

IN-OVO SEXING

*An Alternative to Culling
Day-Old Male Chicks*



animal EQUALITY



The killing of day-old male chicks is one of the most contentious issues in the livestock industry. Life is produced, which is not economically viable and therefore billions of birds must die on the day of their hatch. This report intends to provide information on a possible alternative to the standard practice of chick culling – in-ovo sexing – and to show the different technologies searching for an end of this killing – before hatching. This work must always be viewed in the context of its date of publication, as research constantly progresses and supposedly up-to-date information can age rapidly.

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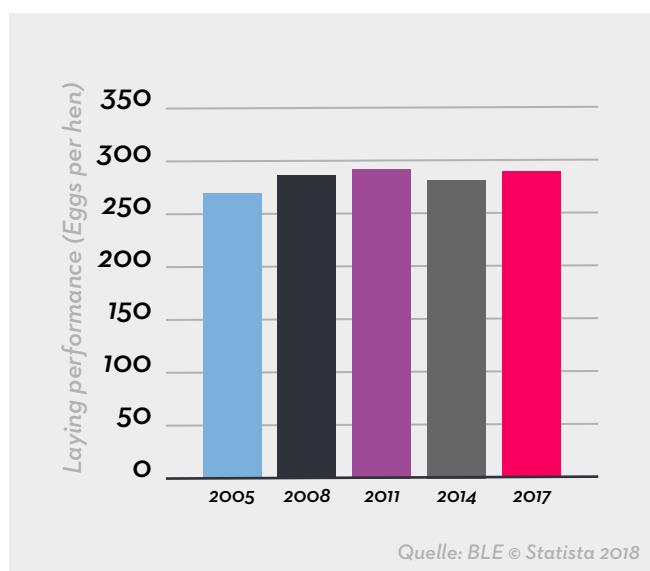
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1. ANIMAL WELFARE CONCERNS

Laying hens can lay around 300 eggs¹ a year. For comparison: a wild chicken (red junglefowl) lays up to 36 eggs a year.² The results of the extreme selective breeding of those birds includes painful inflammation of the laying gut, broken bones (very often the breast bone³), feather pecking and cannibalism⁴.

LAYING PERFORMANCE OF HENS
IN THE YEARS 2005-2018 (EGGS PER HEN)



Naturally, roosters do not lay eggs. It is not profitable rearing them, as they grow less quickly and put on less meat than broiler chickens bred for meat. They are worthless to the industry and are killed on the day they hatch - most commonly either by gassing or maceration in a grinder. This affects all farming methods - even on organic farms.⁵

"There has been no use for male chicks in the rearing of laying hens for around 50 years".⁶ This practice of killing young, healthy animals poses a serious ethical dilemma.^{7,8,9} Financial interests cannot justify the mass culling of animals from a veterinary perspective.¹⁰

Example from Germany

The culling of roosters is not compatible with German animal welfare laws in the view of both lawyers¹¹ and animal protection advocates. However, this practice has been routine for decades, so is it effectively tolerated as common law. In specialist circles, as well as in the public sphere, killing chicks is increasingly criticized as a violation of animal welfare regulations. In 2016, the Higher Administrative Court of Münster stated that this is a 'Conflict between a Functional Food Industry and Ethics', eventually deciding, however, that hatcheries may continue to kill male chicks immediately after hatching¹². It was deemed a disproportionately high expense for the hatcheries to let the male chicks live and rear them to be slaughtered at the abattoir. And so, millions of chicks continue to be killed in Germany. Alternatives to this practice are necessary. Currently, nearly 90 percent of German consumers are aware of this practice, which can be directly attributed to increased reporting in the media over the last few years.¹³

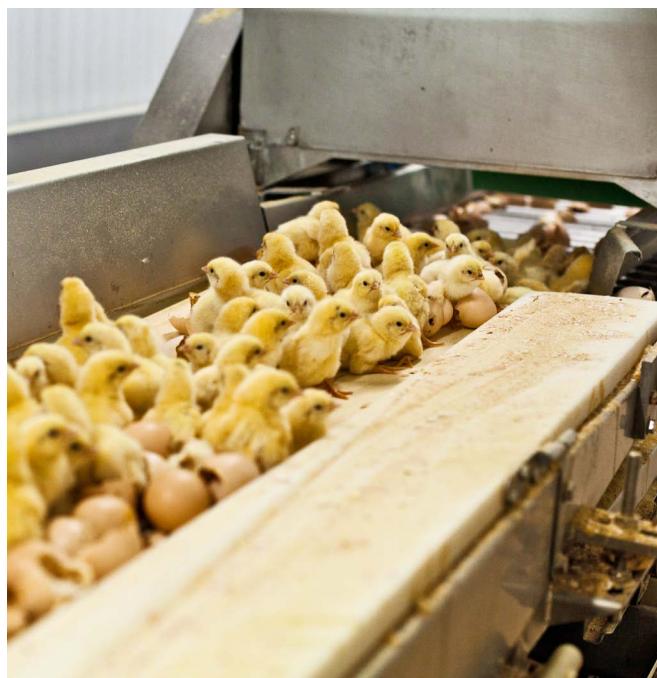
In a representative survey, 81 percent of respondents were in favour of a legal ban on chick killing, while 75 percent of consumers were prepared to spend more money on eggs if chick killing was abandoned.¹⁴



1.1 CULLING METHODS

Most day-old chicks are either killed physically or through the inhalation of chemical substances.

