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MANAGING THE TIME SPAN BETWEEN THE HATCHING OF THE FIRST AND LAST CHICK TO IMPROVE CHICK QUALITY

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Abstract. The objective of study was to determine the exact duration of first and last chick's hatches out and factors affecting this duration. Four consecutive experiments were performed to evaluate the factors affecting hatch window. In experiment no.1 the flocks were divided into four groups (n=134640 eggs for each group) on the basis of hatch window. We found that hatch window significantly (P<0.005) depends upon hatchability percentage; the hatch window becomes short with increase of hatchability e-g the hatch window will be (20-22, 23-24, 25-26, and 27-30) hours if hatchability is (88.33-89.83, 81-85, 76-80 and >75%) respectively. In second experiment two groups of eggs were pre-heated at 80^0F for 5 hours and 80^0F for 3 hours and compared with control. The preheating of both groups significant (P<0.005) effect the hatchability , candling, water loss, chick yield, dead in shells and hatch window as compare to control. In third experiment eggs were stored for 0, 3, 6, 9, 12, 15, 18, 21 and 24 days. Eggs weight loss, hatchability, candling and dead in shell were significantly affected with increase of storage days. Hatch window was 20-22, 23-24, 25-26, 27-28 and 29-30 hours for 0-3, 6-9, 12, 15-18, and 21-24 days of storage respectively. The storage of eggs significantly (P<0.005) affects the hatch window. In last experiment (n=134640 eggs for each incubator) were incubated in single and multi stage incubator. Due to loading and unloading of eggs in multistage incubator, temperature variations were observed. It was observed that all hatchery parameters including hatch window ($25\text{-}26\pm0.024^a$, $28\text{-}30\pm0.082^b$) were significantly (P<0.005) better for single stage incubator as compare to multistage incubators. So, hatch window depends upon hatchability of flocks, proper pre-heating, days of storage and type of incubators.

Keywords: *eggs storage, hatch window, incubators, pre-heating.*

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1. Introduction

Early chick growth is crucial for best performance. The duration or time interval from first to last chick hatches out is called hatch window or spread of hatch (Noiva *et al*., 2014). Not all chicks hatch same time, even in best running commercial hatcheries like 24 hours can elapse between first and last chick hatches out. Some hatcheries may take long than this time leads to dehydration for the early hatch chicks. This variation of time is due to natural and man-made. Variation starts during egg formation in the oviduct. The embryo (or blastoderm) takes about 26 hours during its passage down the oviduct. If the hen decides to hold the egg over until the following day before laying then there could be a further12 hours added to development time. So, when an egg is laid the embryo could be between 26 and 38 hours old a gap which will remain

throughout incubation and hatching (Hodgetts B). Spread of hatch from 24-48 hours becomes source of feed deprivation and dehydration. As hatch spread duration increases the number of chicks deprived with feed and water increases. (Careghi *et al*., 2004) found that delay in hatch causes weight loss and depress growth rate after access to feed. The magnitude of effect depends upon the hatch time within hatch window. Immediate access to feed provides significantly better results. (Hayashi *et al.,* 2013) found that hatch window has effect on development of intestinal mucosa and integrity of gizzard but smaller presence of CD3+ cells in thymus, spleen and ileum. Premature hatch birds may be developed and ready to be transferred to farm even before standard hatch time. Hatch window is one of the most important effecting factors for yolk sac absorption, intestinal development during hatching period and subsequently chick quality. It is very crucial for post hatch performance, feed conversion, and early week mortality control. Correct incubation duration, approximate hatch window range of different age breeders and also egg weight may improve incubation conditions, chick quality as well as post hatch performance (Ipek *et al*., 2014). The storage of eggs also has effects on hatch window. Eggs stored for 3 days and 14 days to check the genes expression PepT1 (H+-dependent peptide transporter) and SGLT1 (sodium–glucose co-transporter) of nutrients transport in the jejunum of early hatch chicks within a hatch window. The length of jejunum and villus width along hatch window were better for the eggs stored for 3 as compare to 14 days of storage. PepT1 expression was higher for 3 days of stored eggs. The chicks taken from 3 days of storage were much better due to genes expression for the absorption of carbohydrates and protein as compare to 14 days of storage at the end of hatch window (Yalcin *et al.,* 2015). The hatchery's key aim to provide uniform start of incubation temperature for the growing embryos placed in a machine. Pre heating is a factor that helps the incubator to provide uniform temperature 25˚C (77 ˚F) in an operating setter, prior to the onset of incubation. The eggs received by a hatchery may have different temperature due to different origins or stored for the target hatch days. Variation in eggs temperature can be reduced when stored by weight and pre heated properly to get short hatch window. Preheating start of low cellular in some of the embryonic cells, this process must not be interrupted once they have begun followed by incubation temperature (Dr. Marleen Boerjan).

