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Research Paper

Rasooli R, Sheibani H, Kheirandish R and Rohollahzadeh H (2018). Hepatoprotective Effects of Cichorium Intybus against Paracetamol Induced Hepatotoxicity in Broiler. *J. World Poult. Res.*, 8(2): 25-30.

Hepatoprotective Effects of Cichorium Intybus against Paracetamol Induced Hepatotoxicity in Broiler.

Rasooli R, Sheibani H, Kheirandish R and Rohollahzadeh H.

J. World Poult. Res. 8(2): 25-30, 2018; pii: S2322455X1800003-8

ABSTRACT
Hepatic damage in poultry occurs either due to metabolic or nutritional disturbances or chemical intoxication. The absence of reliable liver protective drugs and also consumption of broiler meat, limit us in usage of chemical hepatoprotective agents. The aim of this study is to evaluate the protective effects of CichoriumIntybus (CI) extract in paracetamol-induced hepatotoxicity in broiler chicks. One-day-old Ross chicken broilers were divided into four groups. One group was kept as normal and liver damage were induced in other 3 groups by oral administration of 1 ml/kg body weight of paracetamol for four successive days. Of 3 intoxicated groups one was kept as control and two different medicinal plants extracts were administered 0.2 g/kg of CI and 0.4 g/kg of CI extract. The medicinal plant was administered orally for 14 days after paracetamol administration. Then the blood samples were collected and the chicks sacrificed to histopathological examination. Serum liver markers and histopathological assessment of the livers revealed that Cichoriumintybus has protective activity against hepatic damage specially at a dose of 0.4 g/kg body weight and exhibited anti-hepatotoxic activity in broilers. The present study showed that administration of Cichoriumintybus extract at the doses of 0.2 g/kg/day and 0.4 g/kg/day respectively to Paracetamol intoxicated broilers, mitigates liver toxicity and liver histopathological changes.

Keywords: Cichoriumintybus, Hepatotoxicity, Paracetamol, Broiler.

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Research Paper

Growth Performance and Carcass Quality of Broiler Chickens Fed Dried Pawpaw (*Carica Papaya Linn*) Latex.

Haruna MA and Odunsi AA.

J. World Poult. Res. 8(2): 31-36, 2018; pii: S2322455X1800004-8

ABSTRACT
This study is aimed to evaluate the effect of latex of pawpaw (*Carica papaya Linn*) as a feed additive and crude enzyme complex on growth performance, cell-mediated immunity, carcass and organ measurements of broiler chicken. Four experimental diets each were formulated during the starter (1-28d) and finisher (29-49d) phases such that the basal diets were supplemented with 0, 0.1, 0.15 and 0.2% Pawpaw Latex (PL). A total of 120 day-old Arbor Acre chicks were randomly allocated to the four dietary treatments comprising of three replicates each in a completely randomized design. Performance parameters measured include Daily Feed Intake (DFI) and Daily Weight Gain (DWG) while Feed to Gain Ratio (FGR) and Protein Efficiency Ratio (PER) were estimated. At day 49, twelve birds per treatment were randomly selected for slaughter in order to measure carcass cut-up parts (thigh, breast, neck, wing, back, drumstick and abdominal fat), and selected organs were weighed and expressed relative to live weight. The immunity index was also evaluated. Data collected were subjected to one-way analysis of variance and treatment means separated using Duncan Multiple Range Test. PL contained 54.9% crude protein, 6.28% ether extract, 4.65% crude fibre, 5.5% ash and 18.79% nitrogen free extracts. At the starter phase, there was a general decline in DFI, DWG and FGR as levels of PL increased. Between days 28-49, broilers on 0.1%PL had comparable DWG, FGR, PER and carcass yield with those fed PL-free diet. Hypertrophy of gizzard, liver and intestines were recorded with increase in level of PL. Generally, dietary inclusion of pawpaw latex decreased growth performance but maintained carcass yield, improved immune response and survivability of broiler chickens.

Keywords: Carcass, Carica papaya, Immunity, Papain, Performance, Poultry.

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Research Paper

The Effect of Early Setting inside Single Stage Incubator on Stored Eggs.

Jabbar A, Riaz A and Allah Ditta Y.

J. World Poult. Res. 8(2): 37-43, 0218; pii: S2322455X1800005-8

ABSTRACT
Eggs weight loss during storage has been documented well due to water loss. The single stage incubators are designed to use egg water loss as humidity source during incubation. In this experiment one week old eggs (n=430840) were collected in Salman hatchery, Pakistan and divided into two groups, group A was (eggs n=215420) immediately shifted to incubators before 10 hours of incubation to avoid further weight loss) and eggs from group B (n=215420) was stored in eggs room at 23.80 C and 65% humidity with 2cfm/1000 eggs ventilation for 10 hours. After 10 hours of storage both groups were pre-heated at 80 0F for 5 hours leading to incubation conditions. Hatchability % (84.502±2.9221, 84.217±3.0279) candling% (6.5418±0.5605, 6.7682±0.5705) dead in shell% (6.5418±2.3112, 6.7682±2.3702) and hatch window (hours) (22-24±0.142, 26-28±0.1324) were significantly better for A compare to B respectively, Water loss% (11.556±0.1399, 11.545±0.1486), chick yield% (68.835±0.0926, 68.818±0.0928) and chick waste (gram) (19.67±1.721, 19.69±1.7653) were insignificant due to same incubation conditions inside incubator. The water loss from eggs of group A retained inside incubator have an impact on embryonic mortality including the duration of first and the last chick that hatches out. So, the deleterious effects of storage can be avoided by shifting the eggs inside a single stage incubator before 10 hours of incubation including pre-heating.

Keywords: Water loss, Egg storage, Single stage incubator, Candling, Dead in shell, Hatch window.

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Research Paper

Effect of Technological Intervention on the Economics of Vanaraja Chicken Rearing in West Siang District of Arunachal Pradesh, India.

Baruah MS, Raghav ChS and Kalita H (2018). Effect of Technological Intervention on the Economics of *Vanaraja* Chicken Rearing in West Siang District of Arunachal Pradesh, India. *J. World Poult. Res.*, 8 (2): 44-49.

Baruah MS, Raghav ChS and Kalita H.

J. World Poult. Res. 8(2): 44-49, 2018; pii: S2322455X1800006-8

ABSTRACT
The present investigation was conducted to evaluate the comparative economics of two methods of Vanaraja chicken rearing under backyard system i.e. improved technologies demonstrated under Front Line Demonstration (FLD) and Farmer's Practice (FP) traditionally adopted by the farmers. All together 120 farmers from 12 randomly selected villages of West Siang district of Arunachal Pradesh having experience of poultry rearing for more than two years were selected for FLD. The study (from August, 2015 to July, 2017) reveals that, the technologies demonstrated in FLDs recorded higher body weight gain of male chickens (2300g) over FP (1800g) at 20 weeks of age, which was 27.78% higher than that of Farmers' Practice. Mean annual egg production under FLD was recorded as 110 numbers which was 37.50% higher than that of FP (80). The estimated technology gap in body weight gain was recorded as 200 g/bird, whereas for egg production it was 20 numbers/bird. The extension gap of body weight gains and egg production was recorded as 500 g/bird and 30 numbers/bird, respectively with a technology index of 8% in body weight gain and 15.38% in egg production. The benefit cost (B: C) ratio for Vanaraja chicken rearing under FLD and Farmers' Practice was recorded as 2.62:1 and 1.71:1, respectively which indicated that under improved rearing techniques demonstrated under FLD Vanaraja chicken gives much more profit than that of rearing techniques under FP. Non availability of improved germplasm of poultry (93.33%) was given the top ranking while weak market linkage to dispose the produce (35.00%) was given as bottom ranking in the constraints matrix ranking in poultry production. Under client satisfaction index over the performance of FLD analysis reveals 63.33% of high satisfaction index over the performance of FLDs while 27.50% respondent expressed medium level of satisfaction and only 9.17% respondent expressed low level of satisfaction index.

Keywords: Backyard poultry, Front line demonstration, Vanaraja, Benefit cost ratio.

