Research

The Road to SetCare
20 years of research on the optimal start of incubation

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Early deaths

Hatcheries generally strive to achieve high hatchability rates and optimal chick quality. At the bottom line, this is what pays their bills and satisfies their customers. However, even the 25% best performing hatcheries in the world 'only' achieve an average 85.8% hatch of set (Aviagen, 2009). In other words, 14.2% of the hatching eggs that are set in their incubators do not hatch a saleable chick. This only becomes clear after candling at approximately 18 days of incubation, meaning that incubator capacity, predictability of saleable chicks, and above all profitability of commercial hatcheries are greatly reduced by eggs that do not hatch.

Part of this negative impact cannot be prevented by hatcheries, because approximately 5.4% of all hatching eggs is infertile (Figure 1). Obviously, infertile eggs will never hatch a chick regardless of the hatchery's efforts. However, the remaining fertile hatching eggs do contain embryos that could potentially develop into a saleable day-old chick. Instead, 8.8% die at a certain moment during incubation. Especially the start of incubation seems to be a critical period, because half of the total embryo mortality occurs already during the first 3 to 4 days of incubation. These are known in the hatchery business as 'early deaths'. To put this into perspective: for a top quartile broiler hatchery that hatches 1 million chicks per week, this comes down to ±2.5 million eggs that are disposed of each year due to early deaths. Early deaths thereby comprise the biggest economic loss for hatcheries, and with the rising prices of hatching eggs, this loss of profit will only continue to grow.

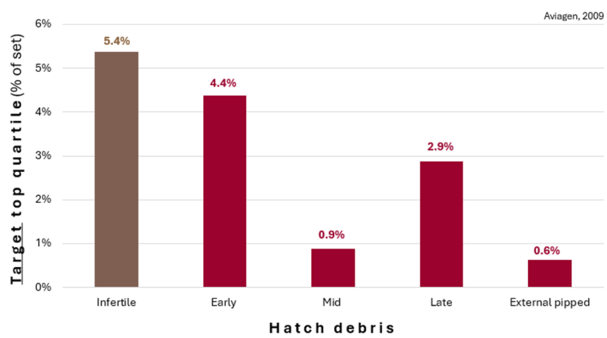

Figure 1. The percentage of eggs from the total of set eggs that were classified as infertile, early deaths, mid deaths, late deaths, or mortality after the egg had been externally pipped for the top quartile best performing hatcheries in the world (adapted from Aviagen, 2009).

Disagreement on current standard prewarming practices

The relatively high percentage of early deaths has always been accepted in the industry due to the assumption that early-stage embryos are simply very vulnerable. Already 20 years ago, HatchTech researchers questioned this was really true. Doctor van Roovert-Reijrink hypothesized that early deaths could potentially be the result of a suboptimal warming procedure at the start of incubation.

Hatching eggs are ideally stored in cool egg storage rooms at maximum 18°C. Once incubation begins, the temperature of the eggs is increased to 37.8°C. This means that egg temperature increases by roughly 20°C at the start of incubation. Early stage embryos are poikilothermic, meaning that their developmental rate fully depends on the environmental temperature. If this 20°C increase in egg temperature at the start of incubation is conducted at a suboptimal rate, early embryonic development may be harmed, possibly explaining the relatively high mortality numbers.

There were various thoughts in the industry on how to warm hatching eggs from storage to incubation temperature. Some advocated to warm eggs as quickly as possible, saving time and incubator capacity. Others believed that some kind of prewarming helps the embryo and, for example, positioned their eggs in a corridor with an intermediate temperature for a couple of hours before setting them in the incubator. Furthermore, prewarming practices were largely dependent on the available technical setup within a hatchery, such as the incubator's heating capacity, or the practice of multistage incubation.

Disagreement about how to warm eggs from storage to incubation temperature still exists today. Current standard practice is to increase the 20°C in hatching egg temperature anywhere in between 3 to 22 hours. This variation in prewarming practices may not only be caused by the hatchery's technical setup, but is likely also caused by the fact that until now, there was a gap in scientific knowledge on the optimal warming procedure. Research showed that setting hatching eggs in a room with almost any intermediate air temperature between storage and incubation temperature is beneficial for hatchability (Funk and Forward, 1960; Proudfoot, 1966; Mayes and Takeballi, 1984; Meijerhof et al., 1994; Piestun et al., 2013; Lin et al., 2017), but these studies lacked information on the exact temperature of the eggs during the timespan within this prewarming room. Besides, no studies had searched for the optimum prewarming duration whilst longer prewarming often showed better results than short prewarming without showing a prewarming duration limit.