2. Material and method

Ethical approval

This experiment was a routine field work in hatchery considering all rules and regulations regarding animal rights and ethic, university of veterinary and animal sciences Lahore Pakistan.

Selection of breeders flocks

Broiler breeder flock Ross, Hubbard, Arbor Acre and Cobb 33-81 weeks of age from Sadiq poultry farms were selected to collect eggs.

Flock Names

Eggs from DR4 (Dharabi rose farm no. 4), KRA and KRB (kallo farm Talagang), AP23-AI and 24 (Arslan Poultry flock no. 23 Artificial insemination and 24), RARB (Bhaghpur Dhari rose), SP101-AI SP103-AI, SP105, SP106-AI, SP104, SP110 were collected for all experiments.

Egg selection

Best-quality hatching egg with good quality shells, without ridges or small lumps of calcified material (pimples) were selected from mention farms. The grading of eggs on the basis of egg weight was performed through egg grading machine MOBA 9A. While the poor shell, crack, bloody stained, elongated eggs were rejected (Khan *et al.,* 2016). Egg room temperature and humidity were kept at 75^0F and 65 respectively with fresh air 2 CFM/1000 eggs during the course of the study.

Site selection

This experiment was carried out at Salman Poultry (Pvt) Limited, Chakri Hatchery Rawalpindi which is situated 5 km from chakri interchange on motorway (M2). The hatchery contains the latest Heating Ventilation and Air Conditioning (HVAC) automation, having ISO (International standard organization) 1900-2000 certified. This hatchery is one of the largest eggs capacity hatchery in south of Asia, which is producing 65,00,000-70,00,000 best quality broiler chicks per month through single stage incubation system (Avida G4, Chick Master USA).

Experimental Design

Experiment no. 1 the flocks were divided into four groups (134640 eggs each group) depending upon hatch window duration. Group A having flocks with hatch window duration 20-22 hours. Group B, C, and D having flocks with hatch window duration 23-24, 25-26 and 27-30 hours.

Experiment no. 2 the eggs were divided into three groups (134640 eggs each group). Group A was preheated at 80^0F for five hours; B was preheated at 80^0F for three hours while C was control. The pre warming was performed before starting incubation profile.

Experiment no.3 For this experiment eggs were divided into nine groups (5000 eggs each group) on the basis of storage days and stored for 0 day (control) the 3, 6, 9, 12, 15, 18, 21 and 24 days at 18˚C and 75% humidity.

Experiment no. 4. For this experiment eggs were divided into two groups (134640 eggs each group) on the basis of single and multi stage incubators.

Weight of eggs

Before setting the eggs weight of individual group was calculated by setting eggs into one setter tray then applying formula,

$$\text{Egg weight} = \frac{\text{Full tray weight at Setting - Weight of empty tray}}{\text{Total No of eggs in tray}}$$

Egg fumigation

Before the weighing, the trial eggs were fumigated with 20 g KMnO4 and 40ml formalin (40%) and 40 ml of water for 100ft 3 areas for 15 minutes through automatic fumigation process provided by Chick Master.