The most commonly used chemical method is gassing with CO₂, while the most commonly used physical killing method is maceration in a grinder. The animals are killed by shredding¹⁵ ("shredding chicks"¹⁶). In this method, the animals are transferred in a machine called a grinder. The birds are alive and fully conscious without any stunning as their bodies are macerated. A recent study stated that the animals were seen to show behavioral signs of suffering in all five different CO₂ gassing protocols tested.¹⁷ In Europe, most day-old chicks are killed using these methods as well as in many other regions of the world. Dismembering male chicks is everyday practice.¹⁸ In other parts of the world, shredding chicks is not allowed.^{19,20} Undercover research in India has shown that day-old chicks are ruthlessly burned, crushed, drowned or shredded.²¹ Switzerland has banned shredding²² Before, around 90 percent of the 3 million male chicks were gassed, while the remaining 10 percent were shredded.²³ In the USA, some animals are also killed by electrocution.^{24,25,26,27} But whatever method is used, killing male chicks should be banned altogether.



1.2 THE SCOPE OF THE PROBLEM

Every year, several billion male chicks are killed worldwide. Estimates range from 2.5 billion to 8 billion.^{28,29,30,30,32,33,34,35,36,37,38,39,40,41,42}

The culling of male chicks affects 330 million animals in the European Union each year,^{43,44} 370 million⁴⁵ in Europe, and around 45 million^{46,47,48,49} to 50 million^{50,51,52,53} in Germany. This amounts to more than 100,000 male chicks in one day – in Germany alone.^{54,55,56}

In the USA, around 300 million⁵⁷ male chicks are killed each year. This means around 30,000 freshly hatched chicks per hour.⁵⁸

The report "Legal Aspects of the Prohibition on Chick Shredding in the German State of North Rhine-Westphalia" by lawyer Amelie C. Buhl comes to the conclusion, that "objectively, the practice of killing male chicks in hatcheries can only be described as gruesome".⁵⁹

INCUBATION AND HATCHING

2. (FROM EGG TO FARM)

2.1 PARENT STOCKS

The parents serve a single purpose: laying eggs to provide the farm with female offspring to ensure egg production.

When rearing breeding animals, the aim is to constantly improve their performance characteristics. The focus is on a high number of fertile eggs and a promising hatching rate.⁶⁰ The goal is to create as many hens as possible for the production of eggs for consumption.

Furthermore, animal welfare for these breeding animals is even less satisfactory than in the livestock industry as a whole. According to a Der Spiegel investigation they are subject to less strict regulations than meat chickens and laying hens; there are no provisions at all.⁶¹ The public is not aware that one "roast chicken" or "boiled egg" doesn't just require one chicken, rather countless parents and grandparents were used for those animal products. The animals themselves are not easy to access for academic studies.⁶² They live and die with even less protections than other chickens.

2.2 HATCHERY: INCUBATION - HATCHING - SEXING

All eggs laid by breeding animals are stored in plastic containers and transported to large hatcheries where the eggs' temperature and humidity are controlled. On the 21st day, thousands of chicks hatch at the same time. Once the majority of the chicks have hatched, sexing - determining the newborn chicks' sex - takes place. Workers tip the day-old chicks onto a conveyor belt and sort them into female and male animals: the industry differentiates by vent sexing. Vent sexing tells the sex of the chicks by squeezing the feces out of the chick to open up the

chick's anal vent (called a cloaca) slightly, allowing the chicken sexer to see if the chick has a small "bump", which would indicate that the chick is a male. The second method is feather sexing, where sex is determined by the growth rate of the chick's wing feathers.⁶³ The workers then toss the hens into plastic boxes and the male chicks are left on the conveyor belt to be killed.

Chicks are typically left without care for 24-72 hours in hatcheries.⁶⁴ They have to perch in the dark without food or water and have a higher mortality rate due to additional unnecessary stress, such as dehydration, hunger and fear. This results in "early hatching chicks [...] losing up to 10 percent of their hatching weight as well as their vitality and robustness".⁶⁵ Worldwide, there is apparently just one hatchery for laying hens that uses an early feeding concept, where feed, water and light are made available to the freshly hatched chicks.⁶⁶

Academic studies have shown that "the time in the hatchery [...] [is] very stressful for the chicks [...] as they are exposed to changes in temperature, sounds, movement, moisture, handling and vibrations."⁶⁷ It is not uncommon in the hatchery for the handling and rapid transportation of the chicks to result in injury, fear and loss of orientation in these young animals (such as due to falling⁶⁸ between different conveyor belts).⁶⁹ Transport from the hatchery to farms puts additional pressure on the chicks as well as fear⁷⁰ and stress. Academics are especially unsettled by the deviations in humidity and extreme temperature changes, as the chicks "have little control over their own body temperature in this phase of life."⁷¹ And the longer the chicks are transported, the more they lose weight and the more stress there is on the animals.⁷²

Multiple stressors also add up as is shown with the concept of "additivity of stressors".⁷³ The concept means that stress experienced during incubation can exacerbate stressors later in life and possibly reduce the bird's ability to deal with them.⁷⁴

3. IN-OVO SEXING

The standard process of killing young and healthy animals has long been unacceptable to animal welfare experts, the public and animal protection advocates, and has been the subject of ongoing research for decades.⁷⁵ With increasing public knowledge and disapproval, the search for alternatives has been intensified. Worldwide, there are various approaches that should make the killing of male chicks superfluous.

