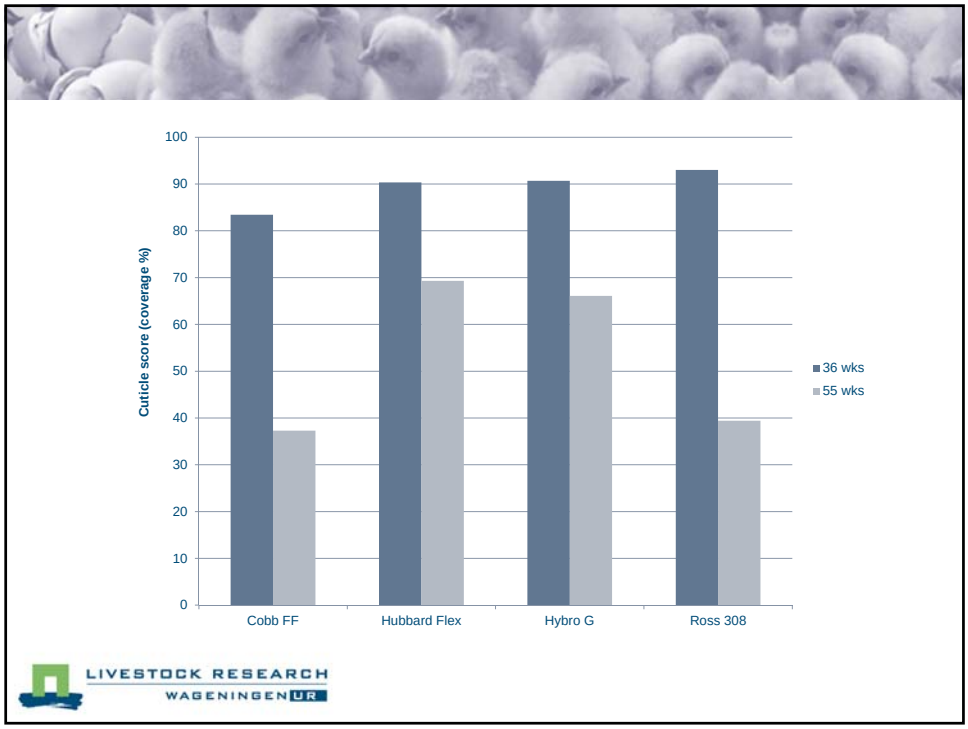
Cuticle score (coverage %)
0 10 20 30 40 50 60 70 80 90 100
Cobb FF
Hubbard Flex
Hybro G
Ross 308
36 wks
55 wks
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Table 1—Effect of cuticle on spoilage of eggs after infection with Pseudomonas aeruginosa

Treatment	Trial	Spoilage time, days 3	5	7	9	11	15	20	25	30
		Percentage of spoilage								
Normally laid	1	—	—	—	—	7	28	57	80	93
	2	—	—	3	8	22	37	71	91	100
Eggs from uterus	1	8	35	41	47	64	98			
	2	43	61	74	89	100				
	3	38	50	68	86	91	100			
Shell-less eggs	1	100								
	2	100								
EDTA Treated eggs	1	—	12	28	45	62	82	100		
	2	—	18	32	51	70	86	100		

Vadhera et al., 1970

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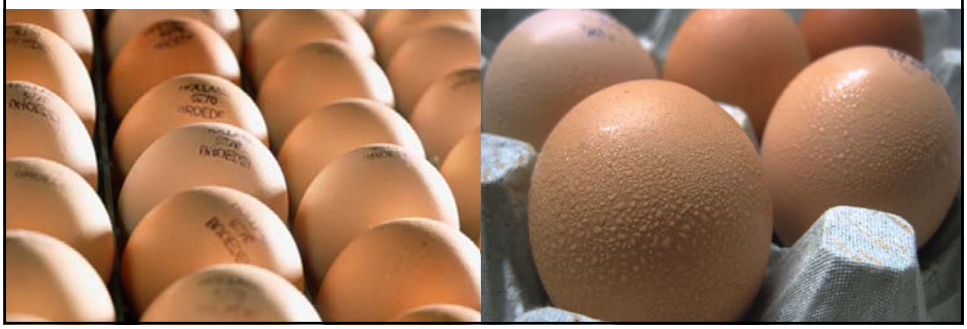
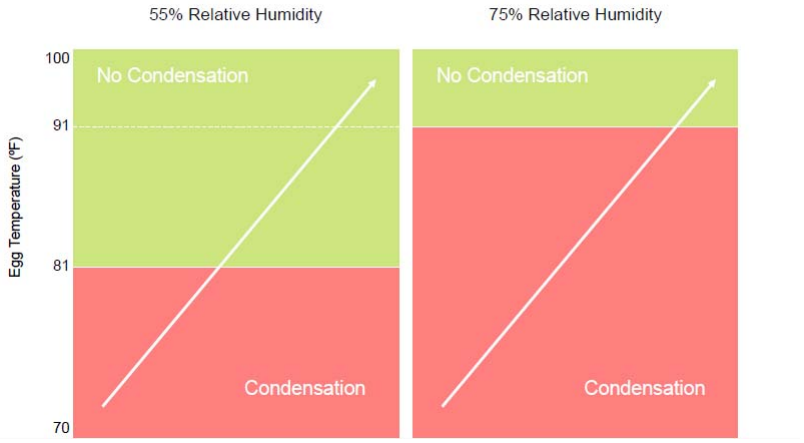
Eggs will 'sweat' if the relative humidity (% RH) outside the storage room is higher than:				
Temperature of storage room[1]	Temperature outside the storage room			
	15 °C	18 °C	21 °C	24 °C
21 °C	...	...	...	> 85 % RH
18 °C	...	...	> 83 % RH	> 71 % RH
16 °C	...	> 89 % RH	> 74 % RH	> 60 % RH
11 °C	> 74 % RH	> 64 % RH	> 53 % RH	> 44 % RH

[1] *Assuming that the temperature of the eggs equals the temperature of the egg storage room.*



Risk of Condensation as Eggs are brought to Incubation Temperature with 100°F Air Temperature