Uniform Embryo Activator

HatchTech researcher Dr. Inge van Roovert-Reijrink was one of the first who investigated the effects of various prewarming eggshell temperature **(EST)** patterns on early deaths. Three main findings were published in her doctoral dissertation at Wageningen University & Research (Reijrink, 2010):

1. **Embryos do not (morphologically) develop below 29.4°C EST**
2. **The rate with which eggs are warmed from storage to 29.4°C EST is irrelevant**
3. **Linearly warming eggs from 29.4°C EST to incubation temperature (37.8°C EST) in 17 hours significantly reduced the percentage of early deaths compared to more rapid rates**

Based on these findings, HatchTech decided in 2011 to introduce the patented Uniform Embryo Activator **(UEA)** to the market. With the UEA, a total prewarming duration of 22 hours is split up into two phases. In phase 1, eggs are linearly warmed from storage to 29.4°C EST in 5 hours. In phase 2, eggs are warmed linearly from 29.4°C EST to incubation temperature in 17 hours. From that moment onwards, the UEA has been applied as a standard feature in all HatchTech setters. HatchTech customers that apply the UEA, note an average 1.2 % increase in hatchability of fertile eggs. The fact that the UEA benefits hatchability has been supported by a scientific study (van Roovert-Reijrink et al., 2018) and recently published studies have shown that a comparable preincubation warming profile of 24 hours, advanced hatchability compared to 6 hours of prewarming (Tikit et al., 2024).

A search for the optimum gradual warming rate

Although the UEA performed well in the field, HatchTech researchers were now triggered to find out what would happen if the warming rate were even slower. After all, this had not been investigated yet. Therefore, project 'SetCare' was initiated, in which the optimum warming rate from storage to incubation temperature was investigated. In consecutive studies, the warming rate of phase 2 (29.4 - 37.8°C) was extended stepwise and compared to the UEA standard (17 hours) until the optimum rate was found.

In each study, between 4,800 and 19,200 hatching eggs from Ross 308 flocks of various ages (29-55 wks old) were stored for relatively long durations (ranging from 14-23 days of storage) to intentionally increase early embryo mortality and help to reveal any treatment effects. Eggs were equally divided into 4 setters in which eggshell temperature was automatically maintained at 100°F with eggshell sensors.

This resulted in a total of 13 consecutive studies that were conducted over a 3-year period (2021-2023). It turned out that the optimum warming rate lasted 6 days! This was much longer than expected, but the benefits also exceeded expectations. Gradual warming with SetCare reduced early deaths by up to 21.8%. For example, in one study, long egg storage resulted in a disappointingly high number of early deaths (38.3%) in the control group (17-hour warming rate), whereas SetCare reduced the number of early deaths to just 16.5%.

It was speculated that embryos that now survived the early incubation process because of SetCare might still die later. In other words, gradual warming may simply delay mortality of embryos that normally would have died during rapid warming. Fortunately, this was not the case. Embryos that survived because of SetCare continued to survive until hatch. Consequently, eggs incubated using SetCare expressed significantly higher hatchability rates, more than could be explained by early embryo survival rates alone. The number of unhatched eggs at pull moment was also lower. It seems that SetCare does not merely benefit the start of embryonic development, but improves embryo survivability throughout the total incubation process.

Improved chick quality

Embryos that survived the early stages of development due to SetCare did not hatch as poor quality chicks. On the contrary, SetCare seemed to benefit embryonic development throughout incubation, expressed by improved chick quality at hatch. First of all, chick body length (Hill, 2001) was greater. In 6 out of 9 experiments , chicks that hatched with SetCare were significantly longer than those from eggs that were warmed relatively rapidly (P<0.05; Table 1), with differences ranging from 1 to 4 mm. Chick length is positively correlated to yolk-free body mass (Wolanski et al., 2004, 2006; Meijerhof, 2006; Willemsen et al., 2008; Sozcu and Ipek, 2015), a measure indicative for chick quality because it indicates how efficiently yolk has been converted to chick body mass during the incubation process.

Prewarming duration From 29.4– 37.8 °C EST	**Body length at hatch** (mm)								
	1	2	3	4	5	6	7	8	9
Control (17 h)	191	188	182	193	185	190	187	191	188
24 hours	194	190							
31 hours		190							
2 days		191	183						
3 days			185						
4 days			186						
6 days (SetCare)				193	186	192	189	191	188
Δ to Control (mm if P<0.05)	**3**	**3**	**4**	**-**	**1**	**2**	**2**	**-**	**-**

Table 1. The difference in chick length at hatch after incubation with SetCare compared to when warmed in 17 hours (= control group) from 29.4°C to 37.8°C at the start of incubation in 9 consecutive studies.

