**Genetic and Hormonal Differences between High Growth Rate Breed (Cobb chicken) and Low Growth Rate Breed (Native Fayoumi chicken)**

**Abstract**

The present study aimed at investigating genetic and hormonal differences between a low growth rate chicken breed (a native breed, Fayoumi chicken) and a high growth rate chicken breed (Cobb chicken). A total number of 100 one-day-old Fayoumi chicks and 100 one-day-old Cobb chicks were used. Chicks of each breed were allocated into three equal replicates. The growth parameters [body weight, Body weight gain)BWG) and Feed conversion ratio(FCR)], genetic expression of some growth related genes (insulin like growth factor1, ghrelin and Myostatin gene) and plasma level of some growth related hormones (Insulin, T3, T4 and corticosterone) were recorded. The obtained results revealed that, Cobb chicken had significantly higher (p<0.05) body weight, BWG and feed intake than Fayoumi chicken but the FCR of Fayoumi chicken was higher (p<0.05) than that of broiler chicken. Cobb recorded significantly (p<0.05) lower plasma level of corticosterone, T3 and T4 than Fayoumi chicken while Insulin is higher (p<0.05) in cobb chicken. Cobb recorded highly significant (p<0.05) values of GH, IGF1 and ghrelin Gene expression while myostatin gene expression was higher (p<0.05) in Fayoumi chicken than in Cobb. From the obtained results could be concluded that, the observed high growth rate in cobb chicken may be attributed the difference gene expression related growth as well as hormonal difference

**Key words**: Fayoumi, Cobb broilers, chicken, growth, gene expression, corticosterone, T3 and T4

1. **Introduction**

Poultry production is a significant and diverse part of farming worldwide. ([**Kaya and Yildiz, 2008**](https://www.ajas.info/journal/view.php?doi=10.5713/ajas.15.0028#b14-ajas-28-12-1686)**).** In chickens selected for low growth rate there is increased expression of genes required for the proliferation of progenitor and differentiation of muscular cells on day of hatching compared to chickens selected for high growth rate **(Yin et al., 2014)**.

The growth hormone / insulin-like growth factor-1 (GH/IGF-1) pathway of the somatotropic axis is the major controller for growth rate and body size in vertebrates, but the effect of selection on the expression of GH/IGF-1 somatotropic axis genes and their association with body size and growth performance in farm animals is not fully understood **(Jia et al., 2018).**

Under optimum conditions for growth, the body weight of layer hens is significantly lower than in broiler chickens as a result of their inner genetic differences. The different expression of genes in broiler breeders and layer hens is indicative of considerable discrepancies in the growth rate of skeletal muscles during development and the difference in body weight gain between broiler chickens and layer hens is most pronounced within 2 to 6 wk of hatching **(Zheng et al., 2009).**

Genetic differences in chicken are seen in yolk sac, hormone and lipid metabolism, gas exchange and thermogenesis, and contribute to differences during hatching or body weight of the chicks **(Buzala et al., 2015).** After hatching, differences are seen in broiler breeder and layer hens mainly in feed consumption, growth rate, efficiency of nutrient utilization, and muscle fat content and development **(Reyer et al., 2015).**

At the same time, overexpression of Mstn led to the reduction of muscle mass suggesting myostatin to be a negative regulator of skeletal muscle growth. During embryogenesis, myostatin is exclusively expressed in skeletal muscle **( McPherron et al., 1997) and** The low levels of MSTN measured during the first weeks of life may contribute to the onset of skeletal muscle development in newly hatched chicks, which is dependent of the rapid initiation of neonatal metabolism **(Mott and Ivarie, 2002).**

**II. Materials and Methods**

***II-1. Experimental design***

A total number of one hundred of healthy one-day-old Cobb chicks (45 ± 5 g body weight) and one hundred of healthy one-day-old Fayoumi chicks (30 ± 3 g body weight) of both sexes were assigned into two groups. Each group was allocated into 3 replicates. Group1: broiler chicks received starter (1:10 days), grower (11: 22days), finisher1 (23:42days) and finisher 2 (43:60 days) rations. Group 2: Fayoumi chicks received starter (0:24days), grower (29; 49 days) and finisher (50:60 days) rations as shown in table1.

***II-2.* Determination of the relative expression of growth related genes (IGF1, myostatin and Ghrelin)**

Samples were collected at zero day and every 2 weeks till the end of experiment (2 months) from liver, skeletal muscle (breast muscle and thigh muscle) and proventriculus to be placed in sterile tubes that immediately stored at -80 oC. Expression of growth related genes (insulin like growth factor1, ghrelin and myostatin) was determined according to **Livak and Schmittgen, 2001.**

***II-3.* Determination of the plasma level of hormones**

Blood samples were collected in vacutainer tubes (coated with Heparin) then was carefully collected and kept frozen at -20 °C till used for determination of T3, T4, Corticosterone and insulin plasma level (**Ottinger et al., 2001).**

**II-4. Growth parameters**

The chicks were weighed individually at the start of experiment, then every week for recording the live body weights till the 8th week. Food intake was measured weekly and body weight gains were recorded (**Abdel-Gawad et al., 2013).**

***II-5.* Statistical analysis**

All the data were statistically evaluated with SPSS/16 software.2011 Hypothesis testing methods included independent sample T test. P values of less than 0.05 were indicated statistical significance. All the results were expressed as mean ± SE

***III-*Results**

***III-1.* Growth parameters ofFayoumi chicken and Cobb Chicken (means ± SE)**

The obtained results (table 3,4,5,6) revealed that, male and female Cobb had significantly (p<0.05) increased body weight , BWG and feed intake than male and female Fayoumi, respectively during whole experimental period (from 0 to 8 weeks of age). On the other hand, Fayoumi recorded significantly (p<0.05) increased FCR than Cobb during whole experimental weeks **except** the 7th and 8th weeks of age where Cobb had significantly (p<0.05) increased FCR.