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www.dpcalc.org

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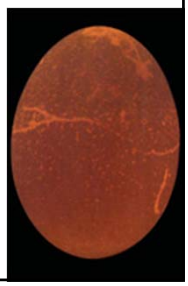
Table 1. Hatchability results of broiler breeder hatching eggs with normal intact shell, untreated hairline-cracked shell and covered hairline-cracked shell

Properties	Fertility (n/100 eggs set)	Hatchability (chicks /100 eggs set)	Hatchability (chicks/100 fertile eggs)
Intact shell egg	93.50±0.7^{a}	86.16±1.0^{a}	92.14±0.6^{a}
Hairline cracked-egg	85.15±1.5^{b}	25.84±2.4^{c}	30.17±2.3^{c}
Covered egg	87.16±1.0^{b}	64.67±1.5^{b}	74.24±2.0^{b}
Significance (P)	**	***	***

: P<0.01,*P<0.001, *^{c}: Mean values with different superscripts within a line differ significantly.

Mean ± S.E.



Simsek, 2009

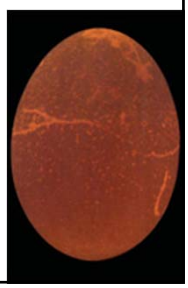
LIVESTOCK RESEARCH WAGENINGEN UR

Table 2. Hatching performance of broiler breeder hatching eggs with normal intact shell, untreated hairline-cracked shell and covered hairline-cracked shell

Properties	Embryonic mortalities (n/100 fertile eggs)		Contaminated egg rate (n/100 eggs set)	Egg weight loss (% of fresh egg weight)	Cull chicks rate (n/100 of living chicks)
	Early (0-18 d)	Late (18-21 d)			
Intact shell egg	2.32±0.6^{b}	5.53±0.7^{c}	0.50±0.1^{b}	10.63±1.2^{c}	3.16±1.4
Hairline cracked-egg	19.66±2.9^{a}	50.15±2.3^{a}	2.84±0.7^{a}	21.28±2.0^{a}	8.77±3.1
Covered egg	7.77±1.4^{b}	17.98±1.8^{b}	1.22±0.5^{ab}	14.41±1.7^{b}	2.88±0.6
Significance (P)	***	***	*	**	NS

NS: P>0.05,*: P<0.05,**: P<0.01,***P<0.001, *^{c}: Mean values with different superscripts within a line differ significantly.

Mean ± S.E.



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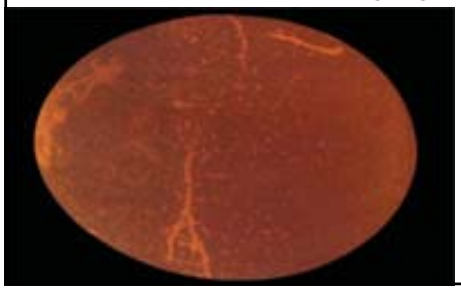
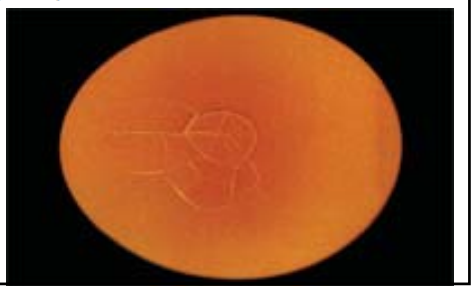
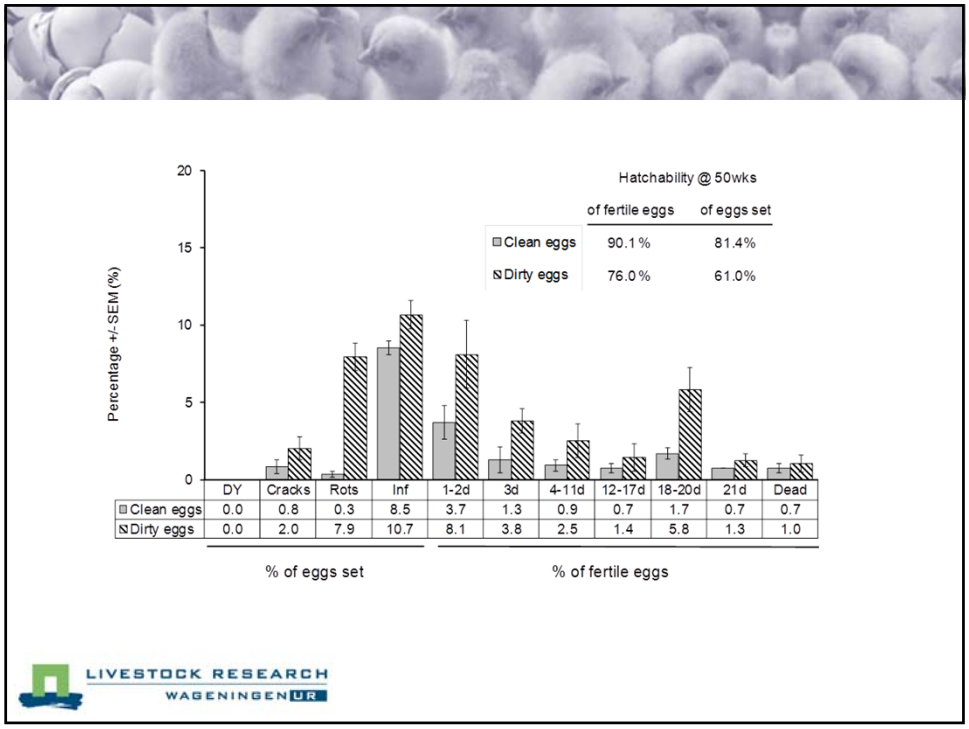