INTRODUCTION: 3.1 SEXING IN THE EGG

The aim of in-ovo sexing is to prevent male chicks from hatching in the first place: the sex of the embryo is established before the hatching date (in the egg, hence ‘in-ovo’ sexing). The male eggs are removed from incubation early on, so only female chicks emerge from the eggs after 21 days of incubation.

Various methods have been developed in the Netherlands, Germany, Israel and Canada. Current approaches are still in development and not yet commercially available, with the exception of the method used by the German company Seleggt GmbH, which brought the first eggs from in-ovo sexed hens to German retailers in November 2018.^{76,77} The eggs are sold under the “respeggt” label and are currently (May 2020) available in the following grocery stores: Rewe, Penny, Marktkauf, Famila, Edeka (Germany), Carrefour (France) and Jumbo (The Netherlands).⁷⁸ The end goal of the research is a process to establish the sex of eggs that have not been incubated, and are therefore still usable for the industry.^{79,80}

3.2 TECHNOLOGY

Various methods and approaches are currently in development or are being tested around the world, and most will become commercially available in a few years.⁸¹ These include molecular biological processes,

hormone analysis (endocrinology) and optical processes (spectroscopy). This report intends to provide insight into these technologies but does not claim completeness. As technologies evolve it is possible that some of the following information will become out of date.

Example: Germany

The two sexing processes seen as most promising in Germany are the endocrinological and spectroscopic approaches promoted by the Federal Ministry for Nutrition and Agriculture (Bundesministerium für Ernährung und Landwirtschaft, BMEL). In order to finally put an end to the practice of killing chicks, the BMEL has pledged around 5 million euro in its support for the development of a solution.⁸³

The **endocrinological process** involves incubating the eggs for around 9 days. A small amount of liquid is then extracted from each egg without touching the inside of the egg. A biotechnological process is used to establish the sex based on these samples.

The **spectroscopic process** involves incubating the eggs for around 4 days. A special light is then shone into the egg’s interior. The reflected light is then analyzed to determine the sex.

The veterinary medicine faculty at the University of Leipzig has joined zoologists, physicists, chemists and engineers from the University of Jena, the Technical University of Dresden, the Fraunhofer Institute, arxes Information Design Berlin GmbH and Lohmann Tierzucht GmbH Cuxhaven to research a method to establish the sex of chicken embryos still inside the egg.⁸⁴

3.2.1 TECHNOLOGIES: GENERAL OVERVIEW

TECHNOLOGY	TESTING TIME	INVASIVE	SPEED	ACCURACY	GENETIC MODIFICATION	COST	COMMERCIALIZATION
EggXYt	Day of laying (Day 1)	Minimally invasive	TBD	100%	Yes	TBD	Pilot project planned for the end of 2019, market ready in a few years
CSIRO	Day of laying (Day 1)	Minimally invasive	TBD	100%	Yes	TBD	Currently not foreseeable
Raman Spectroscopy	After around 3.5 days (84 hours)	Non-invasive	TBD	93% - 95%	No	1¢ - 2¢ per egg	Currently not foreseeable
Hypereye	Day of laying (Day 1)	Non-invasive	30,000 to 50,000 eggs per hour	95% - 99%	No	5¢ per egg	Corrected to 2019/2020
Agri Advanced Technologies (AAT)	4th day of incubation	Minimally invasive	100,000 eggs per day	98%	No	TBD	No date set, as unforeseeable problems have come up
In Ovo	9th day of incubation	Minimally invasive	Around 1 second per egg - aiming for a few microseconds per egg	95%	No	"Tolerable"	Prototype 2019, commercialization planned for 2020
TeraEgg	2nd day of incubation	Non-invasive	TBD	TBD	No	TBD	TBD
LIVEgg	7th day of incubation	Non-invasive	TBD	TBD	No	TBD	2020
Seleggt	8th/9th day of incubation (Aim: 5th/6th day of incubation)	Non-invasive	3,500 eggs per hour 50,000 eggs per day	98% - 99%	No	1¢ - 3¢ per carton of eggs	Market readiness: November 2018 in Germany (223 Rewe and Penny stores); production readiness in 2020: "respeggt"-eggs in all 5.500 REWE and Penny stores; export not currently foreseeable
Orbem Genus	In the first few days of incubation (aim: 7th day of incubation)	Non-invasive	20 million eggs per year 75 eggs per minute (108,000 eggs per day)	TBD	No	0.5¢ to 1¢	Prototype by mid-2019, tests planned in hatcheries for 2020
Planton	9th day of incubation	Minimally invasive	TBD	TBD	No	TBD	Should be ready for the market in 2020 and available for all of Aldi's eggs by the end of 2022 in Germany

CRISPR – GENOME EDITING PROCESS

3.2.2 (MOLECULAR BIOLOGICAL METHODS)

3.2.2.1 EggXYt

EggXYt⁸⁵ was founded in 2016 by Yehuda Elram and Professor Daniel Offen, departmental head of neuroscience at the medical faculty of Tel Aviv University in Israel.

