EFFECTS OF MECHANICAL IMPACTS ON HATCHABILITY OF BROILER BREEDERS

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ABSTRACT

The effects of transport and other mechanical impacts have been mainly investigated in table egg production industry. Although the effects on hatchability are known they have not been examined on a large scale even though sophisticated equipments are widely available on the market to monitor mechanical effects during transport. Transporting hatching eggs from Hungary and incubating them abroad revealed lower hatchability compared to when the eggs were incubated in Hungary. Following transport, there were higher embryo losses and, notably, more malformed embryos. The aim of these initial trials was to determine if a testing device (Crazy Fit Massage machine – CFM machine) was able to replicate and model the mechanical impacts experienced during transport and reproduce the reduction in hatchability and increase the level of malformed embryos as have been observed in commercial practice. Tinytag® high sensitivity shock and vibration loggers were used to monitor the impacts under field and trial conditions.

Applying single 10 minute treatments on the CFM machine using the same frequency (10-30 Hz) as the eggs experience under field conditions induced the negative effect of transport and lower hatching results were experienced. Three trials were conducted. Treated eggs in Trial No. 1 and 2 received automatically and periodical changing vibration in a range between 10-30 Hz for 10 minutes while in Trial 3 two different level of impact were applied at 20 and 30 Hz, respectively.

Hatchability decreased due the treatment although in only Trial No. 3 was the difference significant, also the difference in early dead levels in Trials 2 and 3 and occurrences of malformation in Trial 1 and 3. All these results are in accordance the field experience.

Thus, the trials examined the equipment was able to produce mechanical impacts that were repeatable in order to set up statistically reliable trials on hatching eggs.

Key words: mechanical impacts, hatchability, loggers

Acknowledgments: I like to thank the University of West Hungary, Faculty of Agricultural and Food Sciences, Institute of Animal Sciences Mosonmagyaróvár, Aviagen Kft, the hatchery and personnel of Hegyhát Br. Kft. at Bábolna and Dr. Steve Tullett who is helping with technical inputs into this study.

INTRODUCTION

The effects of transport and other mechanical impacts have been mainly investigated in table egg production (*Carter, 1970*). *Walker et al.* (1972) already stated that, during transport, shaking of the eggs should be held to a minimum since shaking has been found to have a detrimental effect on egg quality.

Their main concerns were the damage during transport on the egg shell integrity and through this the levels of saleable table eggs and other effects on internal egg quality which could affect the value of the table eggs. This is one of the main concerns in hatching eggs also, but because hatching eggs have a higher value, the economic loss is even higher than on table eggs.

The negative effects of mechanical impacts on hatchability are widely known and it was investigated even as early as the *1830s (I. Geoffroy-Saint- Hilaire).* It is common belief that jarring of eggs during shipment may seriously reduce their hatchability. Enquires into this problem have been made by *I. Geoffroy- Saint- Hilaire (1836), Dareste (1867)* and *Launder (1943). Saint-Hilaire* produced malformed chick embryos by subjecting eggs to various environmental conditions including physical trauma (jarring, inversion, pricking) and toxic exposures. However, Proudfoot (1969) observed the hatchability did not appear to be affected the vibration treatments used in his work.

The negative effect of transport on hatchability is known widely and customers are warned about the importance of good transporting conditions by representatives of incubator manufacturers (*Gerd de Lange*) and breeding companies (*Tullett*) but no measurements work has been done so far to determine the threshold for mechanical impacts to minimize the negative effect of transport.

Although there are many data loggers on the market to monitor the actual level of mechanical shock and vibration during egg handling, only one scientific work was accomplished when level of impact was actually measured, in correlation with the hatchability this was done by a Department of Conservation in New Zealand with kiwi and emu eggs (*Potter and Bassett, 2001*). They examined the effects of transportation-induced jarring on ratite embryo development and hatching success. They concluded that jarring did not increase physical abnormalities or defects in developing or hatched chicks within the level of jarring applied in this experiment. However, they collected eggs from the wild forests and therefore some of these eggs were already in the incubation cycle when treated.

Within Aviagen, egg shipments are equipped with shock and vibration loggers to monitor transport conditions. A database has been established but the effect of transport is difficult to interpret

because the location of the pallet and the eggs on the truck has a big effect as have the particular egg characteristics of the load. The observations are often not repeatable because the chances of driving twice with the same pattern over the long distance is very low. Berardinelli et al. (2003) examined the effect of transport by modelling the impacts on a vibrating table of an electro-dynamic shaker, which gave us the idea to use a device for modelling the transport conditions under better controlled and repeatable manner.