	Good quality eggs	Hairline-cracked eggs	
Hatchability (%)			
- Eggs set	74.4	50.5	Significant ($P < 0.05$)
- Fertile eggs	80.9	56.4	Significant ($P < 0.05$)
Chick weight			
- Weight (g)	45.0	43.5	Significant ($P < 0.05$)
- Relative weight (% of eggs set)	69.9	67.5	Significant ($P < 0.05$)
Growth performance			
- D14 body weight	293.5	298.9	Not significant
- Mortality	2	7.5	Significant ($P < 0.05$)
Egg weight loss in the setter (%)	13.4	17.02	Significant ($P < 0.05$)
Embryonic mortality (%)			
- Early (1 - 7d)	7.9	13.9	Not significant
- Mid (8 - 14d)	0.0	2.9	Significant ($P < 0.05$)
- Late (15 - 21d)	4.6	15.5	Significant ($P < 0.05$)
- Cull	5.3	6.2	Not significant
Contaminated or broken (%)	1.2	5.2	Significant ($P < 0.05$)

Reference: Barnet et al. (2004). Hatchability and Early Chick Growth: potential of broiler breeder eggs with - hairline cracks. J. Appl. Poult Res. 13: 65 - 70.


Hatchability @ 50wks
of fertile eggs
of eggs set
Clean eggs 90.1 % 81.4%
Dirty eggs 76.0 % 61.0%
Percentage +/- SEM (%)
20
15
10
5
0
DY Cracks Rots Inf 1-2d 3d 4-11d 12-17d 18-20d 21d Dead
Clean eggs 0.0 0.8 0.3 8.5 3.7 1.3 0.9 0.7 1.7 0.7 0.7
Dirty eggs 0.0 2.0 7.9 10.7 8.1 3.8 2.5 1.4 5.8 1.3 1.0
% of eggs set
% of fertile eggs
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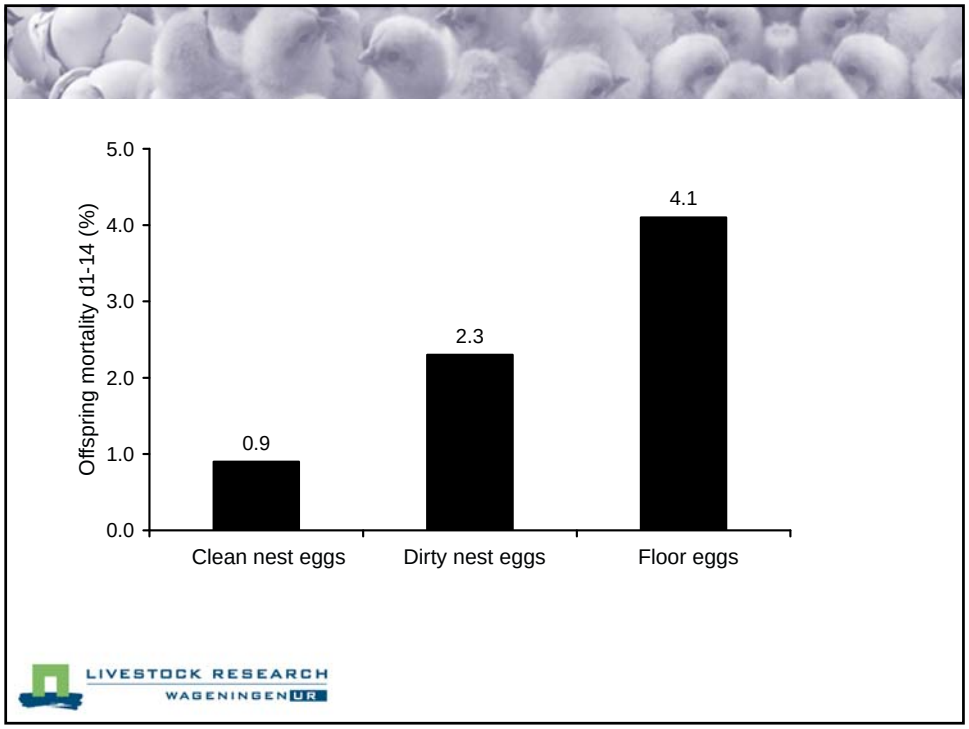
Offspring mortality d1-14 (%)
5.0
4.0
3.0
2.0
1.0
0.0
0.9
2.3
4.1
Clean nest eggs
Dirty nest eggs
Floor eggs
LIVESTOCK RESEARCH
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Danish hatchery: “canalisation” of trouble eggs

Candled DIS to determine fertility

Transferred all eggs to hatching baskets

In a cork screw basket tipper all chicks were covered in dirt...

First week mortality > 2%

Removal of DIS → 1.5 %

Rejection dirty eggs → < 1.0 %

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German Integration (hatching >100 million chicks per year)

Stopped using dirty - and floor eggs (± 1.0 %)

Increased overall hatchability by 0.8 %

Decreased first week mortality by 0.6%

Decreased antibiotics use by 50%!

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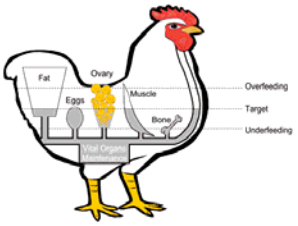
- Deficiencies in feed
- Requirements and allowances do not match
  - Age PS
  - Feather conditions
  - Parasites (worms, red mites)
  - Temperature
  - Diseases
  - Stress
  - ……..
- Incomplete transmission of essential nutrients
  - Young PS: limited fatty acid metabolism of the embryo's -> temperature
  - Incubation conditions (large residual yolk sac)



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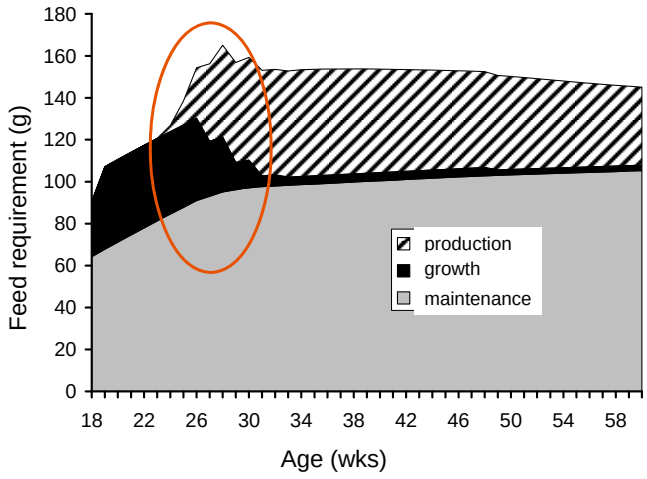