Remark: Using chick length as an indicator for chick quality should always be interpreted with caution. Not only can the measurements be subjective to bias of the observer, but chicks can also grow as much as 1 cm in less than 24 hours (Willemsen et al., 2008). Many scientific studies report chick length measured at hatch, while the length of the chicks was actually measured at pull. In all in-company studies in the current article, chick quality was assessed in dry newly hatched chicks, allowing slightly damp neck feathers, which were collected every 6 or 8 hours during the hatch window. Potential observer bias effects were excluded by adding the observer as a random factor to the statistical model.

In addition to average chick length, the number of "too short" (<18 cm) chicks at hatch is of interest because such chicks are assumed to lag behind in development and are more susceptible to 1st week mortality. Therefore, such chicks are generally disposed as 2nd grade chicks during post-hatch quality control before they leave the hatchery.

SetCare resulted in significantly fewer too short chicks in study 1 and 2 (Figure 2; P<0.03; Δ=6-8%) and tended to hatch fewer too short chicks in study 3 and 4 (P=0.09 and P=0.05; Δ =1% and Δ=2%, respectively) compared to 3-h, 10-h or 22-h warming durations from storage to incubation temperature. In study 5, no too short chicks were found, regardless of how eggs were warmed. Based on these studies it can be assumed that hatcheries will likely have a reduction in chicks that are disposed as 2nd grade if eggs are gradually warmed during 6-days compared to their current standard warming practices.

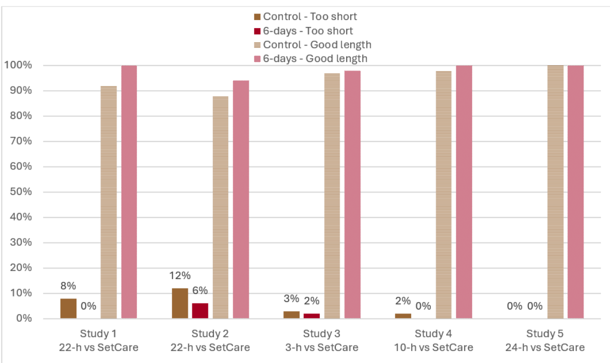

Figure 2. Classification in either too short or good length of good quality chicks at hatch from eggs that were either warmed in 3, 10, 22, 24 hours compared to SetCare (6-day warming) in 5 studies. In each study eggs from a prime flock were used, except for study 1 in which eggs originated from an older flock (50 wks). HatchTech guidelines classify chicks as "too short" when their length is below 17.5, 18.0, or 18.5 cm for young, prime, and old parent flocks respectively.

Chick uniformity also improved with SetCare. Uniformity was expressed as the number of chicks that had a bodyweight within ±10% of the average of that batch. It can be seen from Figure 3 that during incubation, uniformity in embryo weight is at first similar between eggs that were warmed in 24 hours vs eggs incubated with SetCare (6-day warming) (both 56.7% at day 6 of incubation). However, from day 12 of incubation onwards the eggs incubated with SetCare show approximately 10% higher uniformity in embryo weights. This persisted until hatch and uniformity in body weight was 91.7% vs 83.9% for chicks hatched from eggs incubated with SetCare versus eggs that were warmed more rapidly. Chick uniformity at hatch is important because it ensures all chicks start with a similar body weight and developmental status, leading to more consistent growth during rearing. This ultimately results in more uniform broiler sizes at slaughter, which improves processing efficiency and product quality.

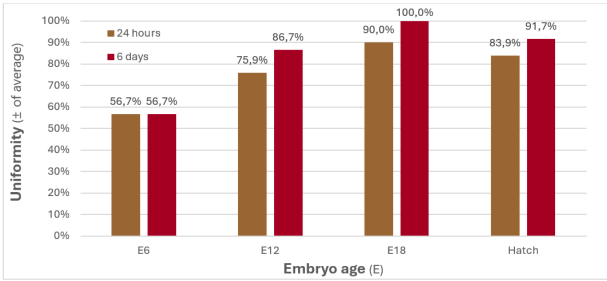

Figure 3. Uniformity (±10% range around the average) of embryo weight at 6, 12, and 18 days of incubation and of chick weight at hatch from eggs that were either warmed in 24 hours or incubated with SetCare (6-day warming).