**III-2. IGF1, ghrelin and Myostatin gene expression of Fayoumi chicken and Cobb Chicken (means ± SE).**

The obtained results (table 7,8,9 and figure 1,2,3) showed that, in one day old chicks there was no significant difference in the relative expression of IGF1 gene in liver between Fayoumi and Cobb chicken, however at day14, day28 and day56, Cobb chicken had significant (p<0.05) higher expression of IGF1 gene than Fayoumi chickens, whereas at day42, Fayoumi chickens had significant (p<0.05) higher expression of IGF1 gene than Cobb chickens.

in one day old chicks there was non significant difference in the relative expression of myostatin gene in muscle between Fayoumi and Cobb chicken, however at day14, day 28, day 42 and day56 , Cobb chicken had significant (p<0.05) lower expression of myostatin gene than Fayoumi chickens. The highest values of myostatin gene expression in muscle in both cobb and Fayoumi chickens on day one and the lowest values were recorded on day56 in Fayoumi chicken and on day 42 in cobb chicken.

on day one there was no significant difference in the relative expression of Ghrelin gene in proventriculus between Fayoumi and Cobb chicken, however at day14, day28, day42 and day56, Cobb chicken had significant (p<0.05) higher expression of Ghrelin gene than Fayoumi chickens

**III-3. corticosterone, T3, T4 and Insulin hormone Level of Fayoumi chicken and Cobb Chicken (means ± SE).**

The obtained results (table 10,11,12,13 figure 4, 5,6 and 7) revealed that, Fayoumi chickens had a significant (p<0.05) higher corticosterone and T3 plasma level than cobb chicken during whole experimental period (from day1 to day56 of age).

The obtained results revealed that Fayoumi chicken had a significant (p<0.05) higher T4 plasma level than cobb chicken except at day14 and day56 there was no significant difference between cobb and fayoumi chicken.

The obtained results revealed that cobb chicken had a significant (p<0.05) higher insulin concentration than Fayoumi chicken during whole experimental period (from day1 to day56 of age).

**IV. Discussion**

**Zheng et al., (2009)** reported that the optimum conditions for growth, the body weight of layer hens is significantly lower than in broiler chickens as a result of their inner genetic differences. The different expression of genes in broiler breeders and layer hens is indicative of considerable discrepancies in the growth rate of skeletal muscles during development and the difference in body weight gain between broiler chickens and layer hens is most pronounced within 2 to 6 wk of hatching. Similar results also reported that Cobb chickens achieved the highest bodyweight, each week. The fastest growing breeds, Cobb, consistently achieved the highest bodyweights compared to the slower growing breeds ([**Pauwels**](https://www.researchgate.net/profile/Jana_Pauwels) **et al., 2015).** The commercial AB line chickens showed a high increased daily growth rate from hatching to 5 weeks of age **(**[**Dou**](https://pubmed.ncbi.nlm.nih.gov/?term=Dou+T&cauthor_id=29740785) **et al ., 2018).** The observed difference in growth rate between Fayoumi and Cobb chickens could be attributed also to genetic and hormonal difference. The chicken growth hormone and growth hormone receptors play a crucial role in chicken performance because of their cardinal functions in growth **(Fisher, 2016)**.

[**Halevy *et al*., 2000**](https://jme.bioscientifica.com/view/journals/jme/46/3/217.xml#bib19) **reported that** broiler chicken has a fast growth rate, higher breast muscle yield, and higher feeding efficiency, which makes the broiler chicken an interesting model for the development of muscle**.**[**Pauwels**](https://www.researchgate.net/profile/Jana_Pauwels) **et al., 2015** reported that Cobb chickens achieved the highest bodyweight, each week. The fastest growing breeds, Cobb, consistently achieved the highest bodyweights compared to the slower growing breeds. Yet, based on the FCR, it should has increased its feed intake by 45 % broiler chickens exhibited higher body weight **(Zhao et al., 2004**).

The present study showed that feed efficiency at w7-w8 of age, Fayoumi chickens had a significant lower in feed conversion ratio than cobb chicken. The observed decrease in feed efficiency of cobb chickens during this period of age compared to fayoumi chickens could be attributed to marked increase in feed intake of cobb chicken during this period of age as observed in the present study.

The obtained results of this study revealed that cobb chicken had a significant higher feed intake than fayoumi chicken during whole experimental period (from 0 to 8 weeks of age). Similar results were observed by **Jia et al., (2018)** the Avian broilers showed a sharp increase in feed intake from weeks 2 to 6, showed a decrease in FCR (i.e. highest efficiency), at each age measured. Moreover **Leeson et al., 1996** noted an increase in feed intake as well as feed in-take to bodyweight gain ratio of broilers when the energy and protein level in the feed were diluted. The chickens’ body weight was significantly affected on day 42 but not on day 49.Differences were found between high and low-weight-selected chickens in feed intake due to differences in gene expression profiles of different neuropeptides in the hypothalamus (**Newmyer et al., 2013; Yi et al., 2015).**

there were significantly higher IGF1 mRNA levels in the high growth rate line than in the low growth rate line **(Beccavin et al., 2001).**

The present study showed that at 6th week, Fayoumi chickens had significant higher expression of IGF1 gene than Cobb chickens, this results is in partial agreement of the results of **Bhattacharya et al.,** (**2015**) Expression in muscle was highest on d 1 and d 28, whereas the low expression occurred on d 42 .The present work showed that on day 1 gene expression of IGF1gene in liver showed non significance difference between Cobb and Fayoumi chickens and exhibited the lowest values in both two strains than 2, 4, 6 and 8th weeks. These results could be attributed to nutrition and feed intake as confirmed by **Zhao et al., (2004)** who reported that transcription of the somatotropic axis genes responded differently to nutrition.