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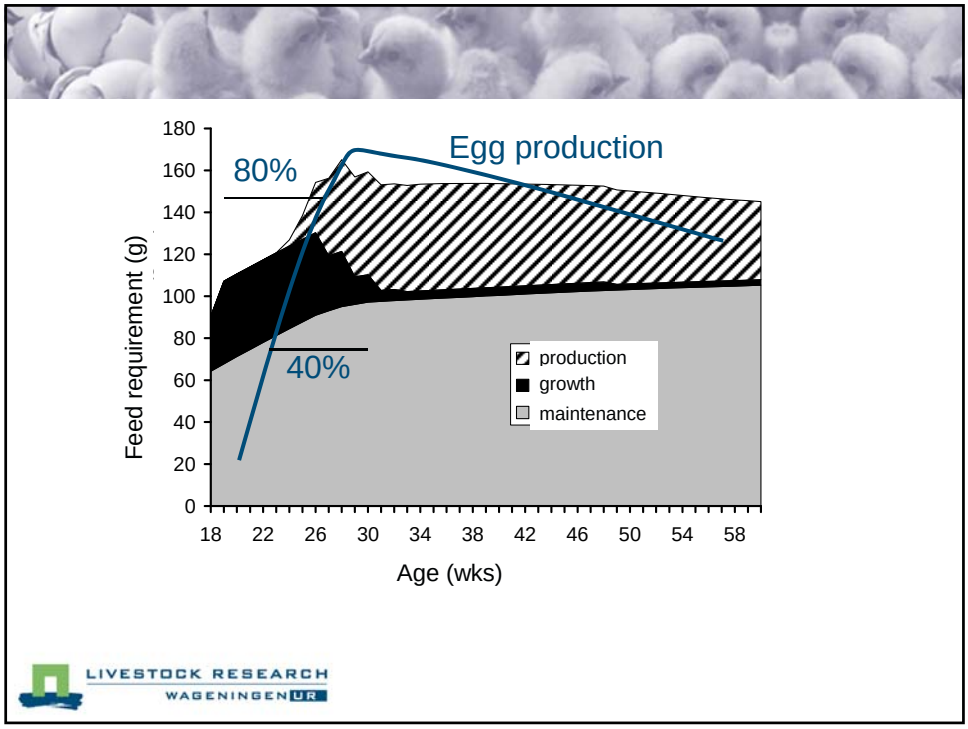
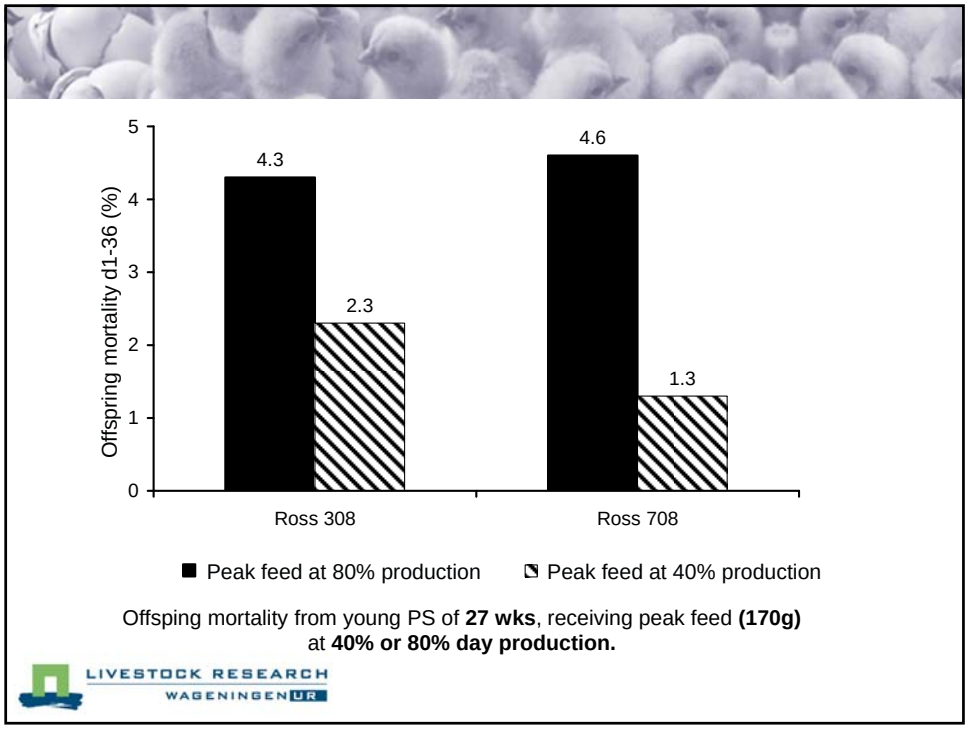

Egg production
80%
40%
Feed requirement (g)
Age (wks)
production
growth
maintenance
0
20
40
60
80
100
120
140
160
180
18
22
26
30
34
38
42
46
50
54
58
LIVESTOCK RESEARCH
WAGENINGEN UR


