DOI: 10.7251/VETJ1801054V **UDK: 636.592.082.474**

Originalni naučni rad

UTICAJ MASE RASPLODNIH JAJA RODITELJSKOG JATA TEŠKOG LINIJSKOG HIBRIDA NA REZULTATE INKUBACIJE

Marinko VEKIĆ[1]*, Mirjana MITRAKOVIĆ[2], Đorđe SAVIĆ[1]

1 Marinko Vekić, ma, viši asistent; dr Đorđe Savić, docent, Univerzitet u Banjoj Luci, Poljoprivredni fakultet, Univerzitetski grad, Bulevar vojvode Petra Bojovića 1A, 78.000 Banja Luka
2 Mirjana Mitraković, dipl. inženjer, Avis DM, Danka Mitrova bb, 78.420 Srbac
* Korespodentni autor: Marinko Vekić, marinko.vekic@agro.unibl.org

Kratak sadržaj: Cilj rada bio je da se ispitaju vrijednosti parametara inkubacije (gubitak mase, oplođenost, valivost uloženih i oplođenih jaja, te ukupan, rani, srednji i kasni embrionalni mortalitet) rasplodnih jaja različite mase teškog linijskog hibrida Cobb 500. Ukupno je ispitano 600 jaja podijeljenih u četiri jednake grupe (n=150) prema njihovoj masi: 57,5 – 62,5 (S); 62,6 – 67,5 (M); 67,6 – 72,5 (L) i 72,6 – 77,50 g (XL), a vrijednosti parametara inkubacije određene su i statistički obrađene standardnim metodama. Masa jaja uticala je statistički značajno na gubitak mase jaja tokom inkubacije ($p<0,05$), pri čemu je taj gubitak bio veći kod jaja manje (grupa S 11,10% i grupa M 11,40%) u odnosu na jaja veće mase (grupa L 10,42% i grupa XL 10,31%). Valivost uloženih jaja u grupama S, M, L i XL iznosila je 76,0; 75,3; 78,7 i 66,0%, redom, a oplođenih 82,0; 81,3; 82,5 i 71,7%, redom, pri čemu nije ustanovljena statistički značajna razlika ($p>0,05$). Masa jaja nije statistički značajno uticala na razliku u vrijednostima mortaliteta embriona, iako je kod jaja grupe XL ustanovljena viša vrijednost ukupnog, ranog i kasnog mortaliteta u odnosu na ostale grupe jaja. Rezultati ovog istraživanja ukazuju na niže vrijednosti valivosti i viši mortalitet embriona u inkubaciji jaja izrazito velike mase u odnosu na ostale grupe, zbog čega izboru jaja za nasad treba posvetiti posebnu pažnju i u pogledu mase.
Ključne riječi: rasplodna jaja, masa jaja, inkubacioni parametri

UVOD

Masa jaja ubraja se u pokazatelje spoljašnjeg kvaliteta, zajedno sa indeksom oblika, te masom, debljinom, čvrstoćom, gustinom, bojom i čistoćom ljuske (King'ori, 2012). Navedeni pokazatelji jednako su važni u procjeni kvaliteta konzumnih i rasplodnih jaja. Uspjeh inkubacije rasplodnih jaja teškog linijskog hibrida, mjeren procentom valivosti i kvalitetom izleženih pilića, pored dužine i uslova skladištenja (Fasenko, 2007), te uslova inkubacije (Molenaar i sar., 2010), u značajnoj mjeri može biti određen kvalitetom inkubiranih jaja (King'ori, 2011). Trijažom rasplodnih jaja prije ulaganja inkubacije odstranjuju se jaja koja ne zadovoljavaju kriterijume, uglavnom zbog lošeg kvaliteta ljuske (npr. nepravilan oblik, fizička oštećenja, zaprljanost), ali i jaja izrazito male ili velike mase (Bell i Weaver, 2002). Masa jaja i rezultati inkubacije u direktnom su međuodnosu, tako da valivost jaja izrazito male i izrazito velike mase ima relativno niže vrijednosti u odnosu na jaja srednje ili prosječne mase opsega 55–65 g (Bell i Weaver, 2002). Masa rasplodnih jaja teškog linijskog hibrida ima trend povećanja tokom perioda eksploatacije, odnosno sa dobom roditeljskih nosilja (Đermanović i sar, 2010) na što mogu uticati i brojni faktori genetske i paragenetske prirode (King'ori, 2012). Kumpula (2004) nije ustanovio razliku u oplođenosti i valivosti među tri težinske grupe jaja porijekom od dva komercijalna teška linijska hibrida. Međutim, isti autor je ustanovio veći procenat pilića prve klase u grupi sitnih i srednjih jaja, i značajno viši procenat kasnog embrionalnog mortaliteta i pilića druge klase u grupi krupnih jaja. Iqbal i sar. (2016) su utvrdili razlike u procentu oplođenosti i valivosti jaja komercijalnog hibrida različite mase, tako da su najvišu oplođenost i valivost imala jaja najmanje mase, potom srednja i krupna jaja, a najviši embrionalni mortalitet i najnižu oplođenost krupna jaja, potom srednja i sitna jaja. Bolju oplođenost i valivost uloženih sitnih u odnosu na srednja i krupna jaja teškog linijskog hibrida opisali su i Malik i sar. (2015). Viši procenat kasnog embrionalnog mortaliteta u grupi krupnih jaja, u odnosu na srednja i sitna jaja, bez razlike u ostalim pokazateljima valivosti opisali su Ulmer-Franco i sar. (2010) i Gahri i sar. (2015), dok Ramaphala i Mbajiorgu (2013) nisu utvrdili uticaj mase jaja na valivost. Relativno viši procenat gubitka mase u inkubaciji sitnih u odnosu na srednja ili krupna jaja ustanovili su Kumpula (2004), Ulmer-Franco i sar. (2010) i Gahri i sar. (2015), dok se taj gubitak među tri težinske grupe jaja u istraživanju koje su sproveli Duman i ekero lu (2017) nije statistički značajno razlikovao. Uticaj mase jaja na rezultate inkubacije u poluintenzivnom gajenju autohtonih rasa kokoši, prema Abudabos i sar. (2017), nije bio konzistentan, dok Singh i sar. (2017) nisu uopšte uočili uticaj masa jaja na rezultate inkubacije.