The EggXYt technique uses CRISPR technology,⁸⁶ a molecular biology method, to target, cut and manipulate DNA. This allows individual genes - or more precisely, DNA building blocks - to be "edited" (hence "genome editing"). CRISPR is the simplest and most reliable genome editing process.⁸⁷

This process can be used to edit the mother chicken's genes. At certain points in the DNA, fluorescent proteins (biomarkers) are added that can be seen using an optical scanner called SeXYt.^{88,89} The unwanted male eggs glow yellow under a UV light. As the ability to lay fluorescent male eggs will be passed down from generation to generation, not every mother chicken will require this genome editing. The laying hens that hatch from female eggs will remain genetically unaffected.

Benefits:

Sexing is possible on the day the egg is laid. This means that the unincubated eggs can be immediately used.⁹⁰ As the eggs have not been punctured or incubated, they can be used for human consumption. The EggXYt company speaks of avoiding the disposal of 7 billion chicks, which could make their way to the market as eggs for human consumption.^{91,92} This method is 100% accurate.⁹³

Considerations:

The biggest problem with this method is that genetic modification is a contentious issue. If the EggXYt genome editing process is judged to genetically modify the animals, special permits to sell the eggs may be necessary - depending on the relevant country. The European market may be very skeptical.⁹⁴ Approval could take years or be refused altogether. It should be a minimally invasive method.⁹⁵

A pilot project was planned for the end of 2019⁹⁶ but it can be presumed that other methods will be market-ready considerably sooner.⁹⁷

3.2.2.2 CSIRO

Australian scientists are also researching along the lines of CRISPR technology. The CSIRO⁹⁸ (Commonwealth Scientific and Industrial Research Organisation) is also working to create a special glowing egg by editing the chicken's genome. This egg is intended to glow light red under UV light.^{99,100}

Benefits:

The technology should make it possible to establish sex on the day of laying. This means that the unincubated eggs - as with the EggXYt eggs - can be immediately used and can also be used for human consumption. This method is 100 percent accurate.

Considerations:

Possible commercial application is currently not foreseeable.¹⁰¹ The biggest issues with these molecular biological methods are the legal hurdles due to genetic technology. It should be a minimally invasive method.¹⁰²

Why Male Embryos Glow

Unlike mammals, male birds (roosters) have two of the same gender chromosomes (ZZ), while female birds (hens) have two different ones (ZW).

If the hens are given a gene for a fluorescent protein (FP) in the Z chromosome, the marked ZFP chromosome will only exist in the male embryos. As a result, only the male eggs will glow and can be visually identified when a suitable light source is used. These eggs will not be incubated and can be passed on for further use. But they will be considered as "genetically modified".

The female embryos with the unchanged Z and W chromosomes will be incubated and will hatch as non-genetically modified laying hens that will lay non-genetically modified eggs.

3.2.3 SPECTROSCOPY

3.2.3.1 Near-Infrared Spectroscopy (NIR)

The use of near-infrared spectroscopy (NIR) to identify the sex was first suggested by a research group headed by Roberta Galli and Gerald Steiner at the Technical University of Dresden together with the University of Jena and University of Leipzig.^{103,104} Professor Maria-Elisabeth Krautwald-Junghanns, Director of the Clinic for Birds and Reptiles coordinates the team of researchers.¹⁰⁵

The project receives subsidies from the Federal Ministry for Nutrition and Agriculture (Bundesministerium für Ernährung und Landwirtschaft, BMEL).^{106,107,108} The methodology used dates back to Indian physicist Chandrasekhara Venkata Raman (1888 – 1970).¹⁰⁹ The starting point for the differentiation of female and male embryos is the different sizes of the gender chromosomes. These can be identified after roughly 84 hours (3.5 days)¹¹⁰ from the egg's fertilization in the embryo's blood cells.¹¹¹ This means that this method requires the egg to be incubated for around 3-4 days^{112,113} and the embryo's blood vessels to be exposed to a near-infrared laser at the blunt end through the intact eggshell.

This light is reflected by molecules in the egg, especially by sex chromosomes. The reflected light is measured using a spectrometer. The shape of the spectrum can be used to establish the size of the chromosomes, and therefore the sex. The female chromosome is significantly smaller than the male one.¹¹⁴ The blood in male embryos is recognized by a special fluorescent stripe that is localized at around 910 nanometers.^{115,116}

Initial calculations place the price increases at around 1 to 2 euro cents per egg.¹¹⁷ Data places the accuracy of this process between 93^{118,119} and 95 percent.¹²⁰

Benefits:

As scientists assume that chicken embryos have not developed any sense of pain up to the 7th day of incubation, the early analysis time of around 84 hours (3.5 days of incubation) prevents any potential suffering of male chicks. This is a non-invasive process¹²¹, whereby the chicken embryo is not harmed.

Considerations:

As no two eggs are alike, the biggest challenge lies in mastering the optical variability of the eggshells.^{122,123} For routine large-scale industrial application, the process must be made significantly faster.^{124,125} It is currently unknown when the technology will be commercially available.