Offspring mortality d1-36 (%)
4.3
2.3
4.6
1.3
0
1
2
3
4
5
Ross 308
Ross 708
Peak feed at 80% production
Peak feed at 40% production
Offsping mortality from young PS of **27 wks**, receiving peak feed **(170g)** at **40% or 80% day production.**
LIVESTOCK RESEARCH
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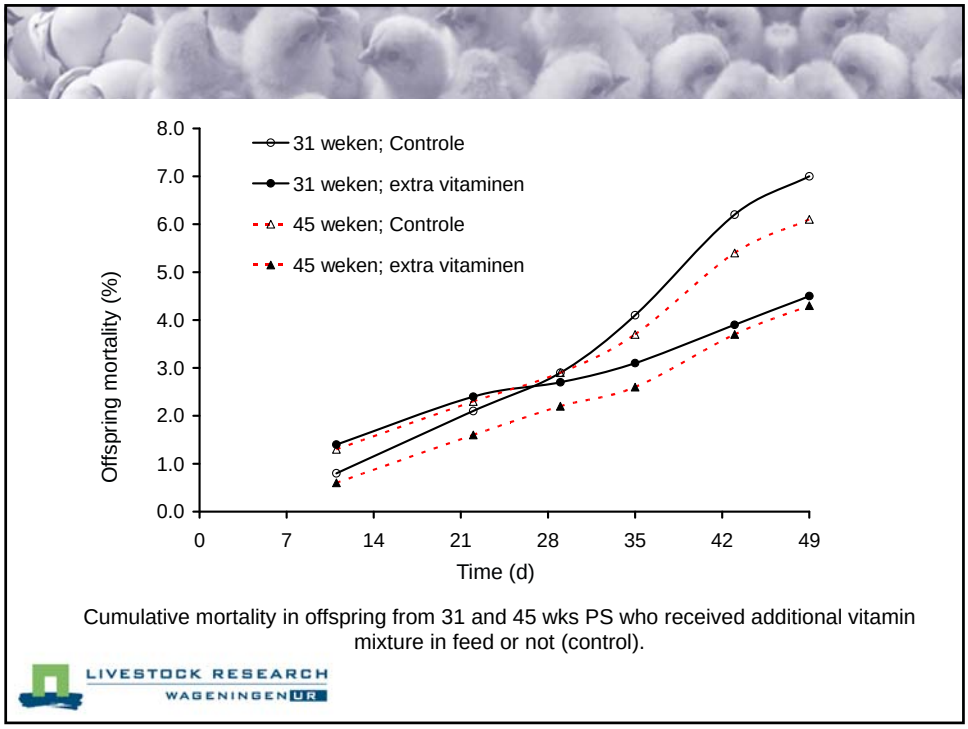

Cumulative mortality in offspring from 31 and 45 wks PS who received additional vitamin mixture in feed or not (control).

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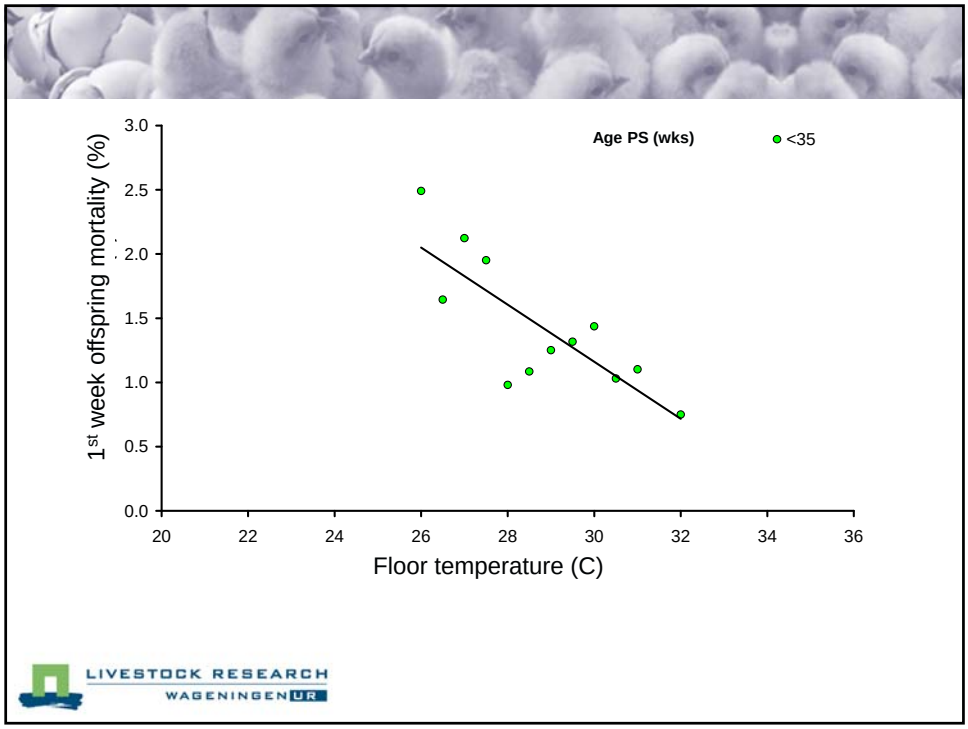