Incubation programme

Standard incubation profiles recommended by chick master were selected on the basis of breeder's age. Pre-heating was performed for all experimental groups following automatically the incubation stage profile (Recommended by Chicks Master USA).

Setter hall and hatcher hall

Environmental conditions in setter hall were at 75 ^{0}F temperatures and 40% Relative humidity; whereas in the hatcher hall temperature was at75 ^{0}F and relative humidity had been increased up to 60%. The positive pressure in setter and hatcher hall

was 15 Pascal and 10 Pascal respectively, while negative pressure inside setter and hatcher plenum was -25 Pascal during the course study.

Candling

Fertility of eggs were performed through candling then shifted to hatchers for next 50 hrs. These entire incubation stage programs have been recommended by chick master USA.

Egg's weight loss

Before being transferred from setter to hatchers water loss e-g egg weight loss was measured from each group individually after 456hrs of incubation in setters by given formula:

$$\text{Water Loss \%: } \frac{\text{Full tray weight at Setting- Full Tray Weight at Transfer}}{\text{Full tray weight at Setting- Empty Tray Wight}} \times 100$$

Chick yield

After hatch pull out immediately, the chick's weight was measured through electrical weight balance to know the chick yield busing following formula:

$$\text{Chick Yield \%: } \frac{\text{Weight of chick's}}{\text{Egg weight}} \times 100$$

Hatch window

Hatch window is the duration between the 1st chicks to last chick hatch out (Noiva *et al*., 2014). The range of hatch window was measured through the graph produced by Maestro software (Chick Master USA). The increase hatching process inside hatcher becomes source of increase humidity which can be easily detected.

Chick grading

Grading of chicks was performed on conveyer and automatic grading table while chicks counting and packing was performed through chick counter (KUHL-USA). Only stranded (shining eyes, soft legs and nose, healed naval and healthy chicks) were shifted to chick's box after counting, while under weight, weak, and unhealed naval chicks were removed as international standard as describe by (Yousaf *et al*., 2017).

Hatch out analysis

Hatch out analysis was performed to investigate the reason of embryo's mortality inside the eggs as described by (Jabbar *et al.*, 2017)

Statistical analyses

All data were analyzed by using Statistical Analysis System package software (SAS version 9.2, SAS Institute Inc., Cary, NC, USA). All means were compared using Duncan's Multiple Range test and results were presented as mean ± SEM (standard error of mean). Results were considered significant if $P<0.05$.

3. Result and discussion

In experiment no.1 we found that the age of breeders flock is insignificant within group but the range of hatch window was same for each group Table.1.The hatch window depends upon hatchability of flocks. In order to ensure efficient gas exchange during *in-ovo* development, different surfaces are used. During the first three days of incubation, gas exchanges are carried out directly by the embryonic cells. After emergence of yolk vascularization, gas exchange is exchanged through the vitelline vessels, which increases with embryonic development, provides more surface area for

gaseous exchange. As the yolk sac is incorporated in the fetal abdominal cavity gases start to be exchanged by the allantoic vessels, which supply the high oxygen requirements for increased fetal metabolism.

After internal pipping, gases gradually begin to be exchanged via the pulmonary respiratory system. After internal pipping, gases gradually begin to be exchanged via the pulmonary respiratory system. The amount of carbon dioxide and requirement of oxygen increases. The carbon dioxide is necessary to trigger piping during hatching process. The high quantity of chicks during hatching increases the amount of carbon dioxide (Boleli *et al.*, 2016). During the first 4 days of incubation, the CO2 concentration can increase up to1% without affecting hatchability. Days 5 and 8 of incubation, embryos can survive CO2 concentrations up to 3%The increase in tolerance of the embryo for high CO2 concentrations after day 4 of incubation may be caused by the establishment of respiratory system around 96 hours of incubation. Between days 9 and 12 of incubation, which is the stage of development in which the greatest rate of growth occurs in the extra embryonic membranes, embryos can survive CO2 concentrations up to 5% (Molenaar *et al*., 2010).