The present work showed that on day 1 gene expression of IGF1gene in liver showed non significance difference between Cobb and Fayoumi chickens and exhibited the lowest values in both two strains than 2, 4, 6 and 8th weeks. These results could be attributed to nutrition and feed intake as confirmed by **Zhao et al., (2004)** who reported that transcription of the somatotropic axis genes responded differently to nutrition.

The observed higher growth rate of Cobb Chickens than Fayoumi Chickens is probably due to confirmed effect of Ghrelin that stimulate secretion of Growth hormone, stimulate appetite and feed intake **(Kaiya et al., 2002; Saito et al., 2005; Richard et al., 2006).** The low-weight selected chicks expressed higher levels of anorexigenic neuropeptides, which may directly contribute to the reduced appetite in low-weight-selected chicks **(Yi et al., 2015).** Fayoumi chickens showed lower feed intake than Cobb chickens as observed in the present study may contribute to the lower expression of ghrelin gene than Cobb chickens. However, **Richard et al., (2006)** reported that ghrelin shown to stimulate growth hormone release but inhibit feed intake.

In poultry, CORT is the principal glucocorticoid (GC) involved in the regulation of fuel metabolism, feed intake (appetite), and immune responses (**Zulkifli et al., 2004; Yuan et al., 2008).** Blood corticosterone (CORT) also participates in regulating the growth of broilers **(Houshmand et al.,****[2012](https://www.sciencedirect.com/science/article/pii/S0032579119579706?via%3Dihub" \l "bib14); Li et al.,****[2019](https://www.sciencedirect.com/science/article/pii/S0032579119579706?via%3Dihub" \l "bib20)**). The decreased growth rate by corticosterone (CORT) was associated with the enhanced energy expenditure, proteolysis and gluconeogenesis **(Lin et al., 2004a,b).** The loss of myofibrillar protein induced by CORT administration is caused mainly by decreased synthesis rather than the accelerated catabolism **(Kayali et al., 1990).** moreover **Hayashi et al., (1985)** reported that the rapid growth of broiler chicken is facilitated by the reduced rate of protein degradation**.** High CORT levels can affect bone growth and significantly reduce feed intake and BW gain in Chicken **(Luo et al.,****[2013](https://www.sciencedirect.com/science/article/pii/S0032579119579706?via%3Dihub" \l "bib19)).** GCs may suppress growth by reducing the absorption of feed through the small intestine, the decrease in the growth rate **(****Hu et al., 2010).** exposing broiler chickens to CORT decreased the ADG in the absence of a change in feed intake **(Yang et al., 2015).** Thereone of the reasons for observed lower growth rate of Fayoumi chicken in the present study is propably due to higher CORT levels than Cobb chickens that affect behavior, feed intake, feed efficiency and weight gain.

This result indicate that one of the reasons of high growth rate in Cobb chicken and weight gain than Fayoumi chickens is probably due to observed high level of plasma insulin that play important role in regulation of CHO and lipid metabolism amd stimulate growth by increasing protein synthesis and affecting the expression of growth-related genes **( Taniguchi et al., 2006)**. The ability for GH to stimulate growth through IGF-1 can be mediated through insulin. In liver, insulin increases GHR expression (**Butler et al., 2003)** and stimulates IGF-1 production itself **(Houston and O’Neill, 1991).** Furthermore, **Matis et al., (2015)** reported that influencing both the pancreatic production and the cellular signaling of insulin may greatly improve it's efficiency in regulation of growth and metabolism.

This result indicate that one of the reasons of low growth rate in Fayoumi chicken and weight gain than Cobb chickens is probably due to observed high level of plasma T4 and T3 that have catabolic effect with higher concentrations that cause further stimulation of protein degradation **(He et al., 2006)**. **Xiao et al.,****(**[**2017**](https://www.sciencedirect.com/science/article/pii/S0032579119579706?via%3Dihub#bib46)**)** reported that T3 and T4 affect almost every physiological process in the body and are important hormones supporting chicken growth. Also they considered as the most important systems regulating embryonic development and posthatch growth in the chicken **(Tsukada et al., 1998). Sahin et al.,****(**[**2002**](https://www.sciencedirect.com/science/article/pii/S0032579119579706?via%3Dihub#bib29)**) and Dai et al.,****(**[**2011**](https://www.sciencedirect.com/science/article/pii/S0032579119579706?via%3Dihub#bib8)) reported thatstress increased the serum concentrations of T3 and T4. Moreover **Jung et al., (2007)** reported that the leg muscle of layer hens shows higher expression of proteins associated with muscle development, growth, oxidative stress and locomotion of hens. These results may suggest that leg muscles of layer hens compared to meat-type chickens are more susceptible to oxidative stress**.**

**Conclusion**

From the obtained results could be concluded that the observed lower growth rate in Fayoumi chickens than Cobb chickens may probably due to lower expression of gene related growth ( IGF1 and Ghrelin gene) and higher expression of myostatin gene in skeletal muscle in addition level of hormones related growth as higher level of plasma corticosterone, T3 and T4 and lower level of plasma insulin than Cobb chickens.

**VI. References**

**Abdel-Gawad, M. M. (2013):** Effect of prebiotic (Bio-Mos) on some physiological parameters of growth and molecular biology in Japanese quail.

**Beccavin, C.; Chevalier, B.; Cogburn, L. A.; Simon, J. and Duclos, M. J. (2001):** Insulin-like growth factors and body growth in chickens divergently selected for high or low growth rate. *Journal of Endocrinology*, *168*(2): 297-306.