The aim of these initial trials was to determine if the testing device (Crazy Fit Massage machine – CFM machine) was able to replicate and model the mechanical impacts experienced during transport when applying the same level of shaking and vibration as the eggs facing with during transport. The long-term plan is to determine whether the g–force or the vibration pattern has the bigger impact and set up a threshold for the more critical parameter for hatching egg transport on the field.

MATERIAL AND METHODS

Eggs

All eggs originated from young GP flocks, which were underweight to consider them as hatching eggs, but they were suitable to test the equipment.

In each trial, the same number of untreated eggs from the same origin and collection period were set as control groups. In the field, eggs were collected and temporarily stored before despatch and after arrival to the destination they are incubated within a few days. The same scenario was used during these trials. In the case of Trials 1 and 3 eggs were stored for less than one day and in the case of Trial 2. three days was the storage period before set.

All eggs were stored in an egg storage room controlled to 16-17^{o}C and 80-85 RH%.

Modelling the transport conditions on CFM machine

The Crazy Fit Massage Machine is a vibration machine with a two dimension vibration plate moved by a motor with the capacity of 1.5 HP. The machine can be set for different levels of vibration between 0-30 Hz, the maximum amplitude is 12 mm.

Treated eggs were placed on Keyes trays (the same type of fibre trays used on the field for transportation) then placed onto the CFM machine in subgroups (each group consisted of 150 eggs) and received single 10 minute long treatments. The motions were were monitored and recorded by a Tinytag® TGP – 0650 vibration logger and Tinytag® TGP – 0605 high sensitivity shock logger/accelerometer to ensure the applied conditions did not exceed those that have been measured under field transport conditions.

In Trials 1 and 2, the trial eggs were treated for 10 minutes with periodically changing vibration in a range between 10-30 HZ. In Trial 3, trial eggs were divided into two groups. Eggs in the first trial

group received a 10 minute treatment of 20 Hz constant vibration, while in the second trial group the eggs received a 10 minute treatment of 30 Hz constant vibration.

Incubation and data collection

Treated eggs were placed onto the same setter trolley as their control group and incubated and hatched together.

The initial egg number in Trials 1 and 2 were 2100 eggs in each of the control and trial groups. In Trial 3, there were 1350 eggs in each of the control and treated groups. Eggs were divided into 150 eggs subunits (capacity of one Petersime setter trays). Treatments and data collection were performed on the individual subunits.

Eggs broken during treatment did not get incubated, but their number was recorded. Eggs with hair line cracks were incubated.

Eggs were incubated and hatched in the hatchery at Bábolna in Petersime machines. The incubation profile was modified according the length of the storage and the characteristics of eggs originating from young flock.

Eggs removed at candling (only in Trial 2) and the hatch debris (in all trials) were broken out in order to determine fertility and the different categories of dead embryos in the unhatched eggs. The following categories were determined during egg break-out: infertile, early-dead embryos, mid-dead embryos, late-dead embryos, embryos with malformations, embryos not in the correct hatch position (malposition), cracked/eggs with shell problems. Pipped embryos were regarded as late deads. No subcategories were determined in the case of malpositions or malformations.

The number of hatched chicks and the result of the egg break-outs were recorded by subunits (setter trays, hatching baskets).

The egg break-out and the categorization of embryos were performed according to the Ross Tech "Investigating Hatchery Practice" (*Tullett, 2009*).

From the data, the hatch of eggs set, hatch of fertile eggs (HOF%), early-dead as a percentage of the fertile eggs (EDoF%), mid-dead as a percentage of the fertile eggs (MDoF%), late-dead as a percentage of the fertile eggs (LDoF%), malformed embryos as a percentage of the fertile eggs (MALFoF%) and embryos in malpositions (MALPoF%) were calculated. Malformations, malpositions and pipped eggs were subcategories under late-dead but their ratios were also calculated separately.

SPSS software was used to analyze the data statistically.