3.2.3.2 “Hypereye”

“Hypereye” technology was developed by Dr. Michael Ngadi at McGill University in Montreal, Canada.¹²⁶ The project receives financial support from the Egg Farmers of Ontario (EFO)¹²⁷ in cooperation with the Livestock Research Innovation Corporation¹²⁸ and the Ontario Poultry Industry Council.¹²⁹

“Hypereye” is a patented scanning technology that uses non-invasive (non-destructive) hyperspectral imaging to establish whether an egg has been fertilized and whether the chick is male or female.¹³⁰

The technology is based on the application of hyperspectral imaging in combination with progressive data processing protocols. The prototype can scan an egg in less than one second. At full capacity, the scanning system is expected to be able to analyze around 30,000¹³¹ to 50,000¹³² eggs per hour. Prototypes are being tested in Canadian hatcheries in Ontario in order to achieve the same accuracy and speed in commercial use as in the lab. The USA, the Netherlands and Sweden have expressed interest in the technology.

Benefits:

“Hypereye” is a non-invasive technology free from genetic modification. Neither the chickens nor the eggs have to be genetically modified. The analysis can take place on the day of laying. The technology facilitates sexing and shows whether the egg has been fertilized or not. The female embryos are then incubated and the male eggs are forwarded to food production.

Considerations:

Additional costs of 5 cents (dollar) per egg have been estimated.¹³³ This method is considered to be 95-99% accurate.¹³⁴ (The accuracy for establishing whether an

egg has been fertilized is almost 100 percent but is somewhat lower for sexing).¹³⁵

It was originally expected that the technology would be available from 2017/2018.^{136,137,138} This estimation has been corrected to 2019¹³⁹ to 2020.¹⁴⁰

Agri Advanced Technologies (AAT) and Innovatec Hatchery Automation (Optical Spectroscopy)

3.2.3.3

Agri Advanced Technologies (AAT), a subsidiary of the EW Group, has developed¹⁴¹ a prototype¹⁴² of a fully automated system to establish the sex on the 4th day of incubation together with the Netherlands-based Innovatec Hatchery Automation. This approach is based on spectroscopy. The technology uses an optical measuring process to recognize the difference between male and female eggs in reflected light. It first identifies the egg's air chamber, uses a CO₂ laser to perforate the eggshell and then removes a part of the eggshell. The perforation and removal of the eggshell take place without touching the membrane. As soon as the embryo's sex has been identified, the egg is closed and only the female embryos are put back into the incubator.

Benefits:

The benefit of this system according to the company is its sustainability - the use of light rather than chemicals - and the fact that there are no additional costs for consumable materials.¹⁴³ In 2017, AAT worked on further requirements for practical application. These include the lowest possible impact on the hatching rate and a detection capacity of up to 100,000 eggs per day.¹⁴⁴ The opening of the egg at the blunt end (site of the air bubble) allows the membrane to remain intact so that the hatching rate is "only minimally" impacted.¹⁴⁵ The eggs also do not have to be turned to establish sex as eggs are generally stored in the incubator with the peak pointing downwards.¹⁴⁶

Considerations:

The system's measurements are 98 percent accurate.¹⁴⁷ Due to unforeseen "problems and challenges", the

company has announced that comprehensive stress tests must be carried out so no date for market introduction can be set¹⁴⁸.

3.2.3.4 In Ovo

Another technology that works with biomarkers and spectroscopy was developed by the Dutch company In Ovo,¹⁴⁹ founded in 2013, together with its investors Evonik^{150,151} VisVires New Protein and Leiden University.¹⁵² The project was started in 2011¹⁵³ by biologist Wouter Bruins and biomedical specialist Will Stutterheim,¹⁵⁴ and is another minimally invasive procedure.

On the 9th day of incubation,¹⁵⁵ a small hole is made in the eggshell that can later be closed. A sample is taken from the egg using a needle, which is then spectroscopically examined for the existence and concentration of natural biomarkers.¹⁵⁶ This minimally invasive test currently takes around 1 second and establishes whether an egg is fertilized as well as the sex. Once full commercialization has taken place, the speed should be increased so that each egg only takes a few microseconds.

A prototype is currently in development, and the company would like to introduce it this year (2019).¹⁵⁷ The prototype should be able to fully automatically analyze and sort eggs by sex.¹⁵⁸ The first commercial product should come onto the market in 2020.^{159,160} In Ovo has decided not to publish any interim results until the prototype is in operation.¹⁶¹

Benefits:

This is a technology free from genetic modification whereby neither the chicken nor the egg has to be altered. The test establishes sex and shows whether the egg has been fertilized. The price increase is expected to be moderate,¹⁶² but the company has not published any precise specifications.

Considerations:

The technology is 95 percent accurate.¹⁶³ The in-ovo method can be carried out from the 9th day of incubation, although scientists currently agree that we can only be sure that the chicken embryo does not feel pain up to the 7th day. This is a minimally invasive method.

3.2.3.5 “TeraEgg”

“TeraEgg” technology was developed by Ovabrite¹⁶⁴, a Texas-based business and subsidiary of Vital Farms, in collaboration with Novatrans, an Israeli technology company¹⁶⁵. The founder and CEO is Matt O’Hayer.¹⁶⁶

“TeraEgg” uses Terahertz radiation to analyze¹⁶⁷ specific volatile organic compounds¹⁶⁸ that leach out of the egg’s pores¹⁶⁹. Terahertz is part of the electromagnetic spectrum between microwaves and infrared¹⁷⁰. Using a special algorithm, biological markers are recognized in a very early embryonic development process.