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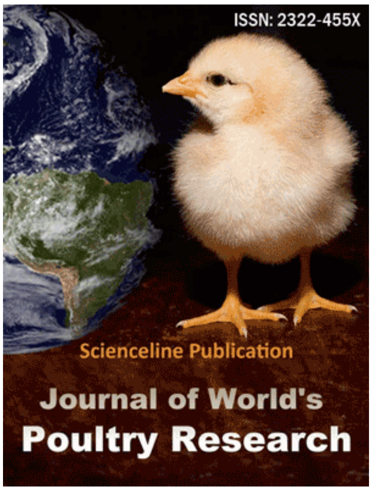

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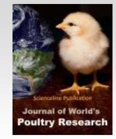

Hepatoprotective Effects of Cichorium Intybus against Paracetamol Induced Hepatotoxicity in Broiler

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ABSTRACT

Hepatic damage in poultry occurs either due to metabolic or nutritional disturbances or chemical intoxication. The absence of reliable liver protective drugs and also consumption of broiler meat, limit us in usage of chemical hepatoprotective agents. The aim of this study is to evaluate the protective effects of CichoriumIntybus (CI) extract in paracetamol-induced hepatotoxicity in broiler chicks. One-day-old Ross chicken broilers were divided into four groups. One group was kept as normal and liver damage were induced in other 3 groups by oral administration of 1 ml/kg body weight of paracetamol for four successive days. Of 3 intoxicated groups one was kept as control and two different medicinal plants extracts were administered 0.2 g/kg of CI and 0.4 g/kg of CI extract. The medicinal plant was administered orally for 14 days after paracetamol administration. Then the blood samples were collected and the chicks sacrificed to histopathological examination. Serum liver markers and histopathological assessment of the livers revealed that Cichoriumintybus has protective activity against hepatic damage specially at a dose of 0.4 g/kg body weight and exhibited anti-hepatotoxic activity in broilers. The present study showed that administration of Cichoriumintybus extract at the doses of 0.2 g/kg/day and 0.4 g/kg/day respectively to Paracetamol intoxicated broilers, mitigates liver toxicity and liver histopathological changes.

Keywords: Cichoriumintybus, Hepatotoxicity, Paracetamol, Broiler.

INTRODUCTION

Nature has bestowed mankind with several plants which contains natural substances which cure diseases & promote health. Due to the limited prevention and treatment options, liver diseases are considered to be one of the most serious health problems in humans and animals. Liver an important organ actively involved in many metabolic functions, the frequent target for a number of toxicants (Jadeja et al., 2017; Meyer and Kulkarni, 2001). Hepatic damage in poultry may occur either due to metabolic or nutritional disturbances or chemical intoxication (Murugesan et al., 2015). Exposure of the liver to the free radicals derived from some xenobiotics and drugs leads to oxidative stress, which is recognized to be an important factor responsible for liver injury or be involved in the pathogenesis of liver disorders (Aseervatham et al., 2018).

In one hand, the absence of reliable liver protective drugs and in the other hand consumption of broiler meat, limit us in usage of chemical hepatoprotective agents. Therefore, herbal therapy seems to be the only logical remedy for liver diseases. A number of plants have shown hepatoprotective effect in Iranian folk medicine (Asadi-Samani et al., 2015). Hepato-protective effect of some plants such as Epaltesdivaricate (Hewawasam et al., 2004), Aspalathuslinearis (Ulicna et al., 2003), Crassoceplalumcrepidioides (Aniya et al., 2005), Sarcostemmabrevistigma (Singh et al., 2003) and Cichoriumintybushas been well established. Cichoriumintybus is referred to as “kasani” in India and “kasni” in Iran. In some states of Iran the leaves of Cichoriumintybus have been used in drinks and in some other regions for the treatment of liver disorders.

Cichoriumintybus is considered to be folk medicines used for the treatment of liver diseases (Street et al., 2013), and its potent hepatoprotective activity related to antioxidant capacity was demonstrated in previous studies (Casas-Grajales and Muriel, 2015; Gilani et al., 1998; Madani et al., 2008). Esculentin, a compound present in Cichoriumintybus has been observed for its protective effects liver damage (Li et al., 2014). To our knowledge there is no published data on the hepatoprotective effect of Cichoriumintybus in broilers. Considering the fact that the initial event in paracetamol-induced hepatotoxicity is a toxic-metabolic injury that leads to hepatocyte death by necrosis. The aim of this study was to evaluate the protective effects of Cichoriumintybus extract in paracetamol-induced hepatotoxicity in broiler chicks.

MATERIALS AND METHODS

Ethical approval

All experiments in this study were performed in accordance with the guidelines for animal research from the School of Veterinary Medicine, Kerman University, Kerman, Iran. Also, we used the recommendations of European Council Directive (2010/63/EU).

Plants material

The aerial parts of Cichoriumintybus were collected from the local market, dried in room temperature and were powdered. The leaf extract of CI was prepared according to the method of Sadeghi et al (Sadeghi and Yazdanparast, 2003). The therapeutic doses of the extract selected were 0.2 g/kg and 0.4 g/kg b.w (Fallah Huseini et al., 2011).

Experimental protocol

A total of 48 one-day-old Ross chicken broilers were used in this experiment. They were divided into four groups of 12 animals each. One group was kept as normal and liver damage were induced in other 3 groups by oral administration of 1 ml/kg body weight of Paracetamol for four successive days. Of 3 intoxicated groups one was kept as control and two different medicinal plants extracts wereadministered0.2 g/kg of CI and 0.4 g/kg of CI extract. The medicinal plant was administered orally for 14 days after Paracetamol administration.

Serum biochemical and histopathology study

After liver intoxication and medicinal plants extracts treatment, the blood samples were collected and the chicks sacrificed. The serum liver enzymes such as alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphates (ALP) and total protein were estimated in all groups. The liver tissues were collected and fixed in 10% neutral buffered formalin for histopathological examination. After fixation, the tissue samples were washed, dehydrated by graded ethanol, cleared, embedded in paraffin wax, sectioned at 4-5 µm, stained with haematoxylin and eosin and examined by a light microscope (Olympus, Japan).

Statistical analysis

All the collected data thus obtained was statistically evaluated by ANOVA using SPSS. $P<0.05$ was considered as significant value. All the results were expressed in mean ± Standard Deviation (SD).

RESULTS

Serum liver enzymes

In control group, a significant decrease in Total Protein (TP) levels and increasing in ALT, AST and ALP concentration were recorded after paracetamol administrations compared to the normal group. These disturbances clearly demonstrate the occurrence of hepatic damage. In 0.2 g/kg of CI and 0.4 g/kg of CI extract received groups, the serum ALT, AST and ALP levels were significantly reduced as compared to the control group.

Besides elevation of TP in these treated groups observed. The dose 0.4 g/kg b.w. was proved more effective in its hepatoprotective action as evidenced by remarkable reduction in liver enzymes and increase in TP levels. The statistical results are shown in Table 1.

Histopathological results

Histopathological photomicrographs of liver sections of the chicks treated with paracetamol showed focal necrosis, sever fatty degeneration, and bile pigment retention (Figures 1A, 1B and 1C). Necrosis, which is a more severe form of injury, was markedly prevented by pretreatment with both 0.2 and 0.4 g/kg doses of the CI extract (Figures 1D and 1E).

Table 1. Effects of Cichorium Intybus on biochemical parameters of serum sample collected from broilers with hepatotoxicity at the end of experiment (62 days old)

Enzymes	Group A	Group B	Group C (P+CI 0.2 g/kg)	Group D (P+CI 0.4 g/kg)
ALT (u/l)	(normal)	(Control)	49.1± 0.58**	44.4 ± 1.96**
AST (u/l)	27.1± 0.64	68.2± 1.14*	164.3±7.12**	137.0±1.04**
ALP (u/l)	115.7±5.02	188.6±4.95 *	68.8±4.5	43.6±2.9**
Total protein (g/dL)	31.5±1.9	77.1±2.6*	3.48±0.31**	3.94±0.44**

*Significant level (P<0.05) when compared with group A, ** Significant level (P<0.05) when compared with group B.