**Bhattacharya, T. K.; Chatterjee, R. N.; Dushyanth, K.; Paswan, C.; Shukla, R. and Shanmugam, M. (2015):** Polymorphism and expression of insulin-like growth factor 1 (IGF1) gene and its association with growth traits in chicken. *British poultry science*, *56*(4): 398-407.

**Butler, S. T.; Marr, A. L.; Pelton, S. H.; Radcliff, R. P.; Lucy, M. C. and Butler, W. R. (2003)**: Insulin restores GH responsiveness during lactation-induced negative energy balance in dairy cattle: effects on expression of IGF-I and GH receptor 1A.‏

**Buzała, M.; Janicki, B. and Czarnecki, R. (2015):** Consequences of different growth rates in broiler breeder and layer hens on embryogenesis, metabolism and metabolic rate: a review. *Poultry Science*, *94*(4): 728-733.

**Dai, S. F.; Gao, F.; Zhang, W. H.; Song, S. X.; Xu, X. L. and Zhou, G. H. (2011):** Effects of dietary glutamine and gamma-aminobutyric acid on performance, carcass characteristics and serum parameters in broilers under circular heat stress. Animal Feed Science and Technology, 168(1-2):51-60.

**Dou, T.; Li, Z.; Wang, K.; Liu, L.; Rong, H.; Xu, Z. and Zhang, J. (2018):** Regulation of myostatin expression is associated with growth and muscle development in commercial broiler and DMC muscle. *Molecular biology reports*, *45*(4): 511-522.

**Fisher, T. (2016):** Specialty poultry production: impact of genotype, feed strategies, alternative feedstuffs, and dietary enzymes on the growth performance and carcass characteristics of heritage breed chickens. Theses and Dissertations--Animal and Food Sciences. 66.

**Halevy, O.; Geyra, A.; Barak, M.; Uni, Z. and Sklan, D. (2000**): Early posthatch starvation decreases satellite cell proliferation and skeletal muscle growth in chicks. *The Journal of nutrition*, *130*(4): 858-864.‏

**Hayashi, K.; Tomita, Y.; Maeda, Y.; Shinagawa, Y.; Inoue, K. and Hashizume, T. (1985):** The rate of degradation of myofibrillar proteins of skeletal muscle in broiler and layer chickens estimated by N r-methylhistidine in excreta. *British Journal of Nutrition*, *54*(1): 157-163.

**He, J. H.; Cao, M. H.; Gao, F. X.; Wang, J. H. and Hayashi, K. (2006):** Dietary thyroid hormone improves growth and muscle protein accumulation of black-boned chickens. *British poultry science*, *47*(5): 567-571.‏

**Houshmand, M.; Azhar, K.; Zulkifli, I.; Bejo, M. H. and Kamyab, A. (2012):** Effects of prebiotic, protein level, and stocking density on performance, immunity, and stress indicators of broilers. Poultry science, 91(2): 393-401.

**Houston, B. and O'Neill, I. E. (1991)**: Insulin and growth hormone act synergistically to stimulate insulin-like growth factor-I production by cultured chicken hepatocytes. *Journal of endocrinology*, *128*(3): 389-393.

**Hu, X. F.; Guo, Y. M.; Huang, B. Y.; Bun, S.; Zhang, L. B.; Li, J. H. and Jiao, P. (2010**): The effect of glucagon-like peptide 2 injection on performance, small intestinal morphology, and nutrient transporter expression of stressed broiler chickens. *Poultry Science*, *89*(9): 1967-1974.‏

**Jia, J.; Ahmed, I.; Liu, L.; Liu, Y.; Xu, Z.; Duan, X. and Wang, K. (2018):** Selection for growth rate and body size have altered the expression profiles of somatotropic axis genes in chickens. Plos one, 13(4): e0195378.

**Jung, K. C.; Jung, W. Y.; Lee, Y. J.; Yu, S. L.; Choi, K. D.; Jang, B. G. and Lee, J. H. (2007**): Comparisons of chicken muscles between layer and broiler breeds using proteomics. *Asian-australasian journal of animal sciences*, *20*(3): 307-312.‏

**Kaiya, H.; Van Der Geyten, S.; Kojima, M.; Hosoda, H.; Kitajima, Y.; Matsumoto, M. and Kangawa, K. (2002):** Chicken ghrelin: purification, cDNA cloning, and biological activity. *Endocrinology*, *143*(9): 3454-3463.‏

**Kaya, M. and Yildiz, M. A. (2008):** Genetic diversity among Turkish native chickens, Denizli and Gerze, estimated by microsatellite markers. Biochemical genetics, 46(7-8): 480-491.

**Kayali, A. G.; Goodman, M. N.; Lin, J. U. D. I. T. H. and Young, V. R. (1990):** Insulin-and thyroid hormone-independent adaptation of myofibrillar proteolysis to glucocorticoids. *American Journal of Physiology-Endocrinology and Metabolism*, *259*(5): E699-E705.‏

**Leeson S.; Caston L. and Summers JD. (1996):** Broiler response to energy or energy and protein dilution in the finisher diet. Poult Sci.; 75: 522–528.

**Li, J. Y.; Liu, W.; Ma, R. Y.; Li, Y.; Liu, Y.; Qi, R. R. and Zhan, K. (2019):** Effects of cage size on growth performance, blood biochemistry, and antibody response in layer breeder males during rearing stage. Poultry science, 98(9): 3571-3577.

**Lin, H.; Decuypere, E. and Buyse, J. (2004):** Oxidative stress induced by corticosterone administration in broiler chickens (Gallus gallus domesticus): 1. Chronic exposure. Comparative Biochemistry and Physiology Part B: Biochemistry and Molecular Biology, 139(4): 737-744.