Benefits:

The “TeraEgg” method is non-invasive¹⁷¹ and able to identify both sex and fertilization on the day of laying before incubation.^{172,173,174} Terahertz waves are not considered harmful¹⁷⁵.

Considerations:

There is no information about the status of commercialization. Initial estimations presumed introduction to the market in 2017.^{176,177,178,179}



3.2.4 “LIVEgg™”

“LIVEgg™”^{180,181} is a biotech company founded in 2015 and run by CEO Alon Blum, founder Yair Adar and chairman Ido Ifat. “LIVEgg™” is a subsidiary of the Baram Group, a leading hatchery and breeding company in Israel. This young company’s mission is to prevent the culling of day-old male chicks through non-invasive technology¹⁸².

“LIVEgg™” offers various products to analyze and monitor the chicken embryo in the egg: “CrystalEgg™” and “ChickMale Saver™”.

The “CrystalEgg™” method developed by “LIVEgg™” is the world’s first monitoring system for chicken embryos¹⁸³ and can deliver precise information about the expected hatching time, development status, mortality, fertility and more parameters from its position in the incubator¹⁸⁴ from the 7th day of incubation. This means that it exceeds the possibilities of other monitoring systems that can only measure environmental influences within the incubator. To

this end, “intelligent” “EggTrays” are placed inside the incubators. The embryo’s physiological signals and environmental conditions are transferred, analyzed and presented using the “CrystalEgg™” app¹⁸⁵. The “CrystalEgg™” system has supposedly already improved hatching rates in high-efficiency hatcheries by 3-4 percent¹⁸⁶ in Africa, Europe and Israel.

Using the “ChickMale Saver™”, set to launch in 2020, a non-invasive procedure can establish the sex of the embryo. The data collected from thousands of hatcheries using a big data information system can be made available in an instant.^{187,188}

Benefits:

It is a non-invasive procedure. The method can establish the embryos’ sex from the 7th day of incubation.

Considerations:

The company has informed us that the system has an 85-87% accuracy rate and they expect to reach 97-98% accuracy by 2022.

3.2.5 SELEGGT (ENDOCRINOLOGY)

Seleggt GmbH was founded in March 2017 as a joint venture of the Rewe Group, one of the largest German retailers, and the leading Dutch hatchery technology company HatchTech in cooperation with the University of Leipzig¹⁸⁹. It is funded by the Federal Ministry for Nutrition and Agriculture (BMEL).^{190,191,192}

The Seleggt method is a non-invasive procedure made up of 2 steps: removal of the amniotic fluid, and the marker/analysis¹⁹³. A laser is used to burn a small hole in the shell of the incubated egg under 0.3 millimeters in diameter. This is used to extract a small amount of amniotic fluid¹⁹⁴. The inside of the incubated egg is untouched and remains unharmed. In the following step, the amniotic fluid is placed on a patented marker outside the incubated egg.

This develops a colored edge if the egg contains the gender-specific hormone estrone sulfate. If this is the case, the egg houses a developing female chick.¹⁹⁵ The egg does not need to be resealed after sexing. The internal membrane of the egg reforms independently and seals the tiny hole from the inside. On the 21st day of incubation, a female chick hatches.

If there is no estrone sulfate, then the egg is male. This is then sorted and processed into hatching egg powder. This can be used in pet food.

The Seleggt method is around 98 percent reliable in practice.¹⁹⁶ The Guardian reports accuracy rates of 98.5 percent.¹⁹⁷ When the method was introduced at EuroTier 2018 in Hanover, Professor Almuth Einspanier reported a 99 percent accuracy.

Benefits:

This is a non-invasive nano-procedure that does not require a needle. The egg is not touched with a tool. This means that the inside of the egg is untouched and unharmed.¹⁹⁸ There are no negative repercussions for the hatching egg. Exactly how the method works is a business secret.¹⁹⁹

Since November 2018, 223 Rewe and Penny stores in Berlin have been offering the first eggs for consumption that came from hens that went through the new process as eggs.²⁰⁰ The Seleggt method was introduced

by Agricultural Minister Julia Klöckner, Seleggt CEO Dr. Ludger Breloh and representative Chairman of the Rewe Group, Jan Kunath.²⁰¹ These eggs are labelled with a "no-kill" logo.²⁰²

Costs per carton of eggs should only increase by 1-3 euro cents.^{203,204} Jan Kunath said that a 6-pack of these eggs should cost 10 euro cents more than a 6-pack of free-range eggs and that this would be accepted by consumers.²⁰⁵

The Rewe Group managed a national market introduction of the "respeggt" labelled eggs across all approximately 5,500 Rewe and Penny stores in Germany in 2020. Parallel to this, Seleggt worked on a business model to make the technology available to the industry as a cost-neutral service. These eggs are sold under the "respeggt" label and are currently (May 2020) available in the following food markets: Rewe, Penny, Marktkauf, Famila, Edeka (Germany), Carrefour (France) and Jumbo (The Netherlands).²⁰⁶