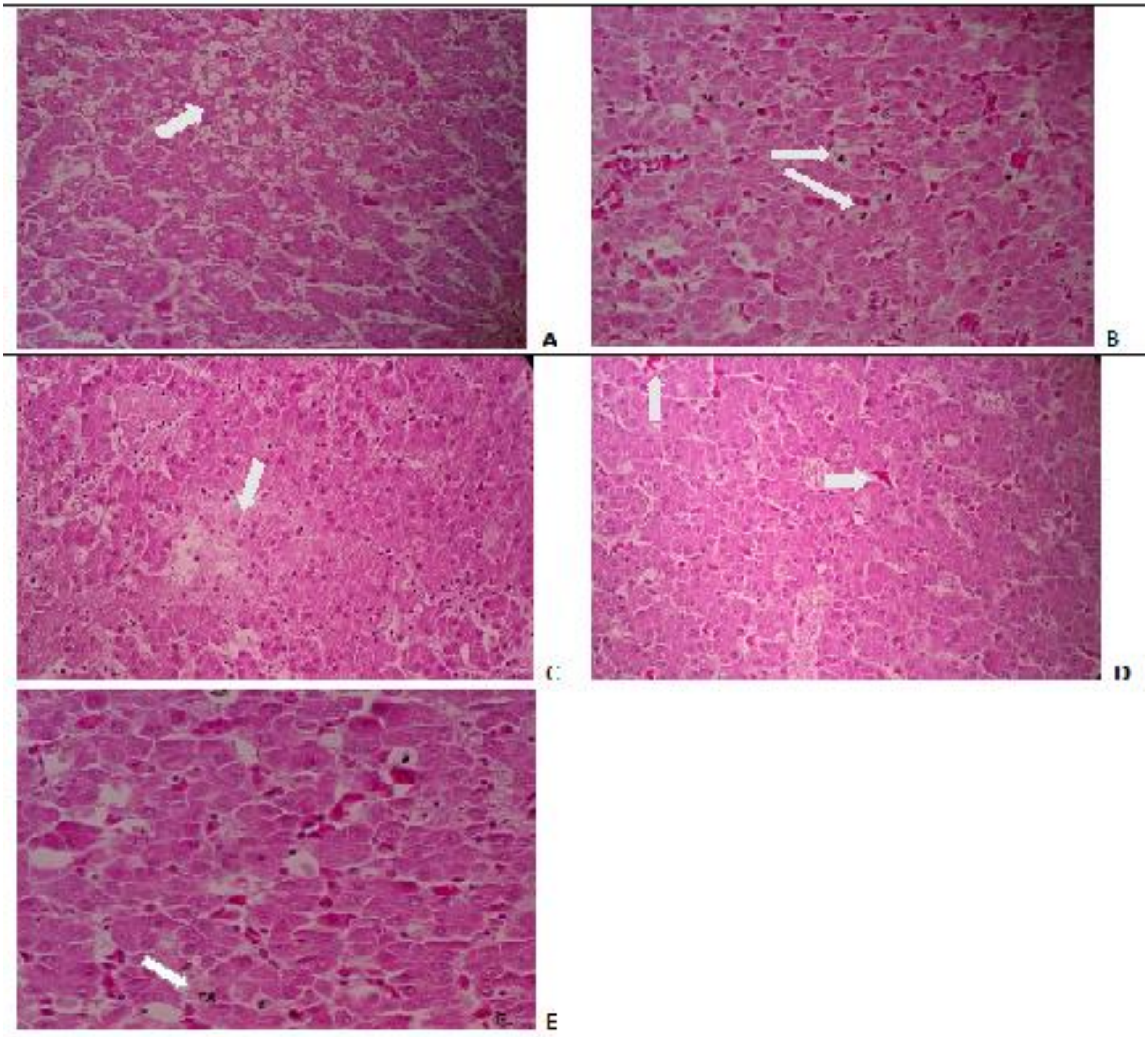

Figure 1. Hepatoprotective effect of CichoriumIntybus in hepatotoxicity of broiler (H&E). A: sever fatty degeneration in paracetamoltoxicated group; B: bile pigment retention in paracetamoltoxicated group; C: focal necrosis in paracetamoltoxicated group; D: congestion in 0.4 g/kg CI treated group; E: mild bile pigment retention in 0.2 g/kg CI treated group

DISCUSSION

Paracetamol (Acetaminophen), a commonly used analgesic, is considered safe at therapeutic doses. However, an overdose can leads to severe hepatotoxicity and necrosis in both humans and experimental animals (Yoon et al., 2016; Elmhdwi et al., 2014). Paracetamol at therapeutic levels, is primarily metabolized by liver through glucuronidation and sulphation; however, a small proportion undergoes cytochrome P450 (CYP450)-mediated bioactivation to N-acetyl-p-benzoquinoimine (NAPQI), which is rapidly quenched by glutathione (GSH) (James et al., 2003). After an overdose of paracetamol, elevated levels of the toxic NAPQI metabolite are generated, and deplete hepatocellular GSH and resulting in hepatocyte death (Tiwari and Khosa, 2010). Although the exact mechanism of cell necrosis is not fully understood, it is generally attributed to lipid peroxidation and oxidative stress (Muriel and Gordillo, 2016).

In the present study, Paracetamol administration to broilers induced hepatic tissue injury as well as significantly changed TP and serum liver enzymes level. Extracts treatment to Paracetamol intoxicated chicks attenuated the liver toxicity as indicated by serum liver enzymes level lowering effect, elevated TP and amelioration in histopathological changes in the liver tissue.

A significant rise in levels of AST, ALT and ALP were observed in hepatotoxicity induced group with paracetamol. This finding is in agreement with the research work reported previously (Hamza and Al-Harbi, 2015; Rajesh et al., 2009) where is observed high AST, ALT and ALP levels after Paracetamol administration. The present results are also similar to the findings of Schmidt and Dalhoff (2002) who reported that administration of Paracetamol can increase the liver enzymes (AST, ALT and ALP) and decrease total protein due to induction of hepatic oxidative stress (Li et al., 2015). The treatment with Cichoriumintybus at doses, 0.2 and 0.4 g/kg b.w. resulted in significant decrease in serum AST, ALT and ALP levels and rise in TP levels which clearly depicts its hepatoprotective action. These findings are in agreement with the findings of Kiran (Butt et al., 2012) who described that Esculetin, a phenolic compound found in Cichoriumintybus has possible protective effects against Paracetamol-induced hepatic damage in rats. Another study demonstrated the hepatoprotective effect of alcoholic extract of Cichoriumintybus (Elgengaihi et al., 2016; Naseem et al., 2009). The results presented also was similar to the study of Jamshidzadeh et al. (2010) that proved the pre incubation of hepatocytes with concentrations between 60 to 600 µg/ml of the Chicory extract for 20 minutes protected hepatocytes against CCl4 -induced cytotoxicity. The protective effect of the Chicory extract in this study was dose-dependent protective effect against CCl4 induced cytotoxicity. It could be due to the presence of Flavonoids and their antioxidant effects (Abbas et al., 2015). In the present study the effective therapeutic dose of Cichoriumintybus for lowering paracetamol induced hepatotoxicity was found 0.4 g/kg as its administration exhibited better reduction in raised AST, ALT and ALP levels while elevation in decreased TP levels.

CONCLUSION

The present findings indicated that, the administration of Cichoriumintybus extract at the doses of 0.2 g/kg/day and 0.4 g/kg/day respectively to Paracetamol intoxicated chicks, mitigates liver toxicity and liver histopathological changes. Further studies are required to evaluate the fractionated extract on hepatotoxicity.

DECLARATIONS

Authors' contributions

R.R., H.Sh., R.Kh. contributed to the conception, design and interpretation of data. H.R. was also involved in the collection of data, statistical analysis and drafting of the manuscript. All authors read and approved the final manuscript.

Acknowledgments

This research was financially supported by grants of Kerman University Research Council.