**Livak, K. J. and Schmittgen, T. D. (2001)**: Analysis of Relative Gene Expression Data Using Real-Time Quantitative PCR and the 2−ΔΔCT Method. [Methods](https://www.sciencedirect.com/science/journal/10462023), 25(4): 402–408.

**Luo, J. W.; Zhou, Z. L.; Zhang, H.; Ma, R. S. and Hou, J. F. (2013):** Bone response of broiler chickens (Gallus gallus domesticus) induced by corticosterone. Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology, 164(2): 410-416.

**Matis, G.; Kulcsar, A.; Turowski, V.; Fébel, H.; Neogrády, Z. and Huber, K. (2015):** Effects of oral butyrate application on insulin signaling in various tissues of chickens. *Domestic animal endocrinology*, *50*: 26-31.‏

**McPherron A.C.; Lawler A.M. and Lee S.J. (1997):** Regulation of skeletal muscle mass in mice by a new TGF-beta superfamily member, Nature 387: 83–90.

**Mott, I. and Ivarie, R. (2002):** Expression of myostatin is not altered in lines of poultry exhibiting myofiber hyper-and hypoplasia. *Poultry Science*, *81*(6): 799-804.‏

**Newmyer, B. A.; Nandar, W.; Webster, R. I.; Gilbert, E.; Siegel, P. B. and Cline, M. A. (2013):** Neuropeptide Y is associated with changes in appetite-associated hypothalamic nuclei but not food intake in a hypophagic avian model. Behavioural brain research, 236: 327-331.

**Ottinger, M.A.; Pitts,S. and Abdelnabi, M. A. (2001):** Steroid hormones during embryonic development of Japanese quail : plasma, gonadal and adrenal levels. Poultry science ,80: 795-799.

**Pauwels, J.; Coopman, F.; Cools, A.; Michiels, J.; Fremaut, D.; De Smet, S. and Janssens, G. P. (2015):** Selection for growth performance in broiler chickens associates with less diet flexibility. *PLoS One*, *10*(6): e0127819.

**Reyer, H.; Hawken, R.; Murani, E.; Ponsuksili, S. and Wimmers, K. (2015):** The genetics of feed conversion efficiency traits in a commercial broiler line. *Scientific reports*, *5*, 16387.‏

**Richards, M. P.; Poch, S. M. and McMurtry, J. P. (2006):** Characterization of turkey and chicken ghrelin genes, and regulation of ghrelin and ghrelin receptor mRNA levels in broiler chickens. *General and Comparative Endocrinology*, *145*(3): 298-310.‏

**Sahin, K.; Sahin, N.; Onderci, M.; Gursu, F. and Cikim, G. (2002):** Optimal dietary concentration of chromium for alleviating the effect of heat stress on growth, carcass qualities, and some serum metabolites of broiler chickens. Biological Trace Element Research, 89(1): 53-64.

**Saito, E. S.; Kaiya, H.; Tachibana, T.; Tomonaga, S.; Denbow, D. M.; Kangawa, K. and Furuse, M. (2005):** Inhibitory effect of ghrelin on food intake is mediated by the corticotropin-releasing factor system in neonatal chicks. *Regulatory peptides*, *125*(1-3): 201-208.‏

**Taniguchi, C. M.; Emanuelli, B. and Kahn, C. R. (2006):** Critical nodes in signalling pathways: insights into insulin action. Nature reviews Molecular cell biology, 7(2): 85-96.

**Tsukada, A.; Ohkubo, T.; Sakaguchi, K.; Tanaka, M.; Nakashima, K.; Hayashida, Y. and Hoshino, S. (1998):** Thyroid hormones are involved in insulin-like growth factor-I (IGF-I) production by stimulating hepatic growth hormone receptor (GHR) gene expression in the chicken. Growth Hormone & IGF Research, 8(3): 235-242.

**Xiao, Y.; Wu, C.; Li, K.; Gui, G.; Zhang, G. and Yang, H. (2017):** Association of growth rate with hormone levels and myogenic gene expression profile in broilers. *Journal of Animal Science and Biotechnology*, *8*(1); 1-7.

**Yang J.; Liu L.; Sheikhahmadi A.; Wang Y.; Li C. and Jiao H., et al. (2015)**: Effects of Corticosterone and Dietary Energy on Immune Function of Broiler Chickens. PLoS ONE 10(3): e0119750.

**Yi, J.; E. R. Gilbert; P. B. Siegel and M. A. Cline. (2015):** Fed and fasted chicks from lines divergently selected for low or high body weight have differential hypothalamic appetite associated factor mRNA expression profiles. Behav. Brain Res, 286:58–63.

**Yuan, L.; Lin, H.; Jiang, K. J.; Jiao, H. C. and Song, Z. G. (2008):** Corticosterone administration and high-energy feed results in enhanced fat accumulation and insulin resistance in broiler chickens. *British poultry science*, *49*(4): 487-495.

**Zhao, R.; Muehlbauer, E.; Decuypere, E. and Grossmann, R. (2004):** Effect of genotype–nutrition interaction on growth and somatotropic gene expression in the chicken. *General and Comparative Endocrinology*, *136*(1): 2-11.

**Zulkifli, I.; Mysahra, S. A. and Jin, L. Z. (2004):** Dietary supplementation of betaine (Betafin®) and response to high temperature stress in male broiler chickens. *Asian-australasian journal of animal sciences*, *17*(2): 244-249.