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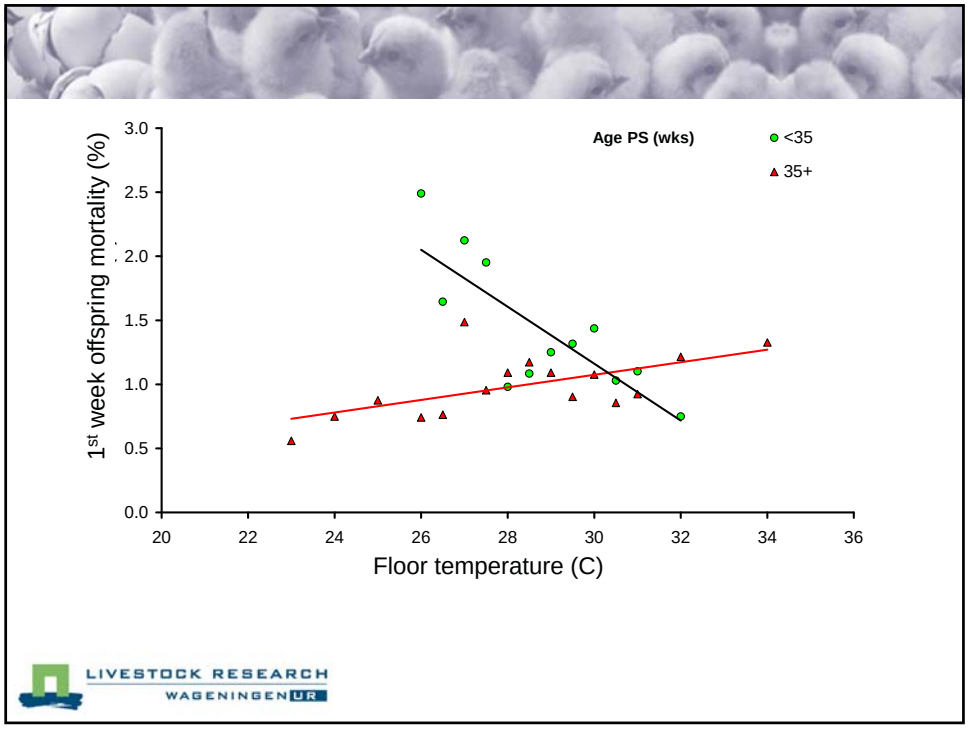
Age PS (wks)
<35
35+
1st week offspring mortality (%)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
20
22
24
26
28
30
32
34
36
Floor temperature (C)
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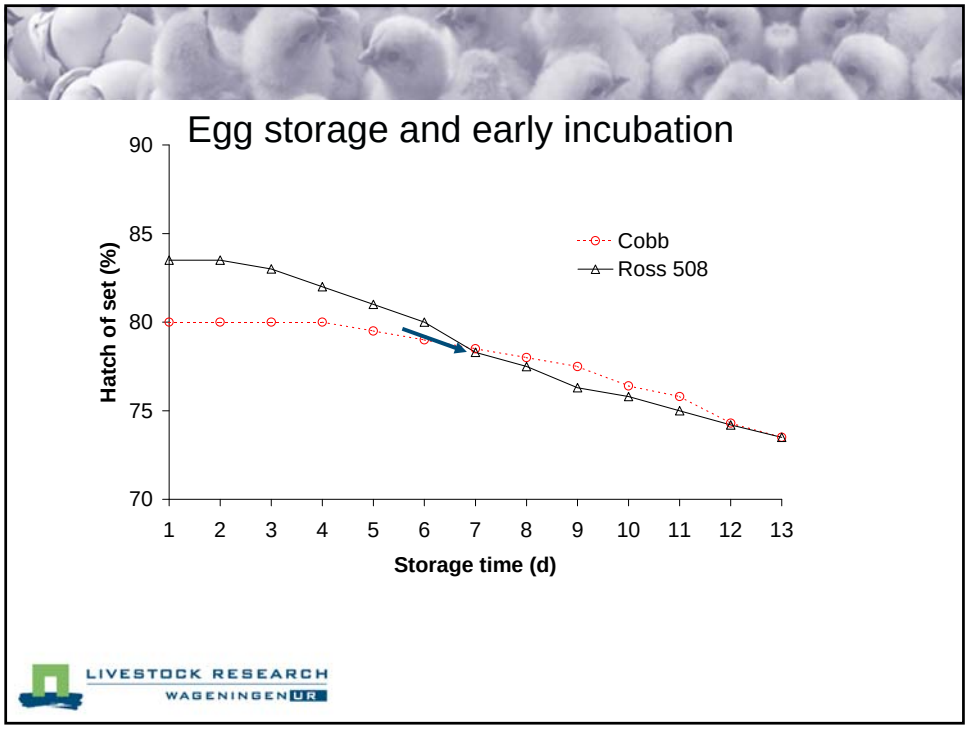
Egg storage and early incubation
Cobb
Ross 508
Hatch of set (%)
90
85
80
75
70
1
2
3
4
5
6
7
8
9
10
11
12
13
Storage time (d)
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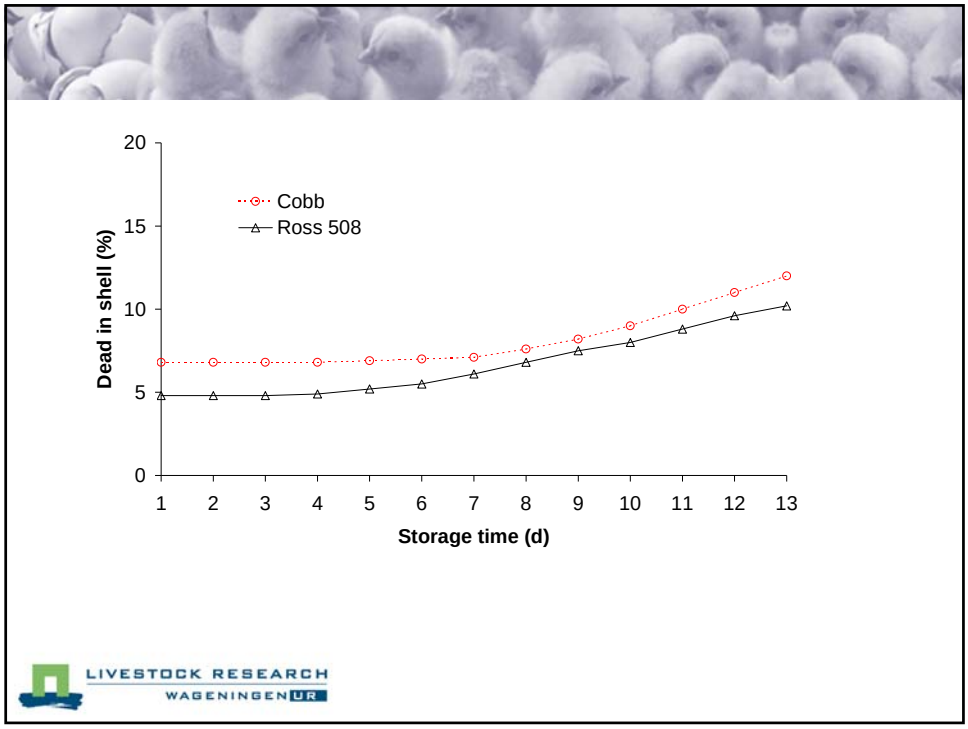
Dead in shell (%)
20
15
10
5
0
Cobb
Ross 508
1
2
3
4
5
6
7
8
9
10
11
12
13
Storage time (d)
LIVESTOCK RESEARCH
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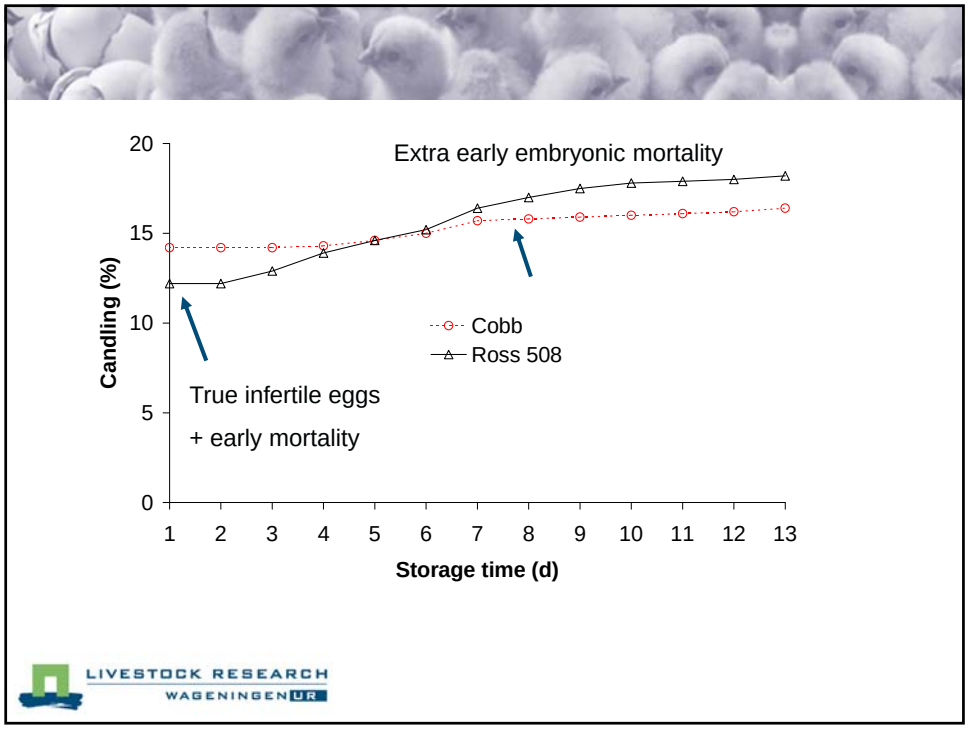
Candling (%)
20
15
10
5
0
Extra early embryonic mortality
Cobb
Ross 508
True infertile eggs
+ early mortality
1
2
3
4
5
6
7
8
9
10
11
12
13
Storage time (d)
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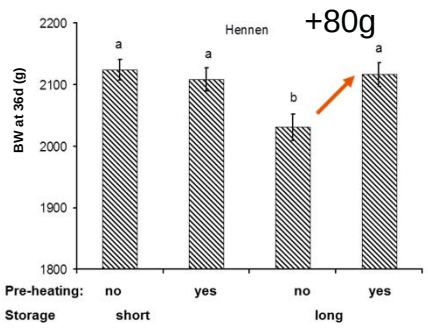
Pre-heating of hatching eggs