Post hatch poultry performance

After it had been shown that SetCare improved hatchability and chick quality, we wondered whether these positive effects would be sustained for broilers during the rearing period. After all, studies have shown that chick length at hatch correlates positively to growth performance during the rearing period (Wolanski et al., 2004 & 2006; Baarendse et al., 2006; Molenaar et al., 2008; Willemsen et al., 2008; Petek et al., 2010; Sozcu and Ipek, 2015).

A pen trial was conducted to assess post-hatch effects of SetCare compared to a conventional setter system in which eggs were warmed in 4 hours from storage to incubation temperature. Long-stored eggs (18 days) originating from a 34 week old Ross 308 broiler flock were used. Day-old-chicks were divided over 32 floor pens with 16 replicates per treatment. Each pen housed 18 chicks with an equal sex ratio. Broilers were grown for 5 weeks under standard management practices until slaughter. Their body weight and feed intake were determined weekly per pen.

Results showed that SetCare resulted in a significantly higher body weight from week 1 up to and including slaughter age (Figure 4; $P<0.02$). At slaughter, SetCare broilers were on average 51 grams heavier. This can be explained by a higher average daily gain (ADG) in SetCare broilers compared to broilers that were incubated in a conventional setter system (Table 2). On average, SetCare broilers grew 1.9 grams more per day during the total rearing period ($P<0.01$). SetCare broilers also consumed more feed. On average, their daily feed intake (ADFI) was 2.1 grams higher ($P=0.03$). When the feed conversion ratio (FCR) of each treatment was corrected to an equal body weight of 2.5 kg (with 2 points per 100 g), SetCare broilers were significantly more efficient in turning feed into body mass with a 1.8 improvement in FCR ($P=0.03$).

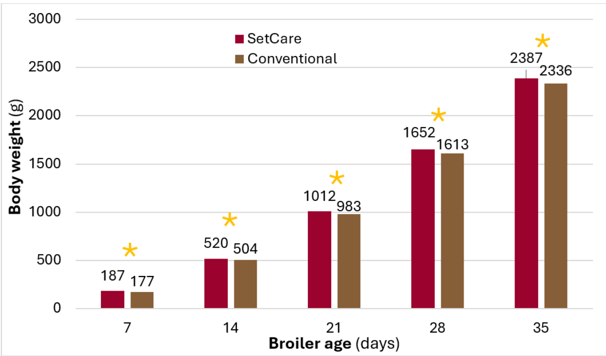

Figure 4. *Weekly body weight (BW) of broiler chickens after using a conventional setter system or SetCare. The asterisks (*) indicate significant difference.*

Table 2. *Average daily gain (ADG), average daily feed intake (ADFI), and feed conversion ratio (FCR) from Ross 308 broilers that were either incubated in a conventional setter system or a SetCare setter system.*

Setter system	ADG (g)	ADFI (g)	FCR[1]
SetCare	66.6[a]	92.4[a]	1.410[b]
Conventional	64.7[b]	90.3[b]	1.428[a]
P-value	<0.01	0.03	0.03

1 Corrected to a body weight of 2.5 kg with 2 points per 100 g

SetCare also benefits short-stored eggs

Previous paragraphs showed that SetCare improved incubation results and post-hatch broiler performance in long-stored eggs. Prolonged egg storage increases the vulnerability of early-stage embryos, which generally results in a relatively high percentage of early deaths, and worse chick quality and post-hatch performance. However, short-stored eggs show the highest risk for embryonic mortality during the first days of incubation. As this may also be caused by a suboptimal warming procedure from storage to incubation temperature, SetCare could potentially benefit short-stored eggs, too.

Numerous studies were conducted between 2023 and 2024 during which the effects of SetCare were studied for short-stored eggs (0-6 days) from both layer and broiler parent flocks of various ages (young, prime, old). These studies showed that SetCare had similar beneficial effects to those found in studies with long-stored eggs, including lower early deaths, higher hatchability, and improved chick quality compared to the UEA. However, the absolute benefits were smaller for short-stored eggs than for long-stored eggs.

It was concluded that hatcheries can expect an average increase of 3.3 % in 1st grade chicks from short-stored eggs. Furthermore, these chicks are more uniform and have greater body length. As indicated, the benefit of SetCare is dependent on egg storage duration and warming rate. Therefore, hatcheries with relatively long egg storage durations, worse egg storage conditions and/or rap id or suboptimal warming practices can expect a larger benefit when using SetCare.