**Table 1: The ingredients composition (%) of diet of the experimental groups**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Ingredients** | **Units** | **Starter (0-10)** | | **Grower (11-22)** | | **Finisher1,2 (23-60)** | | |
| **A** | **B** | **A** | **B** | **A** | | **B** |
| **Yellow corn** | **%** | **55.24** | **56.33** | **58.17** | **64.22** | **60.40** | **63.16** | **65.69** |
| **Soybean meal (44%)** | **35.00** | **33.60** | **33.70** | **25.20** | **30.80** | **28.96** | **24.70** |
| **Corn gluten meal** | **3.00** | **3.80** | **0.40** | **3.80** | **0.70** | **--------** | **3.10** |
| **Vegetable oil** | **2.60** | **1.70** | **3.80** | **2.50** | **4.50** | **4.46** | **2.50** |
| **Dicalcium phosphate** | **1.30** | **1.50** | **1.30** | **1.30** | **1.10** | **1.00** | **1.20** |
| **Lime stone** | **1.30** | **1.30** | **1.15** | **1.20** | **1.20** | **1.15** | **1.15** |
| **L – Lysine** | **0.34** | **0.41** | **0.30** | **0.30** | **0.30** | **0.30** | **0.30** |
| **DL – Methionine** | **0.32** | **0.36** | **0.30** | **0.31** | **0.25** | **0.23** | **0.29** |
| **Vitamin &mineral premix\*** | **0.30** | **0.30** | **0.24** | **0.47** | **0.14** | **0.13** | **0.38** |
| **Sodium chloride** | **0.23** | **0.33** | **0.07** | **0.10** | **0.60** | **0.05** | **0.09** |
| **L – Threonine** | **0.10** | **0.10** | **0.31** | **0.31** | **0.31** | **0.31** | **0.31** |
| **Sodium bicarbonate** | **0.09** | **0.09** | **0.08** | **0.10** | **0.05** | **0.05** | **0.10** |
| **Anticolesterdia** | **0.05** | **0.05** | **0.05** | **0.05** | **0.05** | **0.05** | **0.05** |
| **Antimycotoxin** | **0.05** | **0.05** | **0.05** | **0.05** | **0.05** | **0.05** | **0.05** |
| **Energy enzyme** | **0.05** | **0.05** | **0.05** | **0.05** | **0.05** | **0.05** | **0.05** |
| **Anticoccedia** | **0.03** | **0.03** | **0.03** | **0.03** | **0.03** | **0.03** | **0.03** |
| **Phytase enzyme** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** |
| **Rhonzymr proact** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** |
| **Chemical composition** | | | | | | | | |
| **ME ( Kcal \ Kg diet )** | **( Kcal \ Kg diet )** | **3037.08** | **2,999.60** | **3107.80** | **3142.13** | **3181.62** | **3203.00** | **3179.22** |
| **CP** | **%** | **22.0** | **22.02** | **20.3** | **19.02** | **19.02** | **18.00** | **18.05** |
| **CF** | **5.23** | **3.52** | **2.80** | **5.34** | **3.10** | **3.12** | **5.92** |
| **Linoliec Acid** | **2.28** | **1.93** | **6.39** | **3.09** | **7.13** | **7.13** | **3.07** |
| **Lysine** | **1.32** | **1.35** | **3.53** | **2.33** | **3.37** | **3.29** | **2.60** |
| **Lysine Dig** | **1.21** | **1.24** | **1.19** | **1.20** | **1.05** | **1.00** | **1.11** |
| **Methionine** | **0.64** | **0.69** | **1.09** | **1.10** | **0.95** | **0.90** | **1.02** |
| **Methionine Dig** | **0.60** | **0.65** | **0.58** | **0.61** | **0.53** | **0.49** | **0.57** |
| **Methionine + Cystine** | **0.99** | **1.04** | **0.55** | **0.57** | **0.50** | **0.46** | **0.54** |
| **Methionine + Cystine Dig** | **0.88** | **0.93** | **0.90** | **0.92** | **0.84** | **0.79** | **0.87** |
| **Threonine** | **0.92** | **0.90** | **0.80** | **0.82** | **0.74** | **0.70** | **0.77** |
| **Threonine Dig** | **0.77** | **0.75** | **0.83** | **0.80** | **0.78** | **0.73** | **0.76** |
| **Calcium** | **0.91** | **0.95** | **0.69** | **0.67** | **0.65** | **0.61** | **0.64** |
| **Acid Base Balance** | **me / kg** | 223.76 | **217.83** | **0.84** | **0.84** | **0.81** | **0.76** | **0.81** |
| **Avalible Phosphorus** | **%** | **0.45** | **0.48** | **216.74** | **179.11** | **203.29** | **194.94** | **176.39** |
| **Chloride** | **0.17** | **0.23** | **0.44** | **0.43** | **0.40** | **0.38** | **0.40** |
| **Sodium** | **0.13** | **0.17** | **0.22** | **0.22** | **0.22** | **0.22** | **0.22** |
| **Potassium** | **0.88** | **0.86** | **0.16** | **0.16** | **0.15** | **0.15** | **0.16** |

**Table 2: Forward and Reverse primers of RT-PCR**

|  |  |  |
| --- | --- | --- |
| Gene | Primers (/5------------------/3) | |
| IGF1 | Forward | CACCTAAATCTGCACGCT |
| Reverse | CTTGTGGATGGCATGATCT |
| Myostatin | Forward | CGCTACCCGCTGACAGTGGAT |
| Reverse | CAGGTGAGTGTGCGGGTATTTCT |
| Ghrelin | Forward | CCT TGG GAC AGA AAC TGC TC |
| Reverse | CAC CAA TTT CAA AAG GAA CG |
| 18S | Forward | CGCGTGCATTTATCAGACCA |
| Reverse | ACCCGTGGTCACCATGGTA |