Innovative block-chain technology should ensure that the process is fully traceable. An app will be used so that the hatchery equipped with Seleggt can input relevant data about rearing young hens and egg farming up to egg packaging, which will be visible to everyone in the supply chain.²⁰⁷

Considerations:

The method can establish the sex of an embryo from the 8th/9th day of incubation.^{208,209,210} The reason for this is that a certain minimum concentration of the hormone is required in the amniotic fluid in order to achieve a high level of accuracy with the current marker developed by the University of Leipzig. However, the scientific literature states, as already mentioned, that the chicken embryos can feel pain from the 7th day of incubation.²¹¹ The information about accuracy in practice ranges from 98 percent to 99 percent (see further above). Seleggt would like to try and establish sex on the 5th/6th day of incubation.²¹²

The Seleggt method should be able to inspect 3,500 eggs per hour, so 50,000 units in one day with two 6-hour shifts.²¹³ The German Poultry Association has defined a sorting capacity of around 100,000 eggs per day as economically necessary.²¹⁴

The method was awarded the Innovation Award for Compassion in World Farming in 2018.²¹⁵ Seleggt was awarded the silver medal at the 2018 EuroTier trade fair in Hanover.²¹⁶

On a Chicken Embryo's Ability to Feel Pain

This is incredibly difficult to establish precisely²¹⁷. Currently, scientists agree that chicken embryos cannot feel pain up to the 7th day. The chicken embryo's sensitivity begins on the 7th day of incubation.^{218,219,220} From the 15th day, the embryos definitely feel pain. Scientific opinions differ regarding the ability to feel pain between the 7th and 15th day²²¹.

Animal Equality therefore currently recommends technologies that are able to sex eggs up to and including the 6th day of incubation or sooner, to ensure that no pain is suffered by the embryo.

place completely automatically²³². "Orbem genus" also allows unfertilized eggs to be automatically identified before incubation so they can be rerouted to retail. This amounts to around 15 percent of the eggs.^{233,234} Male eggs that have already been incubated can be made into pet food²³⁵. The prototype should be able to inspect 20 million eggs per year.^{236,237} This amounts to 150 eggs every 2 minutes²³⁸.

Benefits:

This is a contactless^{239,240} non-invasive procedure - the eggshell is unharmed.^{241,242,243} Magnetic resonance imaging is a procedure that has been tested in human medicine millions of times without any negative effect on the body²⁴⁴. The company aims for a cost increase of just 1 euro cent per egg in the development phase.^{245,246} During operation, this should drop to just around 0.5 euro cents²⁴⁷. Measuring time should be around one second per egg²⁴⁸.

Considerations:

It is not known when this process will be ready for practical use, as accuracy still has to be improved²⁴⁹. A prototype was due to be developed by mid-2019. The method should be tested in a hatchery in 2020.^{250,251,252}

3.2.6 "ORBEM GENUS" (MAGNETIC RESONANCE THERAPY)

The process behind "orbem genus" was developed at the Technical University of Munich (TUM).^{222,223} Behind the technology are Professor Axel Haase, Professor Benjamin Schusser, Dr. Maria Laparidou, Dr. Pedro Gómez and M.Sc. Miguel Molina. Bayerische Patentallianz GmbH (BayPAT) accelerated the patenting process and has been tasked with marketing the invention as well as any resulting rights of protection²²⁴. Founded in 2017²²⁵ Orbem won a start-up competition run by the Federal Ministry for the Economy and Energy (BMWi)²²⁶.

This method combines magnetic resonance imaging (MRI), well known in medical fields, with new artificial intelligence methods ("deep learning")²²⁷. "Orbum genus" uses the differences in blood components in male and female embryos that are recognizable thanks to image signals²²⁸.

Sex can be established in the initial days of incubation (by the 7th day of incubation is the clear aim²²⁹), before the embryos can feel pain.^{230,231} This analysis takes

3.2.7 PLANTON

The German retailer Aldi is working with the biotech company Planton²⁵³. Planton's genetic analysis method determines the sex of the egg on the 9th day of incubation. A microscopic hole is pierced in the egg shell using a fine laser beam. Then a small drop of liquid (Allantois) is removed using a fine pipette and analysed (DNA or hormones)²⁵⁴. The developers are currently working to develop the technology, which is already ready for practical use, so that it is ready for series production and can be made available to other market participants²⁵⁵.

4. CURRENT COMPANY GUIDELINES



Companies are already sending meaningful signals to consumers, who increasingly desire more transparency and respect for animal welfare in the production of their foods. These companies are publicly showing that change is possible:

Unilever was the first major company to state their position against the culling of male chicks in 2014, and declared their aim to prevent deaths through in-ovo sexing.^{256,257,258,259} The company has stated that it is closely involved in the development of alternative methods and has pledged to support the market introduction of such technology.²⁶⁰

We are closely involved in the development of alternative options to current practice and are committed to providing support to the market introduction of these technologies once available to our suppliers. Therefore, we welcomed the June 2016 announcement from the United Egg Producers in the US that they are aiming to eliminate the culling of male chicks by 2020, through the introduction of in-ovo sexing of eggs, allowing gender identification before hatching.