24-days of incubation

With SetCare, the total incubation period, from set to pull, takes 24 days. Anyone quick at math will note that this doesn't add up; a conventional 21 days of incubation plus 6 days of gradual warming should result in 27 days of incubation. However, with SetCare, the total time that eggs spend at incubation temperature (37.8°C) is 3 days shorter compared to conventional incubation. This is because significant embryonic development has already started during gradual warming.

Pennings et al. (2025) warmed eggs from storage to incubation temperature in either 10 hours or 6 days, and opened the eggs at the start, halfway, and the end of warming to observe how much embryonic development was progressed (Figure 5). It was observed that only minor morphological development occurred if warming took 10 hours, but considerable embryonic development occurred during the gradual 6-day warming process in SetCare.

Halfway warming, at an egg temperature of 33.6°C, embryos already have a fully developed primitive streak with 4 pairs of somites, which are the very early cell layers that will become organs, muscles, bones, brain, skin, and the nervous system (HH stage 8). At the end of warming, these embryos have a prominently developed brain, a beating heart, organ systems are established, and head, trunk, tail, legs, and wings are clearly visible (HH stage 20). In conventional incubation, this stage of development is only reached after 3 days of incubation at an egg temperature of 37.8°C.

This shows that 'prewarming' should be regarded as true incubation rather than merely 'warming the eggs before incubation starts. Incubation starts at 29.4°C EST, not at 37.8°C. Most people involved in incubation likely assumed that embryos would start to develop at temperatures below standard incubation temperature. After all, hatching eggs are deliberately stored at lower temperatures to control temperature effects on the embryo. However, the true start of incubation was never thoroughly investigated until now, and the great importance of gradual warming and the extent to which embryos develop that has now been revealed was not recognized. **As a result, it can be stated that incubation takes 24 days instead of 21 days.**

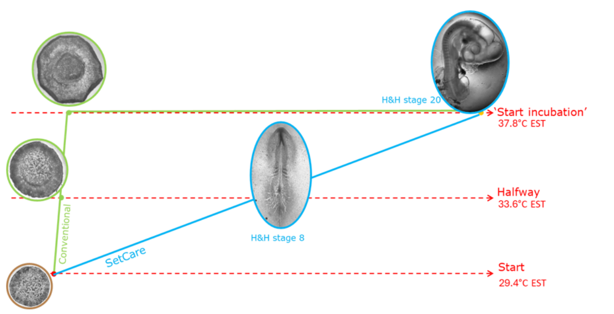

Figure 5. *Progress in embryo development during warming of hatching eggs from storage to incubation temperature in either a conventional setter system including 10 hours of warming or a SetCare setter system including 6 days of warming.*

SetCare is more than 'just' gradual warming

HatchTech decided in 2024 to introduce SetCare to the market. This patented setter system can warm the hatching eggs very gradually over a period of 6 days from storage to incubation temperature. But SetCare is more than 'just' gradual warming.

Firstly, eggs are warmed linearly from storage to 29.4°C EST in 5 hours and secondly, from 29.4°C EST to incubation temperature in 139 hours. In the second warming phase, temperature is increased by only 0.06°C per hour. Very accurate and uniform temperature control within the incubator is crucial to reach such tiny steps. Three features play a key role in accomplishing this:

1. Laminar Airflow through perforated radiators

This is relevant for the total incubation process, but especially for the first warming phase of SetCare. In the first warming phase, eggs are warmed in 5 hours from <18°C to 29.4°C EST. A lot of heat enters the incubator in this phase over a relatively short period. By the end of this phase, embryonic development begins, and suddenly temperature should only be increased in tiny steps. Any overshoot in egg temperature after these first 5 hours will be detrimental to the benefits that could have been achieved. For example, a 2°C overshoot corresponds to nearly 2 days of the intended 6 days of gradual warming.

2. Autofan

Friction heat from the fan can be too much. With the autofan function, the fan speed is automatically adjusted to balance air flow and heat production from the fan.

3. Gas-sealed design

Air that enters the machine, either via ventilation or non-airtight parts, will never be the exact same temperature as required within a tiny warming step. Therefore, the setter is gas-sealed and 'cold spots' are prevented.

During the first six days of gas-sealed incubation, humidity naturally rises to around 70% without causing condensation, while CO_2 reaches approximately 7,000 ppm. This moderate hypercapnia has been shown to promote chorioallantoic blood vessel development (Fernandes et al., 2017) and may contribute to the lower number of unhatched eggs at pull observed with SetCare.

In addition, SetCare's integrated, chemical-free air and surface disinfection system continuously reduces microbial contamination, lowering colony-forming units (CFUs) on eggs by up to 95%.

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