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Conclusions:

- pre-heating technique prevented production loss due to increased storage
- not harmful when applied at 3d storage

But:

- system needs to be monkey proof!!!
- no use in times when demand for hatching eggs is high…
- Who will pay for it??

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Veterinary factors

Virus diseases at PS level and progeny mortality.

Virus diseases	Primary mortality	Vertical transmission	Transmission via eggshell	Disease possible by insufficient maternal protection	Immuno-Suppression

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Veterinary factors

Virus diseases at PS level and progeny mortality.

Virus diseases	Primary mortality	Vertical transmission	Transmission via eggshell	Disease possible by insufficient maternal protection	Immuno-Suppression
NCD	X	??	??		
IB (Infectieus Bronchitis)	X			X	
IBD (Gumboro)	X			X	X
CAV (Chicken Anaemia Virus)	X	X		X	X
IBH (Inclusion Body Hepatitis)	X	X		X	
AE	X	X		X	
Reo tenosynovitis (+ MAS)	X	X		X	X
TRT/ART (Rhinotracheitis)	X	X			
Marek	X				X
Aviaire Leucosis	X	X			x (ALV-J)

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Veterinary factors

Bacterial and fungal infections in PS on progeny mortality

Bacterial- and Fungal diseases	Primary mortality	Vertical transmission	Transmission via eggshell	Disease possible by insufficient maternal protection	Immuno-Suppression
Salmonella	X	X	X		
Campylobacter		x (very low)	X		
Colibacillosis	X	??	X		
ORT	X	X	??		
M. gallisepticum	X	X	X		
M. synoviae		X	X		
Enterococcen / Streptococcen	X	??	X		
Aspergillosis	X	X	??		

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Large effect of incubation conditions on offspring performance

38 + 2 g

O_2 →  60 g egg

→ H_2O

→ CO_2

→ Heat

\+

or

Embryo temperature

37.8ºC = optimal

32 + 8 g

- Mortality
- Poor growth
- Poor developed immune system
- High FCR
- AB use high