RESULTS AND DISCUSSION

In Trial 1, the treated eggs had a lower hatchability, a higher level of dead embryos in every category, more cracks/shell problems and more malformations and malpositions. When independent samples T test was performed it revealed significant ($P< 0.05$) differences only for the percentage of malformed embryos (*Table 1.*)

In Trial 2, the treated eggs had a lower hatchability, higher level of dead embryos in every category, more cracks/shell problems and more malformations and malpositions. When independent samples T test was performed it revealed significant ($P< 0.05$) differences in case of early-deads and the occurrence of malpositioned embryos (*Table 2.*).

In Trial 3, two groups of eggs were treated with different vibrations. Eggs in the first trial group received 10 minutes treatment on 20 Hz constant vibration, while the second trial group received 10 minutes treatment at 30 Hz constant vibration. To analyse if the difference between the results was statistically reliable ANOVA was applied (*see Table 3.*). There were significant differences (at the 0.05 level with Tukey t-test) as follows:

- Hatch of fertiles between the control and the both treated groups and between the two treatment groups
- EDoF and MDoF: between the control group and the 30 Hz treated group and between the two treated groups
- MALFoF: between the control group and the 30 Hz treated group (*Table 3.*).

Table 1. Trial 1 - hatchability and egg break–out results in control and trial groups (eggs received periodical changing vibration in a range between 10-30 Hz for 10 minutes)

	HOF%	EDoF%	MDoF%	LDoF%	Crack/shell problem%	MALFoF%	MALPoF%
Control	61.78[a] ±13.45	18.80[a] ±7.04	0.59[a] ±0.61	11.64[a] ±5.78	3.00[a] ±2.10	1.12[a] ±0.63	5.17[a] ±2.52
Treated group	55.47[a] ±13.62	23.56[a] ±8.59	1.34[a] ±0.93	14.66[a] ±5.87	3.29[a] ±2.21	2.28[b] ±0.97	5.50[a] ±3.03

[a,b] Values containing the same superscript are not significantly different (P>0.05).

Table 2. Trial 2 - hatchability and egg break–out results in control and trial group (eggs received periodical changing vibration in a range between 10-30 Hz for 10 minutes)

	HOF%	EDoF%	MDoF%	LDoF%	Crack/shell problem%	MALFoF%	MALPoF%
Control	80.06[a] ±3.17	9.00[a] ±2.97	0.61[a] ±0.56	7.94[a] ±1.87	0.62[a] ±0.81	0.55[a] ±0.57	2.22[a] ±1.12
Treated group	59.09[a] ±8.11	21.68[b] ±5.29	0.96[a] ±0.95	13.85[a] ±4.04	4.24[a] ±2.21	1.32[a] ±1.12	4.21[b] ±1.51

[a,b] Values containing the same superscript are not significant (P>0.05).

Table 3. Trial 3 hatch and egg break –out results in control and trial groups (eggs received constant vibration for 10 minutes on 20 or 30 Hz, respectively)

	HOF%	EDoF%	MDoF%	LDoF%	Crack/shell problem%	MALFoF%	MALPoF%
Control	80.75[a] ±1.39	9.66[a] ±1.74	0.56[a] ±0.70	2.99[a] ±1.16	1.78[a] ±0.89	0.55[a] ±0.59	1.89[a] ±1.27
20 Hz treated group	76.80[b] ±2.97	11.15[a] ±3.12	0.39[a] ±0.37	2.92[a] ±1.69	1.50[a] ±0.89	1.27[ab] ±1.06	3.37[a] ±1.84
30 Hz treated group	64.89[c] ±4.27	19.52[c] ±4.76	1.68[c] ±0.88	4.69[a] ±2.44	1.50[a] ±0.88	1.85[bc] ±0.77	3.20[a] ±0.97

[a,b,c] Values containing the same superscript are not significant (P>0.05).

The decrease in hatchability was only significant (80.75 a±1.39 vs. 76.80 b±2.97 vs. 64.89 c±4.27) in Trial No.3. The observed loss in hatchability was mainly due to the increased level of embryo mortality in the early-dead category.

The higher level of early-dead was expected based on the field experiments and Trial 2 (9.00^{a}±2.97 vs. 21.68^{b}±5.29) and in the 30 Hz treated group in Trial 3 (9.66^{a}±1.74 vs. 19.52^{c}±4.76) also showed a significant difference in this category. *Besch et al.* (1965b) established in their work that the accelerative force on the blastoderm resulted in cellular displacement and, as the germinal cells were eroded from the blastoderm, the potential hatchability of the egg tended to decrease - although the accelerative force used to apply the high level of g–force would not usually occur under commercial conditions. The microscopic examination of germinal disc and early-dead embryos will be the next step in this project.