Table.1. Effect of Hatchability on Hatch window At Sadiq Poultry Pvt.Ltd Chakri Hatchery Rawalpindi Pakistan (01 January 2018)

A			
Flocks	Age(weeks)	Hatch window(hours)	Hatchability%(86-92)
DR4	36[a]	20-22[a]	89.83[a]
KRA	37[a]	20-22[a]	90.56[a]
KRB	37[a]	20-22[a]	90.52[a]
AP23-AI	66[b]	20-22[a]	88.33[a]
B			
Flocks	Age(weeks)	Hatch window(hours)	Hatchability%(81-85)
RARB	33[a]	23-24[b]	84.13[a]
RB	33[a]	23-2 [b]	85.19[a]
SP101-AI	83[b]	23-24 [b]	85.00[a]
SP103-AI	82[b]	23-24 [b]	85.00[a]
C			
Flocks	Age(weeks)	Hatch window(hours)	Hatchability%(75-80)
SP105	81[a]	25-26[c]	79.58[a]
SRA-AI-A	66[b]	25-26[c]	79.13[a]
SP104	67[b]	25-26[c]	80.47[a]
SP106AI-C	69[c]	25-26 [c]	80.07[a]
SRB-AI-B	66[b]	25-26[c]	79.89[a]
SP-110	33[d]	25-26[c]	80.05[a]
D			
Flocks	Age(weeks)	Hatch window(hours)	Hatchability %(< 75%)
SP106	67[a]	27-30[d]	66.98[a]
SP106AI-D	68[a]	27-29[d]	73.77[a]
SP106-2	69[a]	27-30[d]	73.76[a]
SP110	30[b]	27-28[d]	72.62[a]
AP24-R-2	28[b]	27-30[d]	67.11[a]

Heat production reaches a plateau phase between day15 and 18 of incubation and is approximately 140 mW at day 18 of incubation for a 62-g egg. After internal piping, around day 19 of incubation, embryos switch to lung ventilation, and consequently, heat production is almost increased twofold in broiler embryos. The incubation duration 456 hours remains same inside setter for all kinds of breeder's eggs. The change of incubation duration occurs in hatchers which may be (456+48 hours) total 504hours, (456+50 hours) total 506 hours and (456+54 hours) total 510 hours for the flocks having hatchability ranges (86-92%), (81-85%) and (75-80%) or (< 75%) respectively. The total incubation duration for broiler breeder's eggs becomes 504-510 hours depending upon hatch window which is affected by hatchability percentage, breeder's type, eggs storage, pre warming and type of incubators (Jabbar *et al*., 2017). Due to high metabolic rate of embryo and limited conductance of egg shell the oxygen concentration inside air cell decreases to approximately 14.2% and carbon dioxide concentration increases to 5.6% at the end of incubation near start of hatching. This high concentration triggers the embryo to pip the air cell and emerge from the egg (Molenaar *et al*., 2010). The high hatchability becomes source of huge amount of carbon dioxide which means maximum piping during short time. That's the reason flocks having hatchability more than 86% showing shortest hatch window 20-22 hour's Fig.1. The flocks having hatch ability 81-85% showing hatch window 23-24 hours.

When the chicks starts to pip, it provides beginning of the hatch window which can be easily identified by the ever increasing level of humidity shown in fig.1, 2, 3, by green curve enclosed by black circles. The peak of hatch piping is identified when humidity curve is on peak having high level of humidity in hatchers. As the chicks begin to dry the humidity level decrease and eventually reaches a constant low level, the end of hatch window. These graphs were taken from Hatcher machines during incubation (Maestro Chick Master USA). The green lines indicate humidity level inside hatcher. The ideal hatch window should be 26 hours and peak piping occurs 18-20 hours prior to hatch pulling, but better than this can be achieved with proper eggs care at the time of eggs settings (Maestro Chick Master USA).