<https://www.unilever.com/sustainable-living/what-matters-to-you/farm-animal-welfare.html>

In June 2016, United Egg Producers, representing 95 percent of egg producers in the USA, said it was ready to end the culling of male chicks by 2020 or as soon as the technology is commercially viable.^{261,262,263,264,265}

"As representatives of more than 95 percent of egg production in the United States, United Egg Producers (UEP) and our farmer-members have an obligation to study and adopt practices that improve animal welfare. Our members recognize that this extends to the practice of male chick culling at hatcheries, and as such, our Board, at its May 2016 meeting, took a meaningful step forward to address this difficult issue and approved the following statement:

'United Egg Producers and our egg farmer members support the elimination of day-old male chick culling after hatch for the laying industry. We are aware that there are a number of international research initiatives underway in this area, and we encourage the development of an alternative with the goal of eliminating the culling of day old male chicks by 2020 or as soon as it is commercially available and economically feasible. The U.S. egg industry is committed to continuing our proud history of advancing excellent welfare practices throughout the supply chain, and a breakthrough in this area will be a welcome development.'

<https://unitedegg.com/united-egg-producers-statement-on-eliminating-male-chick-culling/>

More companies have followed. In March 2020 Aldi Nord and Aldi Süd announced that they want to end the cruel killing of male chicks in shell egg production.²⁶⁶ Aldi Nord and Aldi Süd have set themselves the goal of converting their entire egg supply by 2022 at the latest. This would make them the first grocery store in Germany to offer only eggs "without chick killing". In order to implement this as quickly as possible, they are in dialogue with various process developers, such as the biotech company Planton (see above).

ALDI schafft das Kükentöten ab

- Für Schaleneier von ALDI sollen keine männlichen Küken mehr sterben
- Als erste Händler werden die Discounter in Deutschland nur noch Eier „ohne Kükentöten“ anbieten

Essen/Mülheim a. d. Ruhr (11.03.2020) ALDI Nord und ALDI SÜD wollen das Töten von männlichen Küken in der Schaleneier-Produktion beenden. Möglich machen das unter anderem technische Verfahren, die das Geschlecht in den ersten Bruttagen im Ei bestimmen. Eier, aus denen männliche Küken entstehen würden, werden dann nicht mehr ausgebrütet. Die Discounter setzen sich zum Ziel, bis 2022 deutschlandweit die gesamten Lieferketten für ihre Boden-, Freiland- und Bio-Eier umzustellen.

<https://www.planton.de/dokumente/Pressemitteilung-ALDI.pdf>

Aldi ends chick killing

- No more male chicks should die for shell eggs from Aldi
- The discounters in Germany will be the first retailers to offer only eggs produced without chick killing

Aldi Nord and Aldi Süd want to end the killing of male chicks in shell egg production. This becomes possible beside other things, through technical processes that determine the sex in the egg during the first days of incubation. Eggs from which male chicks would hatch are then no longer incubated. The discounters have set themselves the goal of converting the entire supply chain for their barn-, free-range and organic eggs throughout Germany by 2022.



5. CONCLUSION

Globally, up to 8 billion male chicks born into the egg industry are culled every year.²⁶⁷ Whilst this practice has always been of concern amongst the public, legal entities are now catching up. Switzerland banned the use of maceration to cull male chicks in 2019.²⁶⁸ Germany and France have vowed to end all male chick culling by the end of 2021.²⁶⁹

Society, politics and business have recognized the ethical problems with culling chicks en masse, and are working on various alternatives. This practise can be stopped, as more companies invest in a future without the need for male-chick culling.

As long as animals are being bred, farmed and killed for food, any improvement to the system is progress. Of course, the various approaches come with pros and cons, but they have the same goal: to end the routine culling of day-old male chicks - a practise condemned by the egg industry, veterinarians, animal protection groups and the public.

In-ovo sexing and subsequent selection causes less suffering than culling chicks on the day they hatch. The “ideal” in-ovo sexing technological solution would establish the sex of the untouched egg on the day of laying without using genetic modification. These eggs could be retailed without any unnecessary statutory limitations, bringing approximately 8 billion more eggs onto the market for use in food for human consumption, animal feed or vaccines. This has the potential to prevent 29 million hens from being used in the livestock industry each year.²⁷¹

Animal Equality supports any technology that will reduce the number of male chicks culled. However, we encourage companies to adopt a method that sexes the egg up to and including the 6th day of incubation to ensure that the embryo feels no pain.^{272,273,274,275} The incubated eggs could then be used as animal feed.

In-ovo sexing is not only beneficial in terms of animal welfare. The related carbon footprint would also decrease significantly, and estimated annual savings for the global egg industry range from 1.5 to 2.5 billion US dollars.²⁷⁶

It is unlikely that in-ovo sexing will be widely available in 2020.^{277,278} There has been a race to determine who can and will get the most efficient and best solution ready for production the fastest.^{279,280} Seleggt opted for the earliest commercialization providing its technology to several grocery stores in Germany, France and the Netherlands. The other companies listed above are making substantial progress, and we should see further commercially available technology over the coming years.

Whilst no system of animal agriculture can be completely cruelty-free, male chick culling is one of the most cruel, and thanks to technological advances, now unnecessary farming practises. By committing to the development and adoption of in-ovo sexing technology, companies demonstrate to their customers, competitors and the wider industry that they prioritize animal welfare and are forward-thinking in their business approach.

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