**Table 3: live body weights (g) of Fayoumi and Cobb Chickens (means ± SE)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Chicken Groups**  **Weeks of age** | **male Fayoumi Chicken** | **male cobb Chicken** | **female Fayoumi Chicken** | **female cobb Chicken** |
| W0 | 32.83 b ± 0.44 | 50.87 a ± 0.26 | 28.34 b ± 0.60 | 45.39 a  ± 0.59 |
| W1 | 74.49 b ± 1.22 | 167.62 a ± 1.59 | 62.73 b ± 4.00 | 134.06 a ± 1.08 |
| **W2** | 133.00 b ± 1.63 | 423.33 a ± 3.09 | 109.93 b ± 0. 74 | 376.88 a ± 2.30 |
| **W3** | 222.77 b ± 2.33 | 772.92 a ± 4.75 | 187.14 b ± 1.49 | 708.70 a ± 2.79 |
| **W4** | 325.38 b ± 1.99 | 1312.90 a ± 8.50 | 238.57 b ± 6.87 | 1131.20 a ± 12.45 |
| **W5** | 370.50 b ± 5.50 | 1529.60 a ± 22.40 | 298.00 b ± 7.05 | 1370.60 a ± 18.90 |
| **W6** | 430.70 b ± 4.80 | 1826.70 a ± 26.99 | 314.40 b ± 4.46 | 1711.90 a ± 14.17 |
| **W7** | 585.00 b ±14.58 | 2371.70 a ± 26.27 | 467.14 b ± 6.06 | 2328.80 a ± 26.45 |
| **W8** | 767.31 b ±14.76 | 2764.60 a ± 35.90 | 645.70 b ± 7.67 | 2675.60 a ± 22.60 |

Means with different superscript letters at the same row differ significantly at P<0.05

**Table 4: Average weekly weight gain (g) of Fayoumi and Cobb Chickens (means ± SE)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Chicken Group**  **Weeks of age** | **male Fayoumi Chicken** | **male cobb Chicken** | **female Fayoumi Chicken** | **female cobb Chicken** |
| W0-w1 | 41.65 b ± 1.47 | 116.67 a ± 1.54 | 37.30 b ± 1.10 | 88.67 a ± 0.54 |
| W1-w2 | 58.50 b ± 2.17 | 255.71a ± 1.68 | 44.91 b ± 0.80 | 242.81a ± 1.39 |
| **W2-w3** | 89.77 b ± 1.58 | 349.58 a ± 2.90 | 78.00 b ± 0.50 | 331.88 a ± 1.60 |
| **W3-w4** | 102.60 b ± 2.77 | 540.00 a ± 4.39 | 107.50 b ± 5.95 | 422.50 a ± 9.77 |
| **W4-w5** | 47.00 b ± 6.11 | 216.67 a ± 20.84 | 53.30 b ± 10.30 | 239.38 a ± 9.10 |
| **W5-w6** | 145.77 b ± 45.20 | 297.08 a ± 18.28 | 44.17 b ± 3.90 | 341.25 a ± 9.05 |
| **W6-w7** | 154.77 b ± 16.38 | 545.00 a ± 33.73 | 130.00 b ± 6.10 | 616.88 a ± 14.54 |
| **W7-w8** | 182.31b ± 14.16 | 392.90 a ± 27.17 | 170.80 b ± 6.70 | 346.88 a ± 39.14 |
| **W0-W8** | 734.40 b± 14.07 | 2761.60 a ± 36.00 | 617.30 b ± 7.25 | 2630.00 a ± 22.70 |

Means with different superscript letters at the same row differ significantly at P<0.05.

**Table (5): FCR of Fayoumi and Cobb Chickens (means ± SE)**

|  |  |  |
| --- | --- | --- |
| **chicken groups**  **Weeks of age** | **Fayoumi Chicken** | **Cobb Chicken** |
| W0-w1 | 3.20 a ± 0.38 | 1.10 b ± 0.04 |
| W1-w2 | 3.37 a ± 0.11 | 1.30 b ± 0.01 |
| **W2-w3** | 2.39 a ± 0.12 | 1.18 b ± 0.01 |
| **W3-w4** | 3.90 a ± 0.40 | 1.40 b ± 0.04 |
| **W4-w5** | 8.39 a ± 1.09 | 3.10 b ± 0.23 |
| **W5-w6** | 3.93 a ± 0.50 | 1.30 b ± 0.06 |
| **W6-w7** | 3.66 a ± 0.23 | 2.00 b ± 0.08 |
| **W7-w8** | 3.14 b ± 0.15 | 3.85 a ± 0.23 |
| **W0-W8** | 3.40 a ± 0.07 | 1.89 b ± 0.01 |

Means with different superscript letters at the same row differ significantly at P<0.05.

**Table (6): Feed intake (g) of Fayoumi and Cobb Chickens (means ± SE)**

|  |  |  |
| --- | --- | --- |
| **chicken groups**  **Weeks of age** | **Fayoumi Chicken** | **cobb Chicken** |
| W1 | 113.72 b ± 0.96 | 120.70 a ± 0.30 |
| **W2** | 172.50 b ± 1.50 | 333.33 a ± 0.68 |
| **W3** | 198.15 b ± 3.80 | 404.73 a ± 0.96 |
| **W4** | 263.50 b ± 1.90 | 692.58 a ± 0.85 |
| **W5** | 334.00 b ± 3.20 | 651.00 a ± 10.28 |
| **W6** | 183.60 b ± 3.20 | 378.47 a ± 3.60 |
| **W7** | 424.20 b ± 2.10 | 1034.40 a ±12.60 |
| **W8** | 559.13 b ± 2.10 | 1329.10 a ± 8.40 |

Means with different superscript letters at the same row differ significantly at P<0.05.

**Table (7): IGF1 gene expression of Fayoumi and Cobb Chickens (means ± SE)**

|  |  |  |
| --- | --- | --- |
| **Chicken groups**  **Days of age** | **Fayoumi Chicken** | **cobb Chicken** |
| **1d** | 1.1a ± 0.04 | 1.1a ± 0.02 |
| **14d** | 1.3b ± 0.09 | 2.5 a ± 0.40 |
| **28d** | 1.6 b ± 0.20 | 3.8 a ± 0.70 |
| **42d** | 3.8 a ± 1.70 | 3.3 b ± 0.67 |
| **56d** | 2.3 b ± 0.38 | 3.3 a ± 0.63 |

Means with different superscript letters at the same row differ significantly at p<0.05.