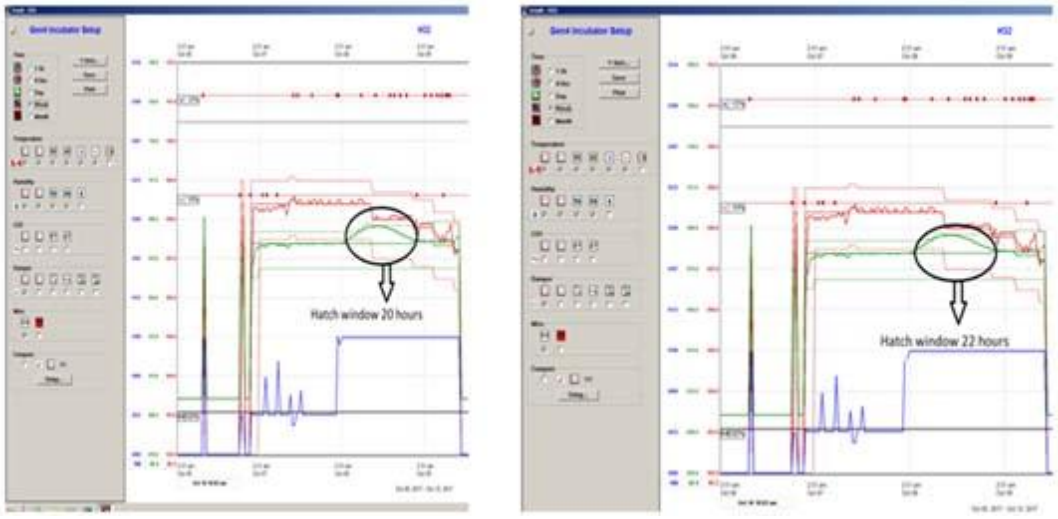
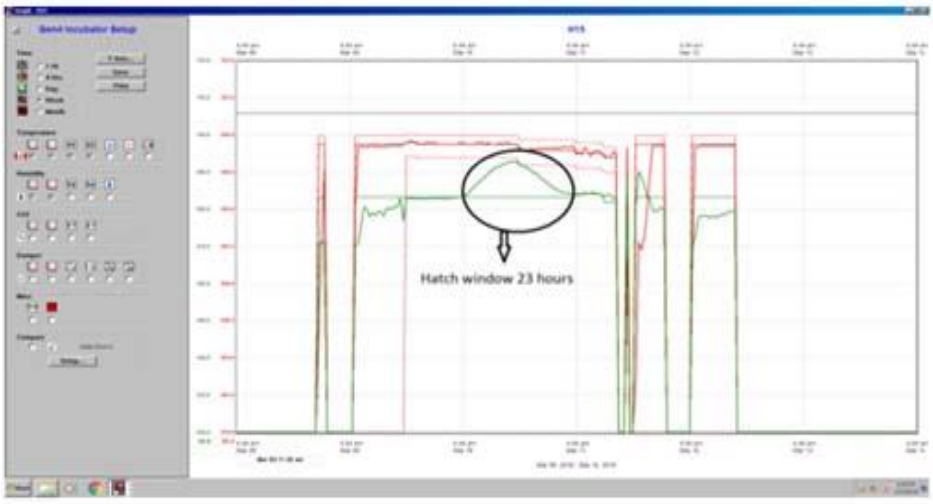


Fig. 1. Hatch window 20 and 22 hours at Sadiq hatchery Chakri Rawalpindi Pakistan