Competing interests

The authors declare that there is no conflict of interest. This research was financially supported by grants of Kerman University Research Council. All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

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Growth Performance and Carcass Quality of Broiler Chickens Fed Dried Pawpaw (*Carica Papaya Linn*) Latex

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ABSTRACT

This study is aimed to evaluate the effect of latex of pawpaw (*Carica papaya Linn*) as a feed additive and crude enzyme complex on growth performance, cell-mediated immunity, carcass and organ measurements of broiler chicken. Four experimental diets each were formulated during the starter (1-28d) and finisher (29-49d) phases such that the basal diets were supplemented with 0, 0.1, 0.15 and 0.2% Pawpaw Latex (PL). A total of 120 day-old Arbor Acre chicks were randomly allocated to the four dietary treatments comprising of three replicates each in a completely randomized design. Performance parameters measured include Daily Feed Intake (DFI) and Daily Weight Gain (DWG) while Feed to Gain Ratio (FGR) and Protein Efficiency Ratio (PER) were estimated. At day 49, twelve birds per treatment were randomly selected for slaughter in order to measure carcass cut-up parts (thigh, breast, neck, wing, back, drumstick and abdominal fat), and selected organs were weighed and expressed relative to live weight. The immunity index was also evaluated. Data collected were subjected to one-way analysis of variance and treatment means separated using Duncan Multiple Range Test. PL contained 54.9% crude protein, 6.28% ether extract, 4.65% crude fibre, 5.5% ash and 18.79% nitrogen free extracts. At the starter phase, there was a general decline in DFI, DWG and FGR as levels of PL increased. Between days 28-49, broilers on 0.1%PL had comparable DWG, FGR, PER and carcass yield with those fed PL-free diet. Hypertrophy of gizzard, liver and intestines were recorded with increase in level of PL. Generally, dietary inclusion of pawpaw latex decreased growth performance but maintained carcass yield, improved immune response and survivability of broiler chickens.

Keywords: Carcass, Carica papaya, Immunity, Papain, Performance, Poultry

INTRODUCTION

Carica papaya Linn (Pawpaw) is an invaluable plant that is prevalent throughout tropical Africa. It belongs to the family Caricaceae. Nigeria is the sixth largest producer of pawpaw globally, and the level of production has been estimated to be 836, 702 metric tonnes, after India, Brazil, Mexico, Indonesia, Dominican Republic (FAO, 2016; Pariona, 2017). The different parts of the pawpaw plant including leaves, seeds, and fruit have been shown to have excellent nutritional and medicinal values (Krishna et al., 2008; Afolabi et al 2011; Pradeep et al., 2014). Pawpaw latex that is obtained from the skin of unripe pawpaw fruitcontains proteolytic enzymes, papain and chymopapain; mixture of cysteine endopeptidases, glutamine cyclotransferase, chitinases, peptidase A and B, lysozymes and an inhibitor of serine protease (Pendzhiew, 2002; Dominguez et al., 2006; Arvind et al 2013). The latex is sometimes referred to as crude papain because papain production relies solely on it (Dubey et al, 2007; Macalood et al, 2013). Crude papain is of crucial importance in many vital biological processes in living organisms (Tsuge et al., 1999) and it is an enzyme of industrial use and of high research interest (Brocklehurst et al., 1981; Mellor et al, 1993; Thomas, 1994). Among the major applications of crude papain or latex are its use in the food industry (Neidlema, 1991), beer clarification (Caygill, 1979), meat tenderizing and preparation of protein hydrolysates (Dupaigne, 1973).

Nutritionally, pawpaw latex (papain) was found to increase body weight and egg production in layer chickens (Lien and Wu, 2012; Battaa et al., 2015); reduce the effect of heat stress in rabbits (El-Kholly, 2008), expand the use of soybean meal and acted as a growth promoter in the diets of weaned piglets (Singh et al, 2011; Baoming et al, 2012). This preliminary study therefore evaluates the inclusion levels of crude pawpaw latex as a feed additive and an enzyme supplement in the diets of broiler chickens. Growth performance, cell-mediated immunity and carcass characteristics were the measures of response.

MATERIALS AND METHODS

Experimental site

The study was carried out at the Poultry Unit of Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, Nigeria. Ogbomoso is located in the derived savannah that lies on longitude 4^0 10^1 East of Greenwich meridian and Latitude 8^0 10^1 North of the equator. The altitude is between 300m and 600m above sea level while the mean temperature and annual rainfalls are 27^0C and 1247mm, respectively as cited by Ayinla (2012).

Collection of pawpaw latex

Pawpaw latex (PL) also referred to as crude papain (Macalood et al., 2013) was obtained from fruits of pawpaw plants growing on the LAUTECH Teaching and Research farms plots. Three to four incisions (about 2 mm deep) were made on the epidermal layer (testa) of the unripe fruits during the early morning hours using clean razor blades. The fruits were tapped at intervals of 4-7 days into plastic containers. Daily collections of latex were subjected to sun drying within the temperature range of 30-40°C for 6-8 hours to obtain bristled particle matter. After drying, they were grounded in a Q link blender into powdered form. Samples of the dried pawpaw latex were analysed for proximate contents (AOAC, 2007) and remainder stored in airtight and light proof containers and kept in the refrigerator prior to use.

Experimental diets, birds and management

Four diets were formulated such that the control was maize – soybean meal basal diet without PL. Three other diets based on the control were thereafter formulated to contain 0.1%PL, 0.15%PL and 0.2%PL at the starter and finisher phases as shown in Tables 1 and 2 respectively. The diets were analysed for proximate composition (AOAC, 2007). The analysed crude protein and calculated metabolizable energy of the diets ranged from (22.68 – 22.93%) and (3054.87 – 3102.21 kcal/kg) for starter diets and (19.20 – 20.42%), (3061.69 – 3215.19 kcal/kg) for finisher diets, respectively. One hundred and twenty day-old Arbor acre broiler chicks were randomly allotted into the four dietary treatments of 3 replicates each. Each replicate had 10 birds to make a total of 30 birds per treatment in a Completely Randomized Design (CRD). On arrival, the birds were offered anti-stress and brooded for 2 weeks. Feed and fresh water were offered *ad-libitum* on a daily basis throughout the experiment, which lasted forty-nine days. Broiler starter diets were offered from 1-28 days while broiler finisher diets were fed from 29–49 days. Routine medications and vaccinations were strictly adhered to.

Data measurements

Growth performance. Data were collected daily on feed intake (DFI) and body weight gain (BWG) while feed to gain ratio (FGR) and protein efficiency ratio (PER) were computed using an appropriate formula.

Cell mediated immunity. The cell-mediated immunity was determined according to the formula of Fu-Chang et al. (2004) as follows:

$$\text{Spleen Index} = \frac{\text{Spleen weight}}{\text{Body weight}}$$

$$\text{Bursa index} = \frac{\text{Bursa weight}}{\text{Body weight}}$$

Carcass and organ evaluation

At day 49, 4 birds per replicate of similar body weights close to the average body weight of each replicate were slaughtered, properly bled by hanging them by their legs and scalded in water at temperature of 60°C. After de-feathering, they were eviscerated and dressed to get the dressed carcass weight. The weights of the cut-up parts (thigh, breast, neck, wing, back and drumstick), organs (heart, kidney, lungs, liver, spleen and gizzard), intestines and the abdominal fat pads were recorded and expressed as a percentage of live weight.

Ethical approval

This study was carried out in strict accordance with the recommendations of institutional guidelines for the care and use of laboratory animals. Chickens were humanely handled in respect of the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Statistical analysis

The data collected were subjected to one-way analysis of variance using the General Linear Model procedure of SAS (2012) to determine treatment effects. Significant mean differences were determined using Duncan Multiple Range Test of the same package. The experimental model was:

$$Y_{ij} = \mu + T_i + \epsilon_{ij}$$

Where:

Y_{ij} = Observed value of the dependent variable
μ = Population mean
T_i = Effect of treatment
ϵ_{ij} = Experimental error assumed to be evenly distributed.