Cilj rada bio je da se na osnovu tehnoloških pokazatelja inkubacije (gubitak mase jaja, procenat oplođenosti, valivosti uloženih i oplođenih jaja, te procenat ukupnog, ranog, srednjeg i kasnog embrionalnog mortaliteta) ustanovi uticaj različite mase rasplodnih jaja porijeklom iz roditeljskog jata teškog linijskog hibrida na krajnje rezultate inkubacije.

MATERIJAL I METOD RADA

Istraživanje je provedeno na komercijalnoj farmi roditeljskog jata teškog linijskog hibrida Cobb 500 i komercijalnoj inkubatorskoj stanici, na uzorku od 600 rasplodnih jaja. Jaja su poticala od roditeljskog jata, starosti 52 nedjelje, i bila su snesena, sakupljena i dopremljena u skladište inkubatorske stanice istog dana, a potom skladištena četiri dana u kartonskoj ambalaži do početka inkubacije. Prikupljena jaja klasifikovana su u grupe prema njihovoj masi, pojedinačnim mjerenjem pomoću tehničke vage (0,01 g) neposredno pred inkubaciju, nakon čega su označena i zavisno od izmjerene mase raspoređena u jednu od četiri grupe: 57,5 – 62,5 g (S), 62,6 – 67,5 g (M), 67,6 – 72,5 g (L) i 72,6 – 77,50 g (XL). Uslovi predgrijavanja i inkubacije jaja pratili su standardnu tehnologiju rada za dati hibrid u komercijalnoj inkubatorskoj stanici i bili su identični za sve grupe u istraživanju.

Podaci dobijeni individualnim mjerenjem mase jaja prije ulaganja u predvalionik i kod prelaganja u valionik poslužili su za izračunavanje procenta gubitka mase (GM):

GM = ((masa jaja prije ulaganja – masa jaja 18. dana inkubacije) / masa jaja prije ulaganja)) × 100.

Pregledom valioničkog ostatka određeni su: broj oplođenih i neoplođenih jaja; broj izleženih pilića, te broj embriona uginulih u prvoj (rani), drugoj (srednji) i trećoj nedjelji inkubacije (kasni mortalitet) na osnovu čega su izračunati sljedeći parametri inkubacije:

Oplođenost jaja (O, %)

O = (broj oplođenih jaja / ukupan broj jaja) × 100;

valivost uloženih jaja (Vu, %)

Vu = (broj izleženih pilića / ukupan broj jaja) × 100;

valivost oplođenih jaja (Vo, %)

Vo = (broj izleženih pilića / broj oplođenih jaja) × 100;

ukupan embrionalni mortalitet (UM, %)

UM = (broj uginulih embriona / broj oplođenih jaja) × 100;

rani embrionalni mortalitet (RM, %)

RM = (broj embriona uginulih do 7. dana inkubacije / broj oplođenih jaja) × 100);

srednji embrionalni mortalitet (SM, %)

SM = (broj embriona uginulih 8 – 14. dana inkubacije / broj oplođenih jaja) × 100

kasni embrionalni mortalitet (KM, %)

KM = (broj embriona uginulih 15 – 21. dana inkubacije / broj oplođenih jaja) × 100.

Statistička obrada podataka za gubitak mase jaja tokom inkubacije izvedena je analizom varijanse na nivou značajnosti $p<0,05$, a za vrijednosti valivosti i mortaliteta pomoću ^{2} testa na nivou značajnosti $p<0,05$.

REZULTATI ISTRAŽIVANJA I DISKUSIJA

Gubitak mase rasplodnih jaja tokom inkubacije prikazan je u tabeli 1.

Tabela 1. Gubitak mase rasplodnih jaja tokom inkubacije (prosječna vrijednost ± stand. greška)

Grupa	Masa uloženih jaja (g)	Masa jaja 18. dana (g)	Gubitak mase (%)
S	$61,27^{d}$ (±0,19)	$54,47^{d}$ (±0,24)	$11,10^{a}$ (±0,24)
M	$65,45^{c}$ (±0,24)	$57,99^{c}$ (±0,30)	$11,40^{a}$ (±0,28)
L	$69,83^{b}$ (±0,22)	$62,56^{b}$ (±0,29)	$10,42^{b}$ (±0,25)
XL	$74,19^{a}$ (±0,25)	$66,54^{a}$ (±0,35)	$10,31^{b}$ (±0,34)

^{abc} – vrijednosti u istoj koloni obilježene različitim slovom su statistički značajno različite (p<0,05)

Najveći gubitak mase jaja tokom inkubacije (11,40%) u ovom istraživanju ustanovljen je u grupi M, a najmanji (10,31%) u grupi XL. Vrijednosti gubitka mase jaja tokom inkubacije u grupama S i M bile su značajno (p<0,05) više u odnosu na grupe L i XL. Iqbal i sar. (2016) su ustanovili značajno viši gubitak mase tokom inkubacije u grupama jaja prosječne mase 60,05 g (11,32%) i 65,03 g (11,12%) u odnosu na grupu jaja prosječne mase 70,03 g (10,62%). Rosa i sar. (2002) su klasifikovali jaja u odnosu na njihovu masu (60,0; 65,1; 66,6; 69,0 i 73,2 g) i ustanovili minimalne razlike u procentu gubitka mase tokom inkubacije (10,9; 10,3; 10,2; 10,1 i 10,0%). Sličan trend opisali su i Gahri i sar. (2015), koji su u tri grupe jaja klasifikovanih prema masi (52,6 – 55,7; 57,2 – 60,2 i 61,7 – 64,7 g) ustanovili smanjenje gubitka mase tokom inkubacije sa porastom početne mase jaja (12,56; 12,13 i 11,63%). Nasuprot ovome su rezultati do kojih su došli Duman i ekero lu (2017), koji među grupama jaja raz ičite mase (55,0 – 60,0; 60,1 – 65,0; 65,1 – 70,0 g) nisu ustanovili statistički značajnu razliku u gubitku mase (13,03; 13,24; 13,02%). Uočeno smanjenje procenta gubitka mase tokom inkubacije sa povećanjem mase jaja vjerovatno nastaje kao rezultat smanjenja odnosa površine ljuske sa masom sadržaja jaja (Ulmer-Franco i sar., 2010; Iqbal i sar., 2016). Optimalne vrijednosti za gubitak mase jaja tokom inkubacije iznose 6,5 – 14,0%, što se smatra dovoljnim za pravilno formiranje vazdušne komore (Molenaar i sar., 2010). Bell i Weaver (2002) navode da na gubitak mase jaja tokom inkubacije mogu uticati i kvalitet ljuske i uslovi inkubacije.