Gerd de Lange in his articles states after transportation, eggs need to be rested for at least 12 hours before starting incubation. Immediate setting will increase early embryonic mortality. In Trials 1 and 3 eggs were set within one day of treatment, while in Trial 2 it was three days after treatment. The effect of the length of storage after treatment will be part of my future investigations.

The significant (0.56^{a}±0.70 vs.1.68^{c}±0.88) increase in mid-term dead embryos in Trial 3 between the control and the 30 Hz treated group was unexpected because embryos tend to be more resistant in that embryonic stage and the probability of embryonic loss is the lowest during the incubation cycle (*Tullett, 2009*).

The fact that there was no significant difference in late-dead embryos in any of the trials is in accordance with the field experience.

Besch et al. (1965a) found in their work on the effect of accelerative forces on avian embryogenesis and the impact force necessary to cause failure of embryo development was in excess of shell failure stress. In the current trials the higher embryonic losses were not due to shell damage. No significant differences were detected in the crack/shell problem category between the control and the trial groups. This could be due to the good shell quality that is usually found in eggs from young flocks. In future trials, eggs originating from flocks of different age will be examined.

The difference in malformations was significant ($P<0.05$) in Trials 1 (1.12^{a}±0.63 vs. 2.28^{b}±0.97) and 3 (0.55^{a}±0.59 vs. 1.85^{bc}±0.77). The explanation could be as found by *Dareste (1877)* where eggs which had been allowed to rest for two days after shipment produced normal embryos, whereas those which had been incubated immediately on arrival gave a majority of abnormal embryos. In Trials 1 and 3 eggs were set within one day, while in Trial 2 they were not set until three days after treatment. The length of storage after treatment will be part of the future investigations.

Tullett (2009) specified the specific malformations (extra legs and/or wings) to be expected as a result of rough handling or jarring of eggs during collection and/or transport. Although the different type of malformations were not recorded in these trials, dead embyros were found with extra legs (Picture 1) and duplication in the face (Picture 2.). Rumplessness was observed in malformed embyros by *Landauer and Baumann* (*1943*) but was not feature of any embryos in this study.

Picture 1. Late dead embryo with extra legs

Picture 2. duplication in the face

In Trial 2, the significant difference (2.22 ^{a}±1.12 vs. 4.21 ^{b}±1.51) in malpositioned embryos could be due to the small eggs on the top of the stack turning upside down due to the higher level of vibration. At the moment this is only an assumption and more trials are needed to test this hypothesis.

CONCLUSIONS

The trials confirmed that the CFM Machine was able to create mechanical impacts that were repeatable in order to set up statistically reliable trials on hatching eggs.

Hatchability decreased significantly due the treatment in Trial No.3 (80.75 ^{a}±1.39 vs. 76.80 ^{b}±2.97 vs. 64.89 ^{c}±4.27). The observed loss in hatchability was mainly due to the increased level of embryo mortality in early-dead stage which is in accordance with the field observations following transportation of eggs. Although the difference in early-dead levels was statistically significant in Trial 2 (9.00^{a}±2.97 vs. 21.68 ^{b}±5.29) and in the 30 Hz treated group in Trial 3 (0.55 ^{a}±0.59 vs. 1.85 ^{bc}±0.77) we need to investigate in more depth the mechanical effect on the early-dead embryos and the supposed damage on the germinal disc will be observed with more sophisticated tools.

The significant (0.56 ^{a}±0.70 vs.1.68 ^{c}±0.88) increase in mid-term dead embryos in Trial 3 between the control and the 30 Hz treated group was unexpected.

There was no significant difference in late-dead embryo levels in any of the trials which is in accordance with the field experience after transportation of eggs.

The significantly higher occurrence of malformations in Trial 1 (1.12 ^{a}±0.63 vs. 2.28^{b}±0.97) and 3 (0.55 ^{a}±0.59 vs. 1.85 ^{bc}±0.77) might be in correlation with the short resting period between the

treatment and the incubation of the eggs. This will be the subject for further trials as well as the significantly increased level of malpositions in Trial 2 ($22^{a}\pm1.12$ vs. $4.21^{b}\pm1.51$).

To analyze further the reason for the elevated number of malformations and malpositions, sub-categories will be introduced when examining the egg break-outs.

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