Table 1. Gross composition of starter diets (day 1- 28) (dry matter %)

Ingredients (%)	Control	0.1%PL	0.15%PL	0.2%PL
Maize	52.1	52.1	52.1	52.1
Soya bean meal	27.0	27.0	27.0	27.0
Groundnut cake	8.00	8.00	8.00	8.00
Wheat offal	5.00	4.90	4.85	4.80
Fishmeal (72%)	3.00	3.00	3.00	3.00
Dicalcium phosphate	3.00	3.00	3.00	3.00
Oyster shell	1.00	1.00	1.00	1.00
Lysine	0.20	0.20	0.20	0.20
Methionine	0.25	0.25	0.25	0.25
Broiler premix*	0.25	0.25	0.25	0.25
Salt	0.20	0.20	0.20	0.20
Pawpaw latex	-	0.10	0.15	0.20
Total	100	100	100	100
Analyzed composition (%)				
Crude protein	22.7	22.9	22.8	22.7
Ether extract	3.25	3.41	3.28	3.28
Crude fibre	3.00	3.40	4.11	3.32
Ash	8.00	7.10	7.20	7.34
Dry matter	92.5	91.6	92.1	92.8
Nitrogen free extract	55.5	54.8	54.7	56.2
ME (kcal/kg)**	3077.8	3071.7	3054.9	3102.2

[1] Premix supplied/kg diet: Vitamin A (15,000 I.U.), Vitamin D3 (3,000 I.U), Vitamin E (20 I.U.), Vitamin K (25 mg), Thiamin (2 mg), Riboflavin (6 mg), Pyridoxine (4 mg), Niacin (40 mg), Cobalamin (0.02 mg), Pantothenic acid (910 mg), Folic acid (1.0 mg), Biotin (0.08 mg), Choline Chloride (0.05 g), Manganese (0.096 g), Zinc (0.06 g), Iron (0.024 g), Copper (0.006 g), Iodine (0.004 g), Selenium (0.024 g), Cobalt (0.02 mg), Antioxidant (0.125 g), PL = Pawpaw Latex, [2]Calculated Metabolizable energy

Table 2. Gross composition of finisher diets (day 29 – 49) (dry matter %)

Ingredients (%)	Control	0.1%PL	0.15%PL	0.2%PL
Maize	57.0	57.0	57.0	57.0
Soya bean meal	23.0	23.0	23.0	23.0
Groundnut cake	4.00	4.00	4.00	4.00
Wheat offal	8.60	8.50	8.45	8.40
Fishmeal (72%)	2.50	2.50	2.50	2.50
Dicalcium Phosphate	3.00	3.00	3.00	3.00
Oyster shell	1.00	1.00	1.00	1.00
Lysine	0.20	0.20	0.20	0.20
Methionine	0.25	0.25	0.25	0.25
Broiler Premix*	0.25	0.25	0.25	0.25
Salt	0.20	0.20	0.20	0.20
Pawpaw Latex	-	0.10	0.15	0.20
Total	100	100	100	100
Analyzed compositions (%)				
Crude protein	20.4	19.9	20.3	19.2
Ether extract	4.51	6.60	6.80	6.73
Crude fibre	5.00	4.60	4.60	5.00
Ash	8.00	6.30	7.00	5.00
Dry matter	92.5	92.0	91.6	90.9
Nitrogen free extract	54.6	54.6	52.9	55.0
Metabolizable energy (kcal/kg)**	3061.7	3215.2	3184.9	3213.4

[1]Premix supplied/kg diet: Vitamin A (15,000 I.U.), Vitamin D3 (3,000 I.U), Vitamin E (20 I.U.), Vitamin K (25 mg), Thiamin (2 mg), Riboflavin (6 mg), Pyridoxine (4 mg), Niacin (40 mg), Cobalamin (0.02 mg), Pantothenic acid (910 mg), Folic acid (1.0 mg), Biotin (0.08 mg), Choline Chloride (0.05 g), Manganese (0.096 g), Zinc (0.06 g), Iron (0.024 g), Copper (0.006 g), Iodine (0.004 g), Selenium (0.024 g), Cobalt (0.02 mg), Antioxidant (0.125 g), PL = Pawpaw Latex. [2]Calculated Metabolizable Energy

RESULTS AND DISCUSSION

Proximate composition of pawpaw latex

The proximate content of PL has been presented in Table 3. The determined crude protein, ash and moisture contents were lower than the values obtained by Macalood et al. (2013) and Battaa et al. (2015) while crude fat and crude fibre were higher. Macalood et al. (2013) and Battaa et al. (2015) recorded crude protein values of 57.24% or 62.0%respectively compared to 54.9% recorded in our laboratory. The variations might be due to pawpaw varietal effects, fruit age and/or processing conditions of the latex. The proximate values showed a higher protein content of the latex compared to other nutrient components as previously observed (Macalood et al., 2013 and Battaa et al., 2015). The enzyme protease activity in the dried pawpaw latex was put at 2655 units/g and 285 units /g for pH 5.5 and pH 9.0 respectively (Macalood et al., 2013).

Table 3. Proximate composition of crude pawpaw latex

Parameters	Values (%)
Crude Protein	54.91+/-0.61
Ether Extract	6.28+/-0.18
Crude Fibre	4.65+/- 0.19
Ash	5.50+/-0.02
Moisture	9.87+/- 0.11
Nitrogen Free Extract	18.79+/- 0.16

Growth performance

The effects of PL on growth performance during starter (1-28d), finisher (29-49d) and combined starter/ finisher phases (1-49d) are presented in table 4. Between 1-28d, there was a linear decrease ($P<0.05$) in BWG, DFI and PER while the FGR worsened ($P<0.05$) as the level of PL increases in the diet between the period of 29-49days, birds fed the control diet had consumed ($P<0.05$) more feed however, there were no significant differences in BWG and PER between birds on the control diet and those on 0.1%PL. Considering the entire feeding period (1-49d), growth performance was significantly ($P<0.05$) influenced by the experimental diets (Table 4). There was a linear reduction in BWG and DFI as the level of PL increased. FGR and PER were similar between broilers on PL–free diet and 0.1%PL diet but better ($P<0.05$) than those on 0.15%PL and 0.2%PL based diets. Survivability of broiler chickens fed 0.2%PL was 100% compared to 90% for those on PL-free control group. The results in the present study have suggested that pawpaw latex impacted negatively on performance response, which does not follow the trends of previous reports in other animal models. El-Kholy et al. (2008) and Zeedan et al. (2009) observed that 0.7% papaya latex enhanced growth performance and immune response in heat stressed growing rabbits and concluded that the latex can be used as an alternative growth promoter. Battaa et al. (2015) fed 0.01, 0.03 and 0.05% natural enzyme (plant papain) to Egyptian local layers. They reported improved egg production, feed conversion ratio, nutrients digestibility, immunity and economic efficiency while feed intake was reduced at 0.05% addition of the natural enzyme. Baoming et al. (2012) fed soybean meal diets containing 0, 50 and 75mg/kg papain to weaned piglets in comparison to a diet containing high-grade animal protein ingredient. They observed that the addition of papain at 75 mg /kg level significantly increased *in-vitro* digestibility and effectively expanded the inclusion limit of soybean meal in piglet diets. The nature of protease enzyme in pawpaw latex is to digest protein, clean up the gastrointestinal tract wall and enable efficient nutrient absorption (Onyimonye and Onu, 2009). Judging by the positive role of pawpaw latex in studies involving layers, piglets and rabbits, it becomes somewhat difficult to explain the poor performance outcome with broiler chickens in this study. At the finisher phase it appears that age of the birds made it easier to deal with the presumed cause of poor performance during the starter phase. The poor response may be due to creation of nutrient imbalances and overlap of reactions rather than to a true failure of the enzyme in the pawpaw latex. Activity of crude pawpaw latex enzymes might have been influenced by the plant source, methods of extraction, purification and processing conditions (Rao et al., 1998) because Baoming et al. (2012) reported the good stability of papain at pH ranges of 5-9 or temperature ranges between 4-65^{o}C. Pawpaw latex with its protease content (expected to elicit nutritional improvement) may have different inherent characteristics causing divergent responses *in vivo* as observed in this study. Different performance responses of protease fed to non-ruminant animals might also be related to compatibility with endogenous proteases (Adeola and Cowieson, 2011). Some reports (Kotaro et al., 2004; Harrison and Bonning 2010) have suggested that cysteine protease to be the toxic component in pawpaw leaves that interact with the cellular aspect of insects resulting in growth inhibition, physiological damages and mortality. The exact mechanism by which this operates is still under investigation (Manjunath et al., 2014). Kotaro et al (2004) also noted that pawpaw is among the few latex-bearing plants whose noxious chemical contents have not been fully reported. Various parts of pawpaw contain carpaine, an alkaloid that is more prevalent in its leaves (Krishna et al., 2008) while other natural toxicants like benzyl glycosinate (BG) and benzyl isothiocyanate are parts of the plant's natural defence mechanism.