Pokazatelji oplođenosti i valivosti jaja različite mase prikazani su u tabeli 2.

Tabela 2. Oplođenost i valivost uloženih i oplođenih rasplodnih jaja (%)

Grupa	Oplođenost jaja (%)	Valivost uloženih jaja (%)	Valivost oplođenih jaja (%)
S	92,7	76,0	82,0
M	92,7	75,3	81,3
L	95,3	78,7	82,5
XL	92,0	66,0	71,7

Oplođenost jaja, kao ključan faktor valivosti, uslovljena je prije svega reproduktivnim funkcijama roditelja, naročito kvalitetom sperme i polnim ponašanjem pijetla, te procesom formiranja jaja i funkcionisanjem tubularnih žlijezda kokoške (King'ori, 2011). Ovaj pokazatelj varira u zavisnosti od uzrasta jata i genotipa (Kumpula, 2004; Abudabos, 2010; Iqbal i sar. 2016), ali svakako i od paragenetskih faktora, kao što je ishrana i odnos polova. Uticaj paragenetskih faktora, prije svega ishrane, na oplođenost jaja posebno je važan za roditeljska jata teškog linijskog hibrida, koji je selekcionisan na tovnost i dobro iskorištavanje hrane, zbog čega su rasplodne jedinke sklone gojenju i neophodno je hraniti ih restriktivno, kako bi se očuvala reproduktivna aktivnost. Mbajiorgu i Ramaphala (2014) u pogledu valivosti jaja različite mase ističu značaj specifičnosti svake rase ili hibrida, ali i uticaj jedinki unutar iste rase ili hibrida. Oplođenost jaja u našem istraživanju bila je najniža u grupi XL (92,0%), neznatno viša u grupama S i M (92,7%), a najviša u grupi L (95,3%), ali bez statistički značajnih razlika među grupama (χ^2 0,106; p>0,05). Ulmer-Franco i sar. (2010) nisu ustanovili razliku u oplođenosti tri grupe jaja prosječne mase 58,3, 62,6 i 66,8 g (84,2; 85,1; 87,5%, redom), ali su uočili njen porast s povećanjem prosječne mase jaja. Gahri i sar. (2015) takođe nisu utvrdili statistički značajnu razliku u oplođenosti tri grupe jaja različite mase (52,62 – 55,65; 57,15 – 60,15 i 61,65 – 64,65 g naprema 91,5; 93,0; 94,7%), ali su potvrdili nalaze drugih autora, da sa porastom mase jaja raste i procenat oplođenosti. Odsustvo značajnih razlika u oplođenosti jaja različite mase opisali su i Abudabos i sar. (2017) i Singh i sar. (2017) kod autohtonih rasa kokoši u slobodnom držanju, te Kumpala (2004) i Duman i Şekeroğlu (2017) kod teškog linijskog hibrida. S druge strane, Iqbal i sar. (2016) su ustanovili statistički značajno opadanje procenta oplođenosti, sa povećanjem mase jaja (96,7; 93,3; 90,3%, redom). Valivost uloženih jaja u našem istraživanju imala je najvišu vrijednost u grupi L (78,7%), a najnižu u grupi XL (66,0%), a razlike među grupama u ovom istraživanju nisu bile statistički značajne (χ^2 1,856; p>0,05).

Valivost oplođenih jaja bila je najviša u grupi L (82,5%), a najniža u XL (71,7%), takođe bez statistički značajnih razlika (χ^2 1,377; p>0,05). Ipak, vrijednosti procenta valivosti u oba slučaja bile su niže u grupi jaja najveće mase (XL) u odnosu na grupe S, M i L koje su imale relativno slične vrijednosti ovih pokazatelja. Kumpula (2004) navodi da inkubacija sitnih, srednjih i krupnih jaja nije pokazala statistički značajnu razliku u valivosti uloženih (85,5; 82,3 i 82,2%) i oplođenih jaja (91,0; 89,9 i 87,9%), ali su njene vrijednosti opadale s povećanjem mase jaja. Ulmer-Franco i sar. (2010) su takođe dobili slične vrijednosti u tri grupe za valivost oplođenih jaja (88,3; 89,9 i 84,3%) i relativno nižu valivost za krupna jaja, što potvrđuju i rezultati do kojih su došli Ramaphala i Mbajiorgu (2013) (jaja mase <49; 50-59 i 60–69 g naprema 92,4; 90,9; 90,9%, redom). Gahri i sar. (2015) navode da su dobili slične vrijednosti za valivost uloženih (81,3; 85,3; 80,3%, redom) i oplođenih jaja različite mase (83,7; 86,4; 83,8%, redom), pri čemu je najbolje rezultate imala grupa jaja srednje mase. Iqbal i sar. (2016) su ustanovili značajnu razliku u valivosti između jaja prosječne mase 60,05, 65,03 i 70,03 g, kako uloženih (89,7; 83,7; 78,3%), tako i oplođenih jaja (92,7; 89,6; 86,7%). Rosa i sar. (2002) su, analizirajući rezultate inkubacije četiri grupe jaja, prosječne mase 60,0, 65,1, 66,6, 69,0 i 73,2 g, ustanovili statistički značajno nižu valivost u grupi jaja najveće mase u odnosu na sve ostale grupe (86,3; 86,6; 85,9; 85,5; 83,6%, redom), što je pokazala i valivost oplođenih jaja (92,5; 92,8; 92,0; 91,6; 89,5%, redom). Duman i Şekeroğlu (2017) su ustanovili bolju valivost oplođenih i uloženih jaja u grupi jaja srednje (88,69 i 85,00%) i manje mase (87,81 i 84,17%) u odnosu na krupna jaja (80,76 i 78,05%). Do suprotnih rezultata došli su DeWitt i Schwalbach (2004), koji su prilikom inkubacije jaja rase njuhempšir i rodajland utvrdili bolju valivost u grupi jaja veće mase.

Procenat embrionalnog mortaliteta u zavisnosti od mase rasplodnih jaja dat je u tabeli 3.