Hatch window 23 hours at Sadiq hatchery Chakri Rawalpindi Pakistan



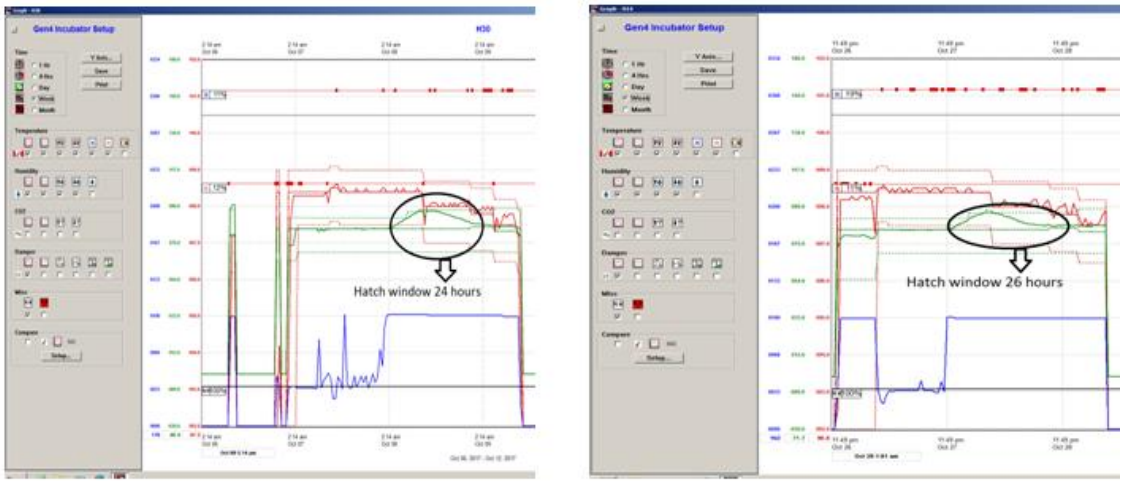


Fig.2. Hatch window 24 and 26 haurs at Sadiq hatchery Chakri Rawalpindi Pakistan

Similarly flocks having hatch ability 75-80% showing hatch window 24-26 hours Fig.2, while flocks having hatch ability less than 75% showing longest hatch window 28-30 hours Figure 3. The hatch window depends upon flock's age as described by many scientists (Bergoug *et al*., 2013) but after artificial insemination we can increase the hatchability for old age flocks as well as decrease the hatch window e-g AP23, SP101, SP103, SP104 and SP 106 table.1. So, hatch window significantly depends upon hatchability of breeders flocks. The total duration of incubation is related to hatch window e-g the setter machine duration 456 hours remains same for all age of flocks but Hatcher duration changes (42-48 hours) due to hatch window which depends upon flock hatchability, pre-heating, eggs storage and type of incubators.