Table 4. Inclusion levels of pawpaw latex on growth performance of broiler chickens during starter, finisher and combined starter/ finisher phases

Parameters \ Diets	Control	0.1%PL	0.15%PL	0.2%PL	SEM
Starter phase (1-28d)					
Daily weight gain, g	33.0^{a}	26.4^{b}	17.9^{c}	14.1^{d}	2.24
Daily feed intake, g	72.0^{a}	69.4^{a}	52.1^{b}	44.6^{b}	3.62
Feed: Gain	2.18^{c}	2.63^{bc}	2.93^{ab}	3.19^{a}	0.13
Protein Efficiency ratio	2.02^{a}	1.66^{b}	1.50^{bc}	1.39^{bc}	0.08
Finisher phase (29-49d)					
Daily weight gain, g	70.7^{a}	67.2^{ab}	61.6^{ab}	51.4^{c}	3.02
Daily feed intake, g	175.9^{a}	142.9^{b}	93.7^{c}	77.4^{d}	12.2
Feed: Gain	2.57^{a}	2.13^{b}	1.52^{d}	1.51^{c}	0.25
Protein Efficiency ratio	2.00^{c}	2.37^{c}	2.87^{b}	3.97^{a}	0.25
Combined phases (1-49d)					
Daily weight gain, g	49.2^{a}	43.8^{b}	36.6^{c}	30.1^{d}	1.32
Daily feed intake, g	116.5^{a}	100.9^{b}	93.6^{c}	65.6^{d}	3.93
Feed: Gain	2.39^{a}	2.30^{a}	1.83^{b}	1.86^{b}	0.15
Protein Efficiency ratio	2.07^{c}	2.19^{c}	2.40^{b}	2.86^{a}	0.06

SEM: ^{a,b,c,d} Treatments on the same row with different superscripts are significantly different (P<0.05)

Cell-Mediated immunity

The spleen and bursa are the immune organs (Table 5) of interest here and both were significantly (P<0.05) influenced. The immune response increased with increase in dietary levels of crude PL. This is in agreement with the observations of El-Kholly et al (2008) and Battaa et al (2015). Fu Chang et al. (2004) also reported that the index of both the spleen and the thymus determines the immunity strength. The bigger the immunity index the stronger the immune response. El-Kholly et al (2008) postulated that pawpaw latex improves lymphocytes production and thymus index, which lead to the production of T-cells. T-cells undergo maturation in the thymus gland and play a major role in cell-mediated immunity (Stephen, 2007). Pawpaw latex also has antibacterial and anti-fungal properties (Afolabi et al 2011), which may further enhance the activity of the immune system.

Table 5. Effect of inclusion level of pawpaw latex on cell-mediated immunity of broiler chickens

Parameters (%) \ Diets	Control	0.1% PL	0.15% PL	0.2% PL	SEM
Spleen	0.10^{b}	0.11^{ab}	0.11^{ab}	0.12^{a}	0.003
Spleen Index ($\times10^{-5}$)	2.26^{c}	2.37^{bc}	2.43^{b}	5.54^{a}	2.2×10^{-6}
Bursa	0.05^{ab}	0.05^{b}	0.05^{b}	0.07^{a}	0.001
Bursa Index ($\times10^{-5}$)	4.33^{b}	4.96^{b}	5.74^{b}	8.77^{a}	0.000

$^{a,\ b\ and\ c}$ Treatments on the same row with different superscripts are significantly different (P<0.05)

Carcass and organ measurements

Table 6 has focused on the carcass, organs and intestinal measurements of broiler chickens. There was no significant difference in dressing percentage and percentage back of the broilers however; there were significant variations in the other cut up parts without any specific trend established. Interestingly, abdominal fat was significantly higher in broilers fed PL-based diets compared to those on PL-free diet. The gizzard, liver and intestinal weights were generally heavier in broiler chickens fed PL based diets whereas heart weights exhibited no significant variations. The highest values were demonstrated in broilers fed 0.2%PL. Hepatic hypertrophy, which was observed in the liver, gizzard and intestines of birds fed with PL, might have been provoked by the toxic effect of the cysteine protease in crude papain (Poulter and Caygall, 1985). Lien and Wu (2012) also observed increased liver weight as the inclusion level of crude papain had increased. The comparable values in the dressing percentage, breast, wing, back and thigh of birds fed diets containing 0 and 0.1%PL agreed with the findings of Esonu et al (2008), Bharathidhasan et al. (2009), Hana et al. (2010), Davood et al. (2012), Azarfar (2013) and Dalolio et al. (2015) that in a balanced and quality diet, enzyme might have no significant effect on carcass values.

Table 6. Carcass, organ and intestinal weights of broiler chickens fed supplemental levels of pawpaw latex (expressed as a percentage of live weight)

Parameters	Control	0.1%PL	0.15%PL	0.2%PL	SEM
Live Weight, kg	2266.7^{a}	2250.0^{a}	1866.7^{b}	1300.0^{c}	53.71
Dressed %	69.2	70.4	69.7	69.9	0.29
Cut-up parts (%)					
Neck	4.53^{c}	5.56^{b}	6.01^{a}	5.65^{ab}	0.87
Breast	23.6^{a}	22.2^{ab}	20.8^{b}	19.8^{c}	0.30
Wing	7.82^{b}	7.71^{b}	7.82^{b}	8.72^{a}	0.08
Thigh	10.6^{a}	10.6^{a}	9.93^{b}	11.1^{a}	0.11
Drum Stick	9.92^{c}	10.81^{b}	11.6^{a}	10.5^{b}	0.11
Back	12.1	12.3	12.5	12.4	0.13
Abdominal Fat	0.62^{b}	1.26^{a}	1.03^{a}	1.26^{a}	0.74
Organs (%)					
Kidney	0.53^{b}	0.59^{a}	0.59^{a}	0.49^{b}	0.01
Lung	0.61^{a}	0.54^{ab}	0.50^{b}	0.56^{ab}	0.01
Heart	0.45	0.44	0.45	0.41	0.01
Gizzard	2.19^{c}	2.25^{c}	3.03^{b}	3.23^{a}	0.06
Liver	1.69^{c}	1.71^{c}	1.90^{b}	2.09^{a}	0.05
Offals (%)					
Small Intestine	2.93^{b}	3.10^{b}	3.66^{a}	3.86^{a}	0.08
Large Intestine	0.17^{bc}	0.16^{c}	0.20^{ab}	0.21^{a}	0.01
Caecum	0.48	0.52	0.56	0.74	0.02

a, b and c: Treatments on the same row with different superscripts are significantly different ($P<0.05$)

CONCLUSION

The crude pawpaw latex used in this study negatively affected the performance characteristics of broiler chickens at the starter phase, which however, was slightly ameliorated during the finishing stage. Improved immune response, sustained carcass yield and better survivability of broiler chickens were however, observed with pawpaw latex at 0.1%. Further research should investigate lower dosage and examine the processing conditions for the pawpaw latex.

DECLARATIONS

Competing interests

The authors declare that they have no competing interests.

Author's contributions

HarunaA. Moshood collected the samples; carried out the field work and wrote the first draft. Odunsi A. Adeyinka supervised the overall research and revised the draft and final script approved by both authors.

Consent to publish

Both authors gave their informed consent prior to their inclusion in the study.

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The Effect of Early Setting inside Single Stage Incubator on Stored Eggs

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ABSTRACT

Eggs weight loss during storage has been documented well due to water loss. The single stage incubators are designed to use egg water loss as humidity source during incubation. In this experiment one week old eggs (n=430840) were collected in Salman hatchery, Pakistan and divided into two groups, group A was (eggs n=215420) immediately shifted to incubators before 10 hours of incubation to avoid further weight loss) and eggs from group B (n=215420) was stored in eggs room at 23.8^0 C and 65% humidity with 2cfm/1000 eggs ventilation for 10 hours. After 10 hours of storage both groups were pre-heated at 80 ^{0}F for 5 hours leading to incubation conditions. Hatchability % (84.502±2.9221, 84.217±3.0279) candling% (6.5418±0.5605, 6.7682±0.5705) dead in shell% (6.5418±2.3112, 6.7682±2.3702) and hatch window (hours) (22-24±0.142, 26-28±0.1324) were significantly better for A compare to B respectively, Water loss% (11.556±0.1399, 11.545±0.1486), chick yield% (68.835±0.0926, 68.818±0.0928) and chick waste (gram) (19.67±1.721, 19.69±1.7653) were insignificant due to same incubation conditions inside incubator. The water loss from eggs of group A retained inside incubator have an impact on embryonic mortality including the duration of first and the last chick that hatches out. So, the deleterious effects of storage can be avoided by shifting the eggs inside a single stage incubator before 10 hours of incubation including pre-heating.

Keywords: Water loss, Egg storage, Single stage incubator, Candling, Dead in shell, Hatch window.