Tabela 3. Prikaz embrionalnog mortaliteta u zavisnosti od mase jaja

Grupa	Embrionalni mortalitet							
	Ukupan		Rani		Srednji		Kasni	
	n	%	n	%	n	%	n	%
S	25	18,0	15	10,8	4	2,9	6	4,3
M	26	18,7	17	12,2	1	0,7	8	5,8
L	25	17,5	17	11,9	1	0,7	7	4,9
XL	39	28,3	25	18,1	3	2,2	11	8,0

Ukupan embrionalni mortalitet u našem istraživanju varirao je od 17,5% u grupi L do 28,3% u grupi XL. Razlike u vrijednostima ovog parametra između ispitanih grupa jaja nisu bile statistički značajne (χ^2 5,317; p>0,05). Ovakav nalaz u skladu je sa podacima koje navode Abudabos i sar. (2017) za inkubaciju jaja autohtone rase kokoši u slobodnom držanju, kao i Duman i Şekeroğlu (2017) za inkubaciju jaja teškog linijskog hibrida. Nasuprot tome, Rosa i sar. (2002) su ustanovili značajno viši ukupan mortalitet u grupi krupnih jaja, prosječne mase 73,2 g (9,6%), u odnosu na jaja prosječne mase 60,0 g (7,0%) i 65,1 g (6,7%), što je u skladu i sa rezultatima do kojih su došli Iqbal i sar. (2016). Kopecký (2015) je ustanovio najviši ukupan mortalitet u grupi jaja mase 70–75 g (16,7%), a najniži u grupi 55–60 g (9,7%). Rani embrionalni mortalitet u našem istraživanju bio je najizraženiji u grupi XL (18,1%), a najmanje izražen u grupi S (10,8%), pri čemu nije bilo statističke značajnosti razlika (χ^2 3,412; p>0,05). Srednji embrionalni mortalitet bio je najviši u grupi S (2,9%), a najniži u grupama M i L (0,7%), takođe bez značajne razlike između grupa (χ^2 3,081; p>0,05). Kasni embrionalni mortalitet varirao je u rasponu od 4,3% u grupi S do 8,0% u grupi XL, takođe bez statistički značajne razlike (χ 1,870; p>0,05). Odsustvo statistički značajnih razlika među jajima različite mase za vrijednosti srednjeg i kasnog mortaliteta ustanovili su Kumpula (2004) i Malik i sar. (2015). Iqbal i sar. (2016) utvrdili su značajno viši rani, srednji i kasni mortalitet u grupi krupnih jaja prosječne mase 70,03 g (3,3; 2,3 i 3,00%, redom) u odnosu na grupu jaja prosječne mase 60,05 g (2,0; 1,3 i 1,67%, redom). Grupa jaja najveće mase (XL) u našem istraživanju imala je više vrijednosti ranog i kasnog mortaliteta, iako nije bilo statistističke značajnosti razlika, što je u saglasnosti sa rezultatima više autora. Ulmer-Franco i sar. (2010) u svom istraživanju nisu ustanovili razliku u vrijednostima ranog i srednjeg embrionalnog mortaliteta, dok je vrijednost kasnog mortaliteta bila značajno viša u grupi krupnih (7,0%) u odnosu na grupu srednjih (4,8%) i sitnih jaja (2,8%). Slično pomenutim autorima, Kumpula (2004) je ustanovio razliku samo u vrijednostima kasnog embrionalnog mortaliteta, koji je bio značajno viši u grupi krupnih (6,1%) u odnosu na jaja manje (1,8%) i srednje mase (4,3%). Gahri i sar. (2015) su najniži rani mortalitet registrovali u grupi srednjih jaja (2,96%) u odnosu na 3,95% kod sitnijih i 4,68% kod krupnih jaja, dok je kasni mortalitet bio viši u grupi krupnih (6,38%) u odnosu na jaja manje (2,85%) i srednje mase (3,63%). Porast mortaliteta sa povećanjem mase jaja, naročito starijeg jata, može biti u vezi sa nemogućnosti embriona da postigne odgovarajuću temperaturu u početnoj fazi inkubacije ili gubitka metaboličke toplote u kasnoj fazi inkubacije (Lourens i sar., 2005).

ZAKLJUČAK

Rezultati ovog istraživanja potvrđuju značaj mase rasplodnih jaja za krajnje rezultate inkubacije, odnosno njihovu međusobnu povezanost, a time i potrebu klasiranja rasplodnih jaja prije ulaganja u inkubatore. Gubitak mase tokom inkubacije bio je proporcionalno manji kod jaja veće mase, najvjerovatnije zbog odnosa mase ili zapremine jaja sa površinom ljuske. Takođe, embrionalni mortalitet imao je relativno više vrijednosti u inkubaciji jaja izrazito velike mase, što govori u prilog tome da za inkubaciju treba izabrati jaja prosječne mase za dato jato. Na rezultate inkubacije utiču i drugi parametri, kao što su hibrid, dob jata, odnos polova, godišnje doba, ishrana i slično, a koje bi trebalo uzeti u obzir u cilju objektivizacije i korektnog tumačenja dobijenih rezultata istraživanja.

LITERATURA

1. Abudabos A. (2010): The effect of broiler breeder strain and parent flock age on hatchability and fertile hatchability. International Journal of Poultry Science, 9: 231– 235.
2. Abudabos A.M.I., Aljumaah R.S.I., Algawaan A.S.I., Al-Sornokh H.I., Al-Atiyat R.M.I. (2017): Effects of hen age and egg weight class on the hatchability of free range indigenous chicken eggs. Brazilian Journal of Poultry Science, 19: 33–40.
3. Bell D.D., Weaver W.D. (2002): Commercial Chicken Meat and Egg Production.
4. DeWitt F., Schwalbach L.M.J. (2004): The effect of egg weight on the hatchability and growth performance of New Hampshire and Red Rhode Island chicks. South African Journal of Animal Science, 34: 62–64.
5. Duman M, ekero lu A. (2017): Effect of egg weights on hatching results, broiler performance and some stress parameters. Brazilian Journal of Poultry Science, 19: 255 –262.
6. Đermanović V., Mitrović S., Petrović M. (2010): Broiler breeder age affects carrying eggs intensity, brood eggs incubation values and chicken quality. Journal of Food, Agriculture and Environment, 8: 666–670.
7. Fasenko G.M. (2007): Egg storage and the embryo. Poultry Science, 86: 1020–1024.
8. Gahri H., Najafi G., Deldar F. (2015): Effect of egg weight of broiler breeder on egg characteristics and hatchery performance. International Journal of Biosciences, 6: 42– 48.
9. Iqbal J., Khan S.H., Mukhtar N., Ahmed T., Pasha R.A. (2016): Effects of egg size (weight) and age on hatching performance and chick quality of broiler breeder. Journal of Applied Animal Research, 44: 54–64.
10. King'ori A.M. (2011): Review of the factors that influence egg fertility and