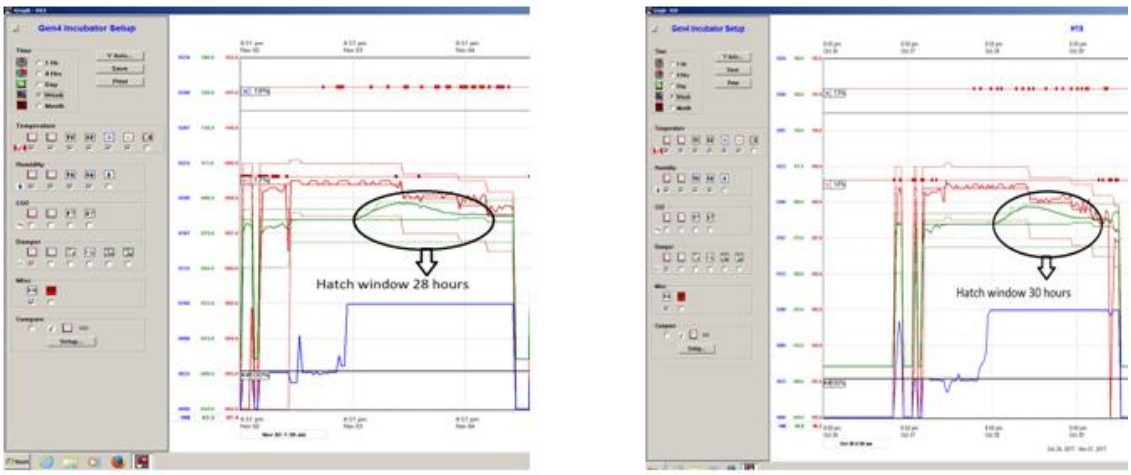


Fig.3. Hatch window 28 and 30 hours at Sadiq hatchery Chakri Rawalpindi Pakistan

(Burke *et al*., 1992) conducted two experiments to determine the influence of chick's sex on incubation duration. Chicks that were removed from hatcher at approximately 6- (5 to 8)h intervals between 490.5 and 527.5h of incubation in experiment 1 and about 2-h intervals between 483 and 524h of incubation in experiment 2. In both experiment, a preponderance of early-hatching chicks were female. The time at which 50% of the females had hatched was significantly (P <0.005) earlier than the 50% hatch time for males (2.68 and 3.32 h in Experiments 1 and 2, respectively). About 71% of the females had hatched by 504 and 509 h in Experiments 1 and 2, whereas only 57 and 52% of the males had hatched at comparable times.

In second experiment group A and B were significantly better for hatchability, dead in shell, water loss, chicks yield and hatch window duration as compare to C control Table 2. The pre-heating provides uniform constant temperature for all the growing embryos. The preheating has positive effect on chick's uniformity (Marandureet *et al*., 2015).

Table.2. Effect of Pre-hating on hatch window and hatchery parameters At Sadiq Poultry Pvt.Ltd Chakri Hatchery Pakistan

Parameters	A (80F for 5 hours)	B (80F for 3 hours)	C (control)
Hatchability%	87.26[a]	86.46[a]	85.05[b]
Hatch window(hrs)	20-22 [a]	20-22[a]	25-26[b]
Candling%	6.41[a]	6.97[b]	7.01[b]
Dead in shell%	6.33[a]	6.57[a]	7.94[b]
Water loss%	12.10[a]	11.58[a]	11.14[b]
Chick yield%	69.01[a]	68.64[a]	68.10[b]
Chick weight(gm)	44.20[a]	43.92[a]	43.27[b]

a-b denote difference in rows (p<0.05)

Experiment no.3. The storage of eggs has negative effect by increasing egg weight loss, yolk weight, yolk pH, albumin pH, yolk lipid oxidation and by reducing

HU and albumin weight due to storage for different intervals (Akter *et al*., 2015). The internal quality of eggs and egg weight loss during storage badly affects the hatching parameters. Increasing the duration of eggs storage the incubation period increases with increasing hatch window (Tona *et al*., 2003) found that the eggs that were stored for hatch better and earlier 490 hours as compared to stored for 18 days 500 hours. Similarly we found that with increasing the storage duration the egg weight loss increases along hatch window duration e-g 0-3 days of storage no effect was found but further increasing the storage days up to 21 days we found significant difference for egg weight loss, hatch ability, candling, dead in shell and hatch window Table 3. The negative effects may be caused by a decrease in embryo viability due to an increase cell death (Reijrink *et al*., 2010).

Table.3. Effect of Eggs storage on hatch window and at Sadiq Poultry Pvt.Ltd Chakri Hatchery Pakistan