INTRODUCTION

Egg storage is a critical issue in poultry industry, both internal as well as hatchability parameters are badly affected by the storage of fertile eggs in different storage conditions. A number of scientists provided different solutions in order to remedy the deleterious effects of storage. Tercic et al. (2016) described that pre-storage heating is based on the fact that embryos at the pre-gastrula stage at ovi position are less able to withstand the stress of storage compared with embryos at the later, gastrula stage.

The major loss during egg storage occurs due to egg weight loss, increasing the days of storage the conditions for the growing embryo becomes more harmful due to increase water loss. Akeem et al. (2013) found that the storage of fertilized eggs at 18 °C for 0, 4, 8 and 12 days becomes a source of egg weight loss and decreases hatchability parameters. Storage of eggs also effects the interior quality (Haugh unit, albumen and yolk indices) with the effect of storage time might indirectly affect the fertility and hatchability of fertile eggs (Khan et al., 2017). Eggs storage effects can be minimized with small end of egg up for 14 days at 18 °C have effect on early embryo mortality, improving hatchability (Lima et al., 2012). The smaller eggs end up with a decreased surface area for the water loss (Lima et al., 2012). Water loss is a critical factor to achieve standard hatchability, chick yield and quality chicks. 11.93-12.24% water loss is necessary to achieve standard quality chicks from 24-65 weeks broiler breeder's eggs during incubation. The only factor we can manipulate to achieve better chick yield is water loss during incubation (Jabbar et al., 2017). Eggs of Rhode Island Red hen (RIR) were stored for 2, 3, 5, 7 or 9 d at 16 °C and 78% humidity, the fertility was not effected as compared to egg weight, hatchability, embryonic development, chick weight as well as a decrease in the albumen weight, yolk weight, albumen index, yolk index and haugh unit value of RIR eggs (Khan et al., 2014). Regardless of the storage of eggs in different storage conditions, to achieve standard quality chicks the water loss should be at 11.93-12.24 % and chick yield should be at 68.46-68.90% from 24-65 weeks broiler breeder's eggs during incubation (Jabbar et al., 2017). So, if water loss occurs during storage we can never achieve standard chick yield and the hatch window necessary to attain best post hatch performance (Bergoug et al., 2013). The aim of study was to evaluate the effect of early setting on hatchability parameters inside single stage incubator on stored eggs.

MATERIALS AND METHODS

Ethical approval

This experiment was a routine field work in hatchery considering the all rules and regulations regarding animal rights and ethics according to (SPCA) society for protection and care of animals. University of veterinary and animal sciences Lahore Pakistan

Selection of breeder's flocks

Broiler breeder flock Ross, Hubbar and Cobb 35-70 weeks of age from Sadiq poultry farms and Islamabad poultry farms were selected for eggs collections. SP (ross) (Sadiq Poultry) 101(Flock No.101)-AI (Artificial Insemination)-A (House A), SP101(ross)-AI-B, SP101(ross)-C, SP108-1(cob), SP108-2 (cobb), SRB (ross) (Sarghoda Farm-B)-AI-C, IS (ross)(Islamabad Poultry)-132-C, SP(hubbard classic)106-1, SP(hubbard classic)106-2, SRA (ross) (Sarghoda Farm-A)-AI-A, SRA(ross)-AI-B, SRA(ross)-AI-C, SRA(ross)-AI-D, IS(ross)-135, SP(ross)102-AI-A, SP103(cob)-AI-A, SP105(ross)-AI-A. Farm name its number and location is necessary for back tracking also helps in abbreviations

Eggs Selection

Best-quality hatching egg (n=430840) with good quality shells, without ridges or small lumps of calcified material (pimples) were selected from mention farms after one week of storage at 18^0C at farm. 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 $20C^0$ and 65% respectively with fresh air 2 CFM/1000 eggs during the course of the study.

Eggs grading is necessary to achieve quality chicks. If we don't perform eggs grading then at the end of hatch the chicks grading will be very long and difficult. It's easy to grade eggs than chicks to get uniform chicks that will give uniform performance at farm.

Site selection

This experiment was carried out at Salman Poultry (Pvt) limited Chakri hatchery Rawalpindi which is situated 5 kms from chakri interchange on motorway (M2). The hatchery contains the latest Heating Ventilation and Air Conditioning (HVAC) automation, having ISO (international standard organization) 1s900-2000 certified. This hatchery is one of the largest eggs capacity hatcheries in south of Asia, which is producing 65,00,000-70,00,000 of best quality broiler chicks per month through single stage incubation system (Avida G4, Chick Master USA).

Group classification

The experimental eggs were divided into two groups group A and group B both contained same number of eggs (n=215420). Both groups' eggs were stored at 18 °C at the farm for one week. Each farm contributed equal number of eggs.

Weight of eggs

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

$$\text{Egg weight (gram):} \quad \frac{\text{full tray weight at Setting- weight of empty tray}}{\text{Total No. of eggs in tray}}$$

Egg fumigation

Before the weighing, the trial eggs were fumigated with 20 g $KMnO_4$ and 40 ml formalin (40%) and 40 ml of water for 100ft 3 areas for 15 minutes through an automatic fumigation process provided by Chick Master (this system is used for fumigation from last two years on commercial level).

Incubation programme

Eggs were received in the hatchery at the same time for both A and B groups with 20 °C receiving temperature. Eggs from group A were immediately shifted to single stage incubator after receiving and kept inside incubator for next 10 hours at 20 °C and 10% ventilation. While for group B eggs were kept in eggs room at 20 °C and 65% humidity with 2fcm/1000 eggs ventilation for 10 hours. After 10 hours in eggs storage the eggs from group B were shifted to the incubator. Both the groups had been pre-heated at 27 °C for 5 hours inside incubators. After completion of the pre-warming the setter started automatically the incubation stage profile (recommended by Chicks Master USA). Incubation duration for young, prime and old was 456 hours in setter (19th day) and 50 hours in hatchers.

Setter hall and hatcher hall

Environmental conditions in setter hall were at $27C^0$ temperatures and 40% relative humidity; whereas in the hatcher hall temperature was at $27C^0$ 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 the setter and hatcher plenum was -25 Pascal during the course study (Chick Master USA)

Candling

Fertility of eggs was performed through candling then they were shifted to the hatchers for next 50 hrs. This entire incubation stage program has been recommended by chick master USA.

Egg's weight loss

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

$$\text{Water Loss \%: } \frac{\text{Full tray weight at setting- full tray weight at transfer} \times 100}{\text{Full tray weight at setting- empty tray weight}}$$

Chick yield

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

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

Hatch window

The hatch window is the duration between the 1st chicks to the last chick's hatching out (Noiva et al., 2014). The range of hatch window is 22-24 hours for group A and it was 26-28 hours for group B.

Chick grading

The chicks pulling were performed by chick shell separator provided by (KUHL USA). Grading of chicks was performed on a conveyer and an 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 the chick's box after counting, while under weight, weak, and unhealed naval chicks were removed according to the international standard as described 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 t-test and results were presented as mean ± SEM (standard error of mean). Results were considered significant if $P<0.05$.

RESULTS AND DISCUSSION

The eggs from group A shifted to single stage incubators before 10 hours to incubation. These kinds of incubators don't have humidity system e-g spray nozzles inside like multistage setters. The single stage incubator uses the eggs water loss as a humidity source for growing embryos. Water loss from eggs retains inside incubator becomes source of humidity for growing embryos throughout incubation. The appropriate humidity level inside the incubator avoids extra water loss from eggs and enhances survival of the embryo. This survival of embryo was significantly ($P<0.05$) better for group A as compare to group B (Table 1). The maximum hatchability difference was recorded for old age flocks of group A e-g SRA-AI-C, SP102-AI-A and SP103-AI-A and minimum for Prime flocks SP 108-1, IS-132 and IS-135 (Figure 1).

Both groups contain same number of eggs from every flock. The column in blue and red colors presents hatchability% of groups A and group B flocks minimum 75% and maximum 88%. The age of broiler breeder's flock significantly affects the water loss during incubation. The older breeder's eggs have more water from the egg as compared to young or prime flocks. This high quantity of waters helps them to minimize the deleterious effects of storage due to water loss (Stępińska et al., 2017). The eggs of young or prime age breeder's flock were more affected by storage due to less proportion of water as compared to older breeder's eggs. The percentage of water loss remains same for the all kind of breeder's eggs during incubation, but quantity of water loss was different due to different proportion of water inside eggs. This water loss difference due to age became source of hatchability difference (Figure 1).