hatchabilty in poultry. International Journal of Poultry Science, 10: 483–492.
11. King'ori A.M. (2012): Poultry egg external characteristics: Egg weight, shape and shell colour. Research Journal of Poultry Sciences, 5: 14–17.
12. Kopecký J. (2015): The effect of hen hatching eggs characteristics and time of its storage on embryonic mortality during incubation. Scientific Papers: Animal Science and Biotechnologies, 48: 146–150.
13. Kumpula B.L. (2004): Comparing hatchability, incubation length and chick quality from three egg sizes from two modern broiler strains. CHEPA Final Report.
14. Lourens A., van den Brand H., Meijerhof R., Kemp B. (2005): Effect of eggshell temperature during incubation on embryo development, hatchability and post-hatch development. Poultry Science, 84: 914–920.
15. Malik H.E.E., Sakin A.I.Y., Elagib H.A.A., Dousa B.M., Elamin K.M. (2015): Effect of egg weight and egg shell thickness on hatchability and embryonic mortality of Cobb broiler breeder eggs. Global Journal of Animal Scientific Research, 3: 186–190.
16. Mbajiorgu C.A., Ramaphala N.O. (2014): Insight into egg weight and its impact on chick hatch-weight, hatchability and subsequent growth indices in chickens - A review. Indian Journal of Animal Research, 48: 209–213.
17. Molenaar R., Reijrink I.A.M., Meijerhof R., Van Den Brand H. (2010): Meeting embryonic requirements of broilers throughout incubation: a review. Brazilian Journal of Poultry Science, 12: 137–148.
18. Ramaphala N.O., Mbajiorgu C.A. (2013): Effect of egg weight on hatchability and chick hatch-weight of Cobb 500 broiler chickens. Asian Journal of Animal and Veterinary Advances, 8: 885–892.
19. Rosa P.S., Guidoni A.L., Lima I.L., Reckziegel Bersch F.X. (2002): Effect of incubation temperature on hatching results of broiler breeders eggs classified by weight and hen age. Revista Brasileira de Zootecnia, 31: 1011–1016. (in Portuguese)
20. Singh M.K., Kumar S., Sharma R.K., Singh S.K., Singh B., Singh D.V. (2017): Assessment of pre and post-incubation parameters in Uttara breeder hens. Indian Journal of Animal Research, 51: 948–951.
21. Ulmer-Franco A.M., Fasenko G.M., O'Dea Christopher E.E. (2010): Hatching egg characteristics, chick quality, and broiler performance at 2 breeder flock ages and from 3 egg weights. Poultry Science, 89: 2735–2742.

Rad primljen: 3.3.2018.
Rad odobren: 12.4.2018.

DOI: 10.7251/VETJ1801054V **UDK: 636.592.082.474**

Original scientific paper

INFLUENCE OF WEIGHT OF MEAT-TYPE HYBRID HATCHING EGGS ON INCUBATION RESULTS

Marinko VEKIĆ[1]*, Mirjana MITRAKOVIĆ[2], Đorđe SAVIĆ[1]

1 Marinko Vekić, MSc, teaching assistant; Đorđe Savić, PhD, assistant professor, University of Banja Luka, Faculty of Agriculture, University city, Bulevar vojvode Petra Bojovića 1A, 78.000 Banja Luka
2 Mirjana Mitraković, BSc, Avis DM, Danka Mitrova bb, 78.420 Srbac
* Corresponding author: Marinko Vekić, marinko.vekic@agro.unibl.org

Abstract: The aim of study was to examine the values of the incubation parameters (weight loss, fertilization, hatchability of placed and fertilized eggs, total, early, middle and late embryonic mortality) of eggs of different weights in brolier hybrid Cobb 500. In total, 600 eggs were divided into four equal groups (n = 150 each) according to their weight: 57.5-62.5 g (S); 62.6-67.5 g (M); 67.6-72.5 g (L) and 72.6-77.50 g (XL). Values of incubation parameters were determined and statistically processed by standard methods. The weight of eggs significantly influenced the loss of egg weight during incubation ($p<0.05$), with this loss being higher in smaller eggs (group S 11.10% and group M 11.40%) compared to larger eggs (group L 10.42% and group XL 10.31%). Hatchability of all eggs in groups S, M, L and XL was 76.0; 75.3; 78.7 and 66.0%, respectively, and for fertilized it was 82.0; 81.3; 82.5 and 71.7%, respectively, with no significant difference ($p>0.05$). The weight of eggs did not significantly affected the difference in embryo mortality values, although in the XL egg group a higher value of total, early and late mortality was found, compared to other groups. The results of this study indicate lower hatchability and higher mortality of embryos in eggs of extremely large weight, compared to other groups, which indicates that special attention should be given to the selection of hatching eggs in terms of their weight.

Key words: hatching eggs, egg weight, incubation parameters

INTRODUCTION

Egg weight is included in external quality indicators, together with the shape index, mass, thickness, strength, density, color and purity of the shell

(King'ori, 2012). These indicators are equally important in assessing the quality of consumable and hatching eggs. The success of the incubation of hatching eggs of meat-type hybrid, measured by the percentage of the hatchability and quality of the chickens, in addition to the length and conditions of storage (Fasenko, 2007), and incubation conditions (Molenaar et al., 2010), can be significantly determined by the quality of incubated eggs. (King'ori, 2011). Eggs that do not satisfy the criteria, mainly due to poor quality of the shell (eg, irregular shape, physical damage, drowsiness) and eggs of extremely small or large mass (Bell and Weaver, 2002), are removed from the hatching eggs before the incubation process.

The mass of eggs and the results of incubation are directly interrelated so that the hatchability of extremely small and extremely large eggs has a relatively lower value than of eggs of medium or average weight of the range of 55-65 g (Bell and Weaver, 2002). The mass of hatching eggs of meat-type hybrids has an increasing trend during the period of exploitation (Đermanović et al, 2010), which can be influenced by numerous factors of genetic and paragenetic nature (King'ori, 2012). Kumpula (2004) did not recognize the difference in fertilization and hatchability between three size groups of two commercial hybrids. However, the same author recognized a higher percentage of A class chickens in the group of small and medium eggs, and a significantly higher percentage of late embryonic mortality and B class chickens in the group of large eggs. Iqbal et al. (2016) found differences in the percentage of fertilization and hatchability of commercial hybrids among different egg sizes, maximum fertility and hatchability ($P \leq 0.05$) was noticed in small egg size group, followed by medium and large egg size groups. However, maximum embryonic mortality and higher percentage of infertile eggs was recorded in large size egg group, followed by medium and small egg size groups. Malik et al (2015) also described better fertility and hatchability of small eggs compared to medium and large eggs. The higher percentage of late embryonic mortality in the group of large eggs, in comparison to medium and small eggs, without distinction in other hatchability indicators, was described by Ulmer-Franco et al. (2010) and Gahri and Sarah. (2015), while Ramaphala and Mbajiorg (2013) didn't affirm the effect of egg size on hatching performance. A relatively higher percentage of mass loss in the incubation of small compared to medium or large eggs was established by Kumpula (2004), Ulmer-Franco et al. (2010) and Gahri et al. (2015), while this loss among the three weight groups of eggs in the research carried out by Duman and Şekeroğlu (2017) did not statistically differ. Effect of egg mass on incubation results in semi-intensive farming of autochthonous hens, according to Abudabos et al. (2017), was not consistent, while Singh et al. (2017) did not notice the effect of egg mass on the incubation results.