Group	Sto-rage days	Egg weight at start of storage (gm)	Egg weight at end of storage(gm)	Egg weight loss (gm)	Hatchability %	Hatch windo w (hrs)	Candling %	Dead in shell %
A	0	65.05±0.1^{a}	65.05±0.1^{a}	0	90.24±0.15^{a}	20-22^{a}	4.72±0.06^{a}	5.04±0.045^{a}
B	3	65.03±0.12^{a}	64.01±0.01^{b}	1.02	90.22±0.12^{b}	20-22^{a}	4.75±0.084^{a}	5.03±0.024^{a}
C	6	65.65±0.14^{a}	63.62±0.02^{c}	2.03	85.35±0.01^{c}	23-24^{b}	5.23±0.085^{c}	9.4±0.017^{c}
D	9	65.65±0.06^{a}	60.60±0.07^{d}	5.05	82.41±0.013^{d}	23-24^{b}	6.87±0.011^{d}	10.72±0.031^{d}
E	12	65.66±0.08^{a}	60.61±0.02^{e}	5.04	76.21±0.002^{e}	25-26^{c}	7.43±0.028^{e}	16.36±0.091^{e}
F	15	65.45±0.09^{a}	58.41±0.021^{f}	7.04	70.61±0.02^{f}	27-28^{d}	8.93±0.017^{f}	20.46±0.037^{f}
G	18	65.88±0.09^{a}	55.28±0.01^{g}	10.60	66.18±0.041^{g}	27-28^{d}	10.89±0.03^{g}	22.93±0.028^{g}
H	21	65.90±0.03^{a}	52.30±0.07^{h}	13.60	60.17±0.03^{h}	28-30^{e}	12.58±0.04^{h}	27.25±0.031^{h}
I	24	65.99±0.06^{a}	50.19±0.065^{i}	15.80	53.14±0.014^{i}	28-30^{e}	15.98±0.097^{i}	30.8±0.036^{i}

a-b denote difference in columns ($p<0.05$)

Experiment no.4. Single stage incubator better results which exceed that of multistage by good hatchability, less culling chicks, less dead in shell, more precise water loss, chick yield and hatch window Table 4. Results also proved reduced first week mortality rates, improved growth rate and improved feed conversion (Bennett, 2015).

Table.4. Effect of single and multistage Incubator on hatch window and hatchery Parameters At Sadiq Poultry Pvt.Ltd Chakri Hatchery Pakistan

Parameters	Single stage	Multistage
Hatchability%	88.54±0.047 [a]	85.39±0.024 [b]
Hatch window(hrs)	25-26±0.024[a]	28-30±0.082 [b]
Candling%	5.67±0.064 [a]	6.68±0.046 [b]
Dead in shell%	5.79±0.047 [a]	7.93±0.047 [b]
Water loss%	12.11±0.091 [a]	10.92±0.094 [b]
Chick yield%	69.01±0.047 [a]	67.31±0.017 [b]
Chick weight(gm)	44.85±0.028 [a]	43.40±0.061 [b]

a-b denote difference in rows ($p<0.05$)

All in and all out technique provide uniform temperature for all growing embryos while in multistage incubator we find regular variation in temperature due to loading and unloading of eggs. These interruptions extend both incubation time and hatch window. Such factor can be avoided with single-stage incubators ((Hodgetts B). More over single stage incubator uses eggs water loss as humidity source for growing embryo, which becomes a good source for uniform temperature at every point of incubator. Recently single stage incubators are designed to incubate breeder's eggs according eggs weight, breeder's age, breeders breed, season as well as combine breeders incubation profiles. Single stage incubators with proper incubation profile along single pull are known to produce best quality day old chicks (Jabbar *et al*., 2017)

4. Conclusion

Hatch window decreases with increase in hatchability. Eggs storage duration have negative impact on hatch window, while pre-heating has positive impact on hatch window. The total incubation duration depends upon flock age, hatchability, pre-heating, eggs storage and type of incubators.

Author's contribution

Dr. Adnan Jabbar Ansari was main author responsible for tabulation of experimental data and article writing. Dr. Yasir Allah Ditta and Dr. Amjad Riaz helped in data collection and statistical application.

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Conflict of interest

The authors declare that they have no conflict of interest with respect to the research, authorship, and/or publications of this article.

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Dr. Marleen Boerjan Pas Reform Integrated hatchery solutions Pre-heating - an effective tool for chick uniformity https://www.pasreform.com/academy/frequently-asked-questions/incubation/137-pre-heating-an-effective-tool-for-chick-uniformity.html

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