Candling

The pre-gastrula stage of embryo at ovi position is less able to withstand the stress of storage compared with embryos at the later, gastrula stage. There is higher embryo livability and hatchability, and shorter incubation when hypoblast stage is achieved before long storage periods (Silva et al., 2008). So, if embryo mortality occurs at pre-gastrula stage/hypoblast stage, the embryo detection through candling not possible and fertile egg will be counted as clear/candling egg. The high hatchability of group A flock was due to significantly (P<0.05) low candling (Table 1 and Figure 2).

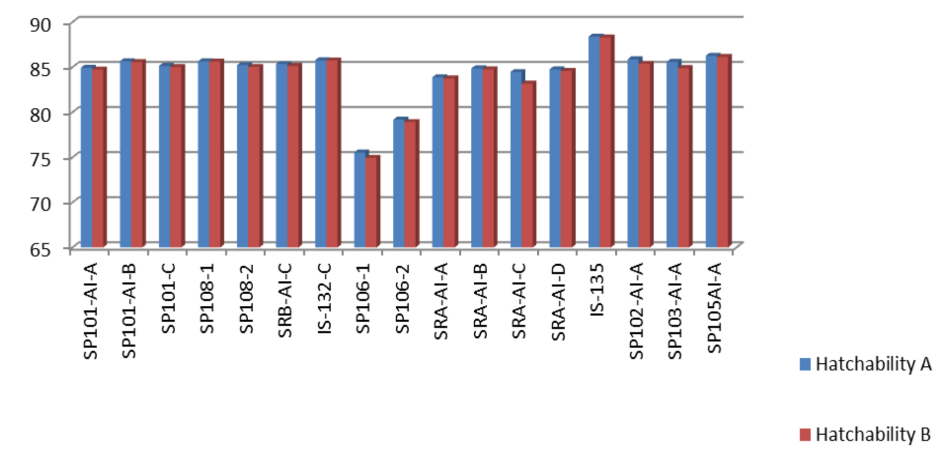

Figure 1. Effect of early setting inside single stage incubator on hatchability at Salman hatchery Chakri Rawalpindi Pakistan during April 2017. The column in blue and red colors presents candling % of groups A and group B flocks respectively from 4.5 to 13.9%. Both groups contain same number of eggs from every flock.

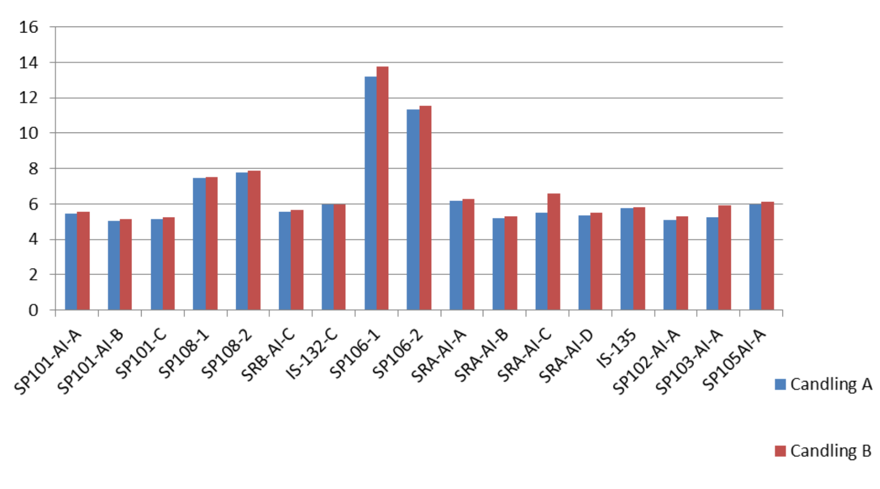

Figure 2. Effect of early setting inside single stage incubator on candling at Salman hatchery Chakri Rawalpindi Pakistan during April 2017

Water loss and chick yield

Water loss and chick yield were insignificant (P<0.05). The percentage of water loss was the same for both groups due to similar incubation conditions inside incubators that's why the chick yield was also same for both groups (Table 1). Flocks from group B show an increasing trend of water loss as compared to group A (Figure 3). The water loss from group A was retained inside incubator and when subjected to incubation temperature show less water loss as compare to group B. Water loss and chick yield are related to each other. If egg weight loss up to pipping has been correct, but the chick yield is lower than 66 % of the fresh egg weight, then incubation duration is too long. It needs to be adjusted by setting eggs later or by pulling chicks earlier. Every one per cent loss in chick yield is equivalent to about three hours extra in the hatcher (Tullett et al., 2010).

Dead in shell and hatch Window

Embryo development starts in the oviduct of the hen. After ovi-position, the embryo development becomes latent until the egg has been placed in optimal conditions for incubation. Due to excess water loss during storage, the optimum humidity requirement inside eggs for growing embryo can't be fulfilled by incubators. The hatching chicks become dry and chicks die in the egg shell during hatching process figure 4 (Bergoug et al., 2013). Moreover the hatching process from first to last chick hatches out (hatch window) becomes too long (Egbeyale et al., 2013). The dead in shell and hatch window of A and B were significantly (P<0.05) different for all flocks (Table 1).

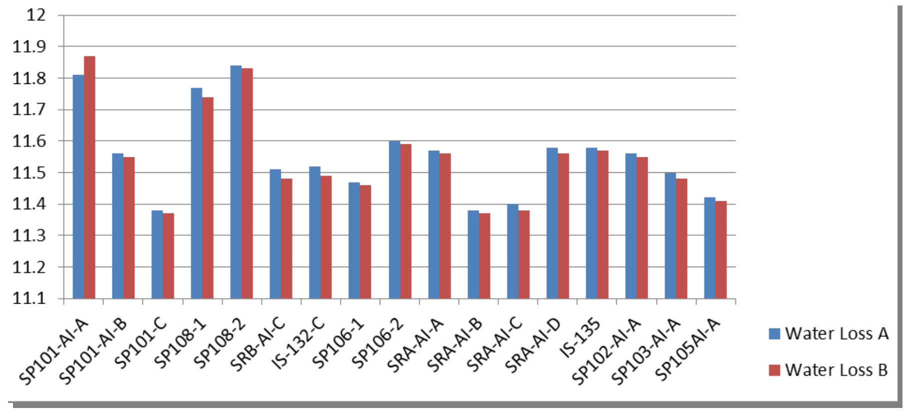

Figure 3. Effect of early setting inside single stage incubator on water loss at Salman hatchery Chakri Rawalpindi Pakistan during April 2017. The column in blue and red colors presents water loss % of groups A and group B flocks respectively from 11.35 to 11.85%. Both groups contain same number of eggs from every flock.

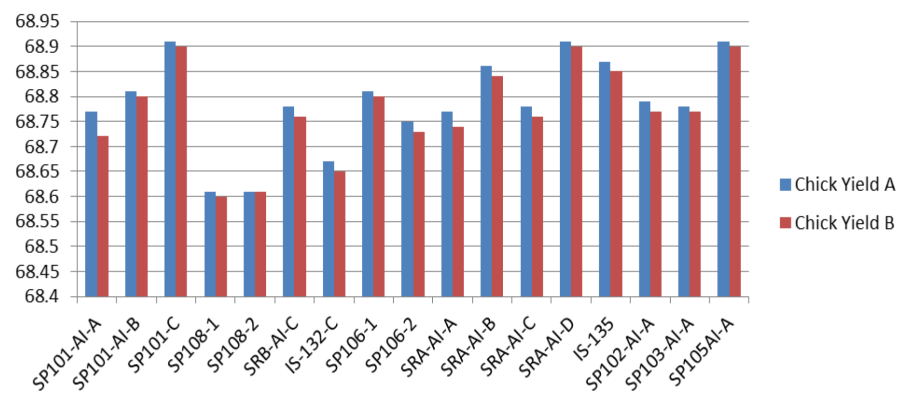

Figure 4. Effect of early setting inside single stage incubator on chick yield at Salman hatchery Chakri Rawalpindi Pakistan during April 2017. The column in blue and red colors presents chick yield% of groups A and group B flocks respectively from 68.6 to 68.95%. Both groups contain same number of eggs from every flock.