The aim of this study was to determine,

on the basis of technological indicators of incubation (loss of egg mass, percentage of fertilization, hatchability of placed and fertilized eggs, and percentage of total, early, middle and late embryonic mortality), the effect of different size eggs from parent stock on the final results of incubation.

MATERIAL AND METHOD OF WORK

The research was carried out on the commercial farm of Cob500 parent stock and the commercial incubator station on a sample of 600 hatching eggs. The eggs originated from the parent stock, aged 52 weeks, and were hatched, collected and delivered to the storehouse of the incubator station on the same day, and then stored for four days in the cardboard boxes until the incubation began. The collected eggs are classified into groups according to their mass, by individual measurement using a technical scale (0.01 g) immediately before incubation, after which they are marked and depending on the measured mass distributed in one of four groups: 57.5 - 62.5 g S), 62.6-67.5 g (M), 67.6-72.5 g (L) and 72.6-77.50 g (XL). Pre-heating and egg incubation conditions followed the standard work technology for the given hybrid in the commercial incubator station and were identical to all groups in the study.

Data obtained by measuring individual eggs before putting them in the setter and after transferring them to the hatcher was used to calculate the mass loss percentage (GM):

GM = ((Egg mass before placing in setter - egg mass on the 18th day of incubation) / egg mass before placing in setter) × 100.

Inspection of the hatcher residue determined: number of fertilized and unfertilized eggs; the number of hatched chickens, and the number of embryos that died in the first (early), second (middle) and third week incubation (late mortality),on the basis of this data the following parameters of incubation were calculated:

Fertilization of eggs (O,%)

O = (number of fertilized eggs / total number of eggs) × 100;

Hatchability of all eggs (Vu,%)

Vu = (number of hatched chickens / total number of eggs) × 100;

Hatchability of fertilized eggs (Vo,%)

Vo = (number of hatched chickens / number of fertilized eggs) × 100;

Total embryonic mortality (UM,%)

UM = (number of dead embryos / number of fertilized eggs) × 100;

Early embryonic mortality (RM,%)

RM = (number of dead embryos in up to 7 days of incubation /number of fertilized eggs) × 100);

Middle embryonic mortality (SM,%)

SM = (number of dead embryos in 8-14 days of incubation / number of fertilized eggs) × 100

Late embryonic mortality (KM,%)

KM = (number of dead embryos in 15-21 days of incubation / number of fertilized eggs) × 100.

Statistical data processing for loss of egg mass during incubation was carried out by analyzing variance at the level of significance p <0.05, while χ2 test at the significance level p <0.05 was used for hatchability and mortality values.

RESULTS OF RESEARCH AND DISCUSSION

Weight loss of hatching eggs during incubation is shown in Table 1.

Table 1. Weight loss of hatching eggs during incubation ("Mean ± SEM")

Group	Egg weight(g)	Egg weight on 18.day (g)	Weight loss (%)
S	$61{,}27^{d}$ (±0,19)	$54{,}47^{d}$ (±0,24)	$11{,}10^{a}$ (±0,24)
M	$65{,}45^{c}$ (±0,24)	$57{,}99^{c}$ (±0,30)	$11{,}40^{a}$ (±0,28)
L	$69{,}83^{b}$ (±0,22)	$62{,}56^{b}$ (±0,29)	$10{,}42^{b}$ (±0,25)
XL	$74{,}19^{a}$ (±0,25)	$66{,}54^{a}$ (±0,35)	$10{,}31^{b}$ (±0,34)

^{abc} – values in the same column marked with different letters have statistically significant difference (p <0.05)

The highest loss of egg mass during incubation (11.40%) in this study was detected in group M, and the smallest (10.31%) in group XL. The values of loss of egg mass during incubation in groups S and M were significantly (p <0.05) higher than in groups L and XL. Iqbal et al (2016) found a significantly higher loss of weight during incubation in egg groups of average weight of 60.05 g (11.32%) and 65.03 g (11.12%) compared to the group of eggs with an average weight of 70.03 g (10, 62%). Rosa et al. (2002) classified eggs in relation to their weight (60.0, 65.1, 66.6, 69.0 and 73.2 g) and found minimal differences in percentage of mass loss during incubation (10.9, 10, 3; 10.2; 10.1 and 10.0%). A similar trend was described by Gahri et al. (2015), who classifed eggs in three groups by their weight (52.6-55.7, 57.2-60.2 and 61.7-64.7 g) and they found found a decrease in weight loss during incubation with the initial egg mass increase (12.56, 12.13 and 11.63%). However, Duman and Şekeroğlu (2017) did not find statistically significant difference in loss of weight (13.03; 13.24; 13.02%) among groups of eggs with different weight (55,0-60,0; 60,1-65,0; 65,1-70,0 g). The observed reduction in the percentage of mass loss during incubation with the increase in egg mass is probably due to a decrease in the ratio of the shell surface to the mass of egg contents (Ulmer-Franco et al., 2010; Iqbal et al., 2016). Optimum values for loss of egg mass during incubation are 6.5-14.0%, which is considered sufficient for the proper formation of the air chamber (Molenaar et al., 2010). Bell and Weaver (2002) state that the quality of the shell and the conditions of incubation can also affect loss of egg mass during incubation.

Indicators of fertilization and hatchability of eggs of different mass are shown in Table 2.