**Table (8): myostatin gene expression of Fayoumi and Cobb Chickens (means ± SE)**

|  |  |  |
| --- | --- | --- |
| **Chicken groups**  **Days of age** | **Fayoumi Chicken** | **cobb Chicken** |
| **1d** | 1.20 a ± 0.020 | 1.10 a ± 0.050 |
| **14d** | 0.90 a ± 0.010 | 0.70 b ± 0.400 |
| **28d** | 0.70 a ± 0.030 | 0.40 b ± 0.008 |
| **42d** | 0.72 a ± 0.020 | 0.20 b ± 0.007 |
| **56d** | 0.50 a ± 0.010 | 0.40 b ± 0.009 |

Means with different superscript letters at the same row differ significantly at p<0.05.

**Table 9: Ghrelin gene expression of Fayoumi and Cobb Chickens (means ± SE)**

|  |  |  |
| --- | --- | --- |
| **Chicken groups**  **Days of age** | **Fayoumi Chicken** | **cobb Chicken** |
| **1d** | 1.10 a ± 0.100 | 1.10a ± 0.03 |
| **14d** | 1.65 b ± 0.050 | 3.04 a ± 0.090 |
| **28d** | 2.17 b ± 0.040 | 5.50 a ± 0.100 |
| **42d** | 2.90 b ± 0.020 | 4.90 a ± 0.180 |
| **56d** | 2.99 b ± 0.008 | 4.10 a ± 0.120 |

Means with different superscript letters at the same row differ significantly at p<0.05.

**Table (10): Plasma levels of corticosterone hormone of fayoumi and Cobb chickens (means ± SE)**

|  |  |  |
| --- | --- | --- |
| **Chicken groups**  **Days of age** | **Fayoumi Chicken** | **cobb Chicken** |
| **1d** | 13.04 a ± 1.4 | 4.56 b ± 0.57 |
| **14d** | 19.87 a ± 0.00 | 8.21  b ± 0.77 |
| **28d** | 19.56 a ± 0.00 | 5.80  b ± 0.81 |
| **42d** | 20.23 a ± 0.00 | 9.41  b ± 1.14 |
| **56d** | 40.65 a ± 0.00 | 12.65  b ± 0.84 |

Means with different superscript letters at the same row differ significantly at p<0.05.

**Table 11: Plasma levels of T3 hormone of Fayoumi and Cobb chickens (means ± SE)**

|  |  |  |
| --- | --- | --- |
| **Chicken groups**  **Days of age** | **Fayoumi Chicken** | **cobb Chicken** |
| **1d** | 29.46 a ± 3.59 | 16.98 b ± 2.04 |
| **14d** | 47.20 a ± 3.40 | 28.52 b ± 2.37 |
| **28d** | 78.63 a ± 7.37 | 30.71 b ± 1.04 |
| **42d** | 80.45 a ± 6.82 | 46.97 b ± 3.63 |
| **56d** | 61.84a ± 2.03 | 36.77 b ± 2.40 |

Means with different superscript letters at the same row differ significantly at p<0.05.

**Table (12): Plasma levels of T4 hormone of Fayoumi and Cobb chickens (means ± SE)**

|  |  |  |
| --- | --- | --- |
| **Chicken groups**  **Days of age** | **Fayoumi Chicken** | **cobb Chicken** |
| **1d** | 0.60 a ± 0.06 | 0.28 b ± 0.02 |
| **14d** | 1.37 a ± 0.30 | 0.69 a ± 0.11 |
| **28d** | 0.88 a ± 0.03 | 0.33 b ± 0.04 |
| **42d** | 1.70 a ± 0.27 | 0.83 b ± 0.05 |
| **56d** | 1.91 a ± 0.13 | 1.31 a ± 0.23 |

Means with different superscript letters at the same row differ significantly at p<0.05.

**Table 13: Plasma levels of insulin hormone of Fayoumi and Cobb chickens (means ± SE):**

|  |  |  |
| --- | --- | --- |
| **Chicken groups**  **Days of age** | **Fayoumi Chicken** | **cobb Chicken** |
| **1d** | 9.07 b ± 1.21 | 16.91 a ± 1.75 |
| **14d** | 13.84 b ±1.39 | 22.93 a ±1.99 |
| **28d** | 14.26 b ± 2.00 | 24.53 a ± 1.95 |
| **42d** | 7.43 b ± 0.82 | 15.06 a ± 1.17 |
| **56d** | 6.60 b ± 0.70 | 16.38 a ± 0.75 |

Means with different superscript letters at the same row differ significantly at p<0.05.

**Figure 1: Graphical presentation of real-time quantitative PCR analysis of the expression of IGF1 gene in muscular tissues of Cobb and Fayoumi chicken**

**Figure 2: Graphical presentation of real-time quantitative PCR analysis of the expression of myostatin gene in muscular tissues of Cobb and Fayoumi chicken**

**Figure 3: Graphical presentation of real-time quantitative PCR analysis of the expression of ghrelin gene in proventriculus of Cobb and Fayoumi chicken**

**Figure 4: Graphical presentation of corticosterone concentration of Cobb and Fayoumi chicken**

**Figure 5: Graphical presentation of T3 concentration of Cobb and Fayoumi chicken**

**Figure 6: Graphical presentation of T4 concentration of Cobb and Fayoumi chicken**

**Figure 7: Graphical presentation of insulin concentration of Cobb and Fayoumi chicken**