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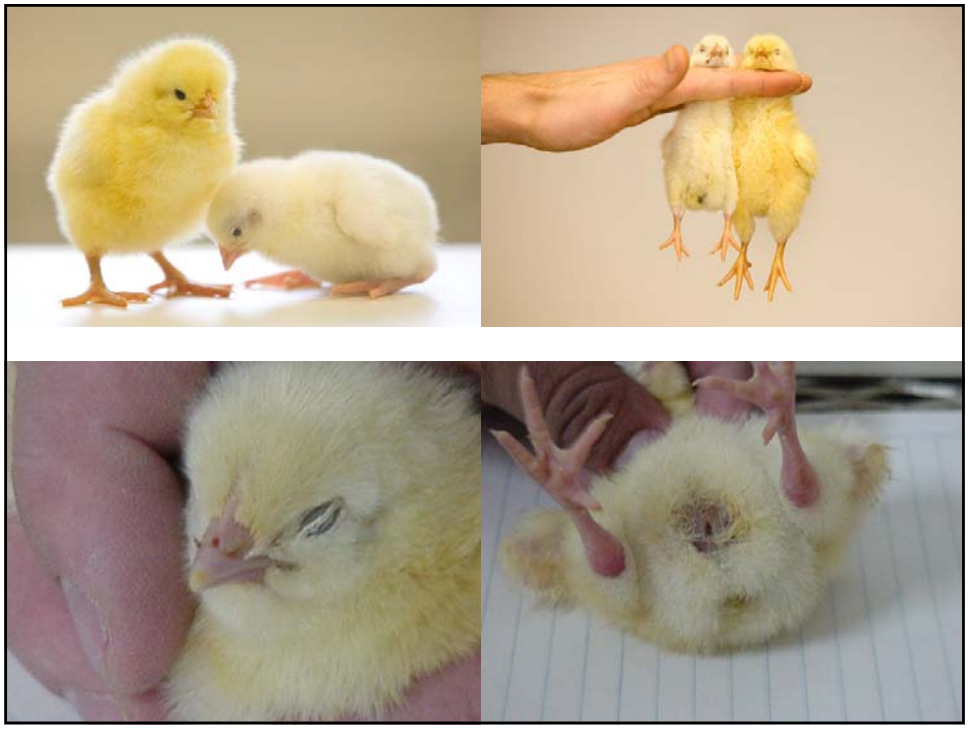
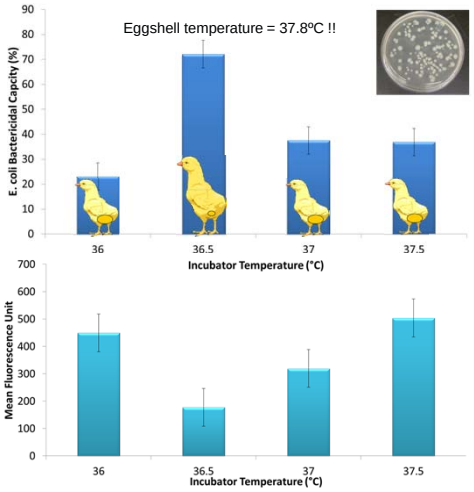


Eggshell temperature effects on innate immune function



Uptake and killing of E. Coli by macrophages Is most effective in chicks hatched from eggs incubated at 37.8ºC EST!

Lower uptake of fluorescent particles: under optimal development the macrophages are more selective!

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UNIVERSITY OF ALBERTA

Day 16-21 temp (embryo)	Bodyweight	Fcr (2 kg)
99	2.214[a]	1.82[a]
101	2.263[b]	1.75[b]
103	2.166[a]	1.80[a]

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Experiment (Penn State, Gladys et al)

Upstream quality investments pay off down stream...

So who will initiate these quality investments?

What about the financial model?

And what are these failure costs that can be saved easily?

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Experiments and field results:

- sign. differences in hatch, growth, feed conversion, mortality etc
- experiments: FCR effect 3-7 points
- field results Holland, 18 million broilers, 4.2 points FCR

Suppose difference is 2,5 points: 50 gram feed/2.0kg broiler

- machine 100.000 eggs, 17 eggs/egg place/year
- 80% hatch, 95% livability

Profits

- 100.000 x 17 x 80% x 95% x 0.05 = 64.600 kg feed / machine!!
- In Holland this relates to € 15.000 - € 20.000

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Example of the effect of improvements in technical results for an integration setting a million eggs per week. **Assumptions:**

Setting capacity	1.000	x 1.000 hatching eggs / week
Setter and hatcher costs	0,50	€ / egg place
Interest rate	5	% / yr
Maintenance costs	2	% / yr
Depreciation costs	10	% / yr
Hatching egg price	0,18	€
DOC price	0,25	€
Days in setter	18	d
Days in hatcher	3,5	d
Feed costs	25,00	€ / 100 kg
Broiler meat price	0,80	€ / kg
Filet price	5,00	€ / kg
Broiler weight	2,0	kg
FCR	1,6	kg feed / kg growth
Mortality	3,5	%
Filet yield	20,0	%

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Example of the effect of improvements in technical results for an integration setting a million eggs per week. **Extra income:**

	Extra income (per year)	Unit
Hatchability	€ 130.000	per %
Survival	€ 290.000	per %
Broiler slaughter weight	€ 180.000	per 10 g
FCR	€ 215.000	per point
Medicine use	?	Kg of ddd
Filet	€ 223.000	per 0.1 %

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German integration (top down)		Extra income (per year)
Hatchability	+ 1,2 %	€ 156.000
Survival	+0.8 %	€ 232.000
Broiler slaughter weight	+40 g	€ 720.000
FCR	-4 points	€ 430.000
Medicine use	Down by 50 %	?
Filet	+0.3 %	€ 669.000
Totaal		**> € 2.207.000**

Combination of factors:

- Incubation at embryo temperature
- All floor eggs discarded (1.0%)
- Measuring and controlling chick temperature during the first week

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- Large effect of breeder and hatchery on offspring mortality!
- What can you do as broiler farmer??
  - Ask for the PS background (broiler passport?)
    - Flock age?
    - Vaccination chart?
    - First week mortality in foregoing flocks of the same breeder?
    - How many PS farms and houses used to complete the batch?
    - Health status and medicine use?
    - Farm egg storage time? Hatchery egg storage time?
    - Floor eggs included?
    - Selection for cracks and misshapen eggs?
  - Measure chick temperatures daily!

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As an integration,

Make a plan, work together with breeder farms, hatchery and broiler farmers

Share information and do not optimise each sector with their own specific goals

Train farmers how to achieve and maintain good quality chicks

Give broiler farmers the choice to pay more for good quality chicks

Give other broiler farmers the choice to buy cheaper less quality chicks

Introduce upstream quality investments:

- Feed + water quality
- Automatic laying nests + good ventilation
- Egg storage facility
- Egg and chicken transport
- Equipment to preheat hatching eggs before storage
- Incubator equipment, Hatchbrood, Hatchcare, X-treck
- Etc.

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