Table 2. Fertilization and hatchability of placed and fertile hatching eggs (%)

Group	Fertalization of eggs (%)	Hatchability of placed eggs (%)	Hatchability of fertilized eggs (%)
S	92,7	76,0	82,0
M	92,7	75,3	81,3
L	95,3	78,7	82,5
XL	92,0	66,0	71,7

The fertilization of the eggs, as a key factor of hatchability, is conditioned by the reproductive functions of the parents, in particular by the quality of sperm and full behavior of the cock, as well as by the process of egg formation and the functioning of hens' tubular glands (King'ori, 2011). This indicator varies depending on the age of the flock and the genotype (Kumpula, 2004; Abudabos, 2010; Iqbal et al., 2016), but also on paragenetic factors, such as nutrition and sex ratio. The influence of paragenetic factors, primarily nutrition on egg fertilization, is particularly important for the parent stock which is selected for fattening and well-used food, which is why they are prone to weight gain and it is necessary to feed them restrictively in order to preserve reproductive activity. With regard to the eggs hatchability of different masses Mbajiorgu and Ramaphala (2014) emphasize the importance of the specificity of each race or hybrid, but also the influence of individuals within the same race or hybrid. The fertilization of eggs in our study was the lowest in group XL (92.0%), slightly higher in groups S and M (92.7%), and the highest in group L (95.3%), but without statistically significant differences among groups (χ^2 0.106; $p > 0.05$). Ulmer-Franco et al. (2010) did not find the difference in fertilization of three groups of eggs with an average mass of 58.3, 62.6 and 66.8 g (84.2, 85.1, 87.5%, respectively), but they noted its increase with an increase in average mass of eggs. Gahri et al. (2015) also did not find a statistically significant difference in fertilization of three groups of eggs of different masses (52.62-55.65; 57.15-60.15 and 61.65-64.65 g at 91.5; 93.0; 94.7%), but they confirmed the findings of other authors that with the increase in egg mass percentage of fertilization also increases. The absence of significant differences in the fertilization of eggs of different masses was also described by Abudabos et al. (2017) and Singh et al. (2017) in autochthonous breeds of free-range chicken,and Kumpala (2004) and Duman and Şekeroğlu (2017) described this absence in meat-type hybrids. On the other hand, Iqbal et al. (2016) found a statistically significant decrease in the percentage of fertilization, with an increase in the weight of eggs (96.7, 93.3, 90.3%, respectively). Hatchability of placed eggs in our study had the highest value in group L (78.7%), and the lowest in group XL (66.0%), and the differences among the groups in this study were not statistically significant ($\chi 2$ 1.856; p> 0 , 05). Hatchability of fertilized eggs was the highest in group L (82.5%), and the lowest in XL (71.7%), also without statistically significant differences ($\chi 2$ 1.377; p> 0.05). However, the percentage values of hatchanility in both cases were lower in the group of eggs of the highest mass (XL) compared to the groups S, M and L which had relatively similar values of these indicators. Kumpula (2004) states that the incubation of small, medium and large eggs did not show a statistically significant difference between the placed eggs (85.5; 82.3 and 82.2%) and the fertilized eggs (91.0; 89.9 and 87.9 %), but its values decreased with increasing egg mass. Ulmer-Franco et al. (2010) also received similar values in three groups for the hatchability of fertilized eggs (88.3, 89.9 and 84.3%) and relatively lower hatchability for large eggs, as confirmed by the results obtained by Ramaphala and Mbajiorgu (2013) (egg masses <49; 50-59 and 60-69 g for 92.4; 90.9; 90.9%, respectively). Gahri et al.(2015) state that they got similar valuees for hatchability of placed eggs (83.3%, 85.4%, 80.3%, respectively) and fertilized eggs of different masses (83.7; 86.4; 83.8%, respectively); where the best results were scored by a group of medium-sized eggs. Iqbal et al. (2016) found a significant difference between the eggs of an average weight of 60.05, 65.03 and 70.03 g, for placed eggs (89.7, 83.7, 78.3%) and for fertilized eggs (92, 7; 89.6; 86.7%). Analyzing the results of the incubation of four groups of average weight eggs (60.0, 65.1, 66.6, 69.0) and 73.2 g, Rosa et al. (2002) found statistically significant decreased hatchability in the group of eggs of the highest mass compared to all other groups (86.3, 86.6, 85.9, 85.5, 83.6%, respectively), which was also shown by the hatchability of fertilized eggs (92.5; 92.8; 92.0; 91.6; 89.5%, respectively) Duman and ekero lu (2017) discovered better hatchability of fertilized and placed eggs in the medium egg group (88.69 and 85.00%) and lower mass group (87.81 and 84.17%) compared to large eggs (80.76 and 78.05%) DeWitt and Schwalbach (2004)got the opposite results during the incubation of eggs of the New Hampshire and Rhode Island breed as they found better hatchability in a group of larger eggs.

The percentage of embryonic mortality, depending on the weight of hatching eggs, is given in Table 3.

Table 3. Embryonic mortality depiction, depending on the weight of eggs

Group	Embryonic mortality							
	Total		Early		Mid		Late	
	n	%	n	%	n	%	n	%
S	25	18,0	15	10,8	4	2,9	6	4,3
M	26	18,7	17	12,2	1	0,7	8	5,8
L	25	17,5	17	11,9	1	0,7	7	4,9
XL	39	28,3	25	18,1	3	2,2	11	8,0

The total embryonic mortality in our study ranged from 17.5% in group L to 28.3% in group XL.

The differences in the values of this parameter between the egg groups were not statistically significant ($\chi2$ 5,317; p> 0,05). This finding is consistent with the data reported by Abudabos et al. (2017) for the incubation of eggs of autochthonous free-range chickens, and those by Duman and Şekeroğlu (2017) for the egg incubation of meat-type hybrid. On the contrary, Rosa et al. (2002) found a significantly higher total mortality in the group of large eggs of an average weight of 73.2 g (9.6%), compared to eggs of an average weight of 60.0 g (7.0%) and 65.1 g (6 , 7%), which is consistent with the results obtained by Iqbal et al. (2016) Kopecký (2015) found the highest total mortality in the group of eggs weighing 70-75 g (16.7%), and the lowest in the group weighing 55-60 g (9.7%). Early embryonal mortality in our study was most pronounced in group XL (18.1%), and lowest in group S (10.8%), with no statistically significant differences ($\chi2$ 3,412, p> 0.05). The mid embryonic mortality was highest in the S group (2.9%) and the lowest in the M and L groups (0.7%), also without significant difference between the groups (2 3.081, p> 0.05). Late embryonal mortality ranged from 4.3% in group S to 8.0% in group XL, also without statistically significant difference (χ 1.870, p> 0.05) Kumpula (2004) and Malik and Sar. (2015) determined the absence of statistically significant differences between eggs of different masses for the mid and late mortality. Iqbal et al. (2016) found significantly higher early, mid and late mortality in the group of large eggs of an average weight of 70.03 g (3.3, 2.3 and 3.00%, respectively) in relation to the group of eggs of an average weight of 60.05 g (2.0; 1.3 and 1.67%, respectively). The largest mass group (XL) in our study had higher values of early and late mortality, although there was no statistically significant difference, which is in accordance with the results of several authors. Ulmer-Franco et al. (2010) did not find a difference in the values of early and middle embryonic mortality, while the value of late mortality was significantly higher in the group of large (7.0%) compared to the group of middle-sized (4.8%) and small eggs (2, 8%). Similarly to the mentioned authors, Kumpula (2004) found the difference only in the values of late embryo mortality, which was significantly higher in the group of large (6.1%) compared to small (1.8%) and medium eggs (4.3 %). Gahri and sar. (2015) registered the lowest early mortality in the group of medium eggs (2.96%) compared to 3.95% for smaller eggs and 4.68% in large eggs, while the late mortality was higher in the group of large (6.38%) compared to small (2.85%) and medium eggs (3.63%).

The increase in mortality with an increase in the mass of eggs, especially in older flock, may be associated with the inability of the embryo to achieve an appropriate temperature at the initial stage of incubation or loss of metabolic heat in the late incubation phase (Lourens et al., 2005).

CONCLUSION

The results of this study confirm the importance of breeding eggs for the ultimate incubation results, ie their interrelation, and therefore the need to classify hatching eggs before placung them in incubators. The loss of mass during incubation was proportionally smaller in eggs of higher mass, most likely due to the ratio of egg mass or volume to the shell surface. Also, embryonal mortality had a relatively higher value in the incubation of exceptionally large eggs, which suggests that average –sized eggs from the flock should be selected for incubation. The incubation results are influenced by other parameters such as hybrid, age, sex ratio, nutrition and similar, which shoud all be taken into account for the purpose of objectivation and correct interpretation of the research results.

REFERENCES

1. Abudabos A. (2010): The effect of broiler breeder strain and parent flock age on hatchability and fertile hatchability. International Journal of Poultry Science, 9: 231-235.
2. Abudabos A.M.I., Aljumaah R.S.I., Algawaan A.S.I., Al-Sornokh H.I., Al-Atiyat R.M.I. (2017): Effects of hen age and egg weight class on the hatchability of free range indigenous chicken eggs. Brazilian Journal of Poultry Science, 19: 33-40.
3. Bell D.D., Weaver W.D. (2002): Commercial Chicken Meat and Egg Production.
4. DeWitt F., Schwalbach L.M.J. (2004): The effect of egg weight on the hatchability and growth performance of New Hampshire and Red Rhode Island chicks. South African Journal of Animal Science, 34: 62-64.

5. Duman M, Şekeroğlu A. (2017): Effect of egg weights on hatching results, broiler performance and some stress parameters. Brazilian Journal of Poultry Science, 19: 255-262.
6. Đermanović V., Mitrović S., Petrović M. (2010): Broiler breeder age affects carrying eggs intensity, brood eggs incubation values and chicken quality. Journal of Food, Agriculture and Environment, 8: 666-670.
7. Fasenko G.M. (2007): Egg storage and the embryo. Poultry Science, 86: 1020-1024.
8. Gahri H., Najafi G., Deldar F. (2015): Effect of egg weight of broiler breeder on egg characteristics and hatchery performance. International Journal of Biosciences, 6: 42-48.
9. Iqbal J., Khan S.H., Mukhtar N., Ahmed T., Pasha R.A. (2016): Effects of egg size (weight) and age on hatching performance and chick quality of broiler breeder. Journal of Applied Animal Research, 44: 54-64.
10. King'ori A.M. (2011): Review of the factors that influence egg fertility and hatchabilty in poultry. International Journal of Poultry Science, 10: 483-492.
11. King'ori A.M. (2012): Poultry egg external characteristics: Egg weight, shape and shell colour. Research Journal of Poultry Sciences, 5: 14-17.
12. Kopecký J. (2015): The effect of hen hatching eggs characteristics and time of its storage on embryonic mortality during incubation. Scientific Papers: Animal Science and Biotechnologies, 48: 146-150.
13. Kumpula B.L. (2004): Comparing hatchability, incubation length and chick quality from three egg sizes from two modern broiler strains. CHEPA Final Report.
14. Lourens A., van den Brand H., Meijerhof R., Kemp B. (2005): Effect of eggshell temperature during incubation on embryo development, hatchability and post-hatch development. Poultry Science, 84: 914-920.
15. Malik H.E.E., Sakin A.I.Y., Elagib H.A.A., Dousa B.M., Elamin K.M. (2015): Effect of egg weight and egg shell thickness on hatchability and embryonic mortality of Cobb broiler breeder eggs. Global Journal of Animal Scientific Research, 3: 186-190.
16. Mbajiorgu C.A., Ramaphala N.O. (2014): Insight into egg weight and its impact on chick hatch-weight, hatchability and subsequent growth indices in chickens - A review. Indian Journal of Animal Research, 48: 209-213.
17. Molenaar R., Reijrink I.A.M., Meijerhof R., Van Den Brand H. (2010): Meeting embryonic requirements of broilers throughout incubation: a review. Brazilian Journal of Poultry Science, 12: 137-148.
18. Ramaphala N.O., Mbajiorgu C.A. (2013): Effect of egg weight on hatchability and chick hatch-weight of Cobb 500 broiler chickens. Asian Journal of Animal and Veterinary Advances, 8: 885-892.

19. Rosa P.S., Guidoni A.L., Lima I.L., Reckziegel Bersch F.X. (2002): Effect of incubation temperature on hatching results of broiler breeders eggs classified by weight and hen age. Revista Brasileira de Zootecnia, 31: 1011-1016. (in Portuguese)
20. Singh M.K., Kumar S., Sharma R.K., Singh S.K., Singh B., Singh D.V. (2017): Assessment of pre and post-incubation parameters in Uttara breeder hens. Indian Journal of Animal Research, 51: 948-951.
21. Ulmer-Franco A.M., Fasenko G.M., O'Dea Christopher E.E. (2010): Hatching egg characteristics, chick quality, and broiler performance at 2 breeder flock ages and from 3 egg weights. Poultry Science, 89: 2735-2742.

Paper received: 03.3.2018.

Paper accepted: 12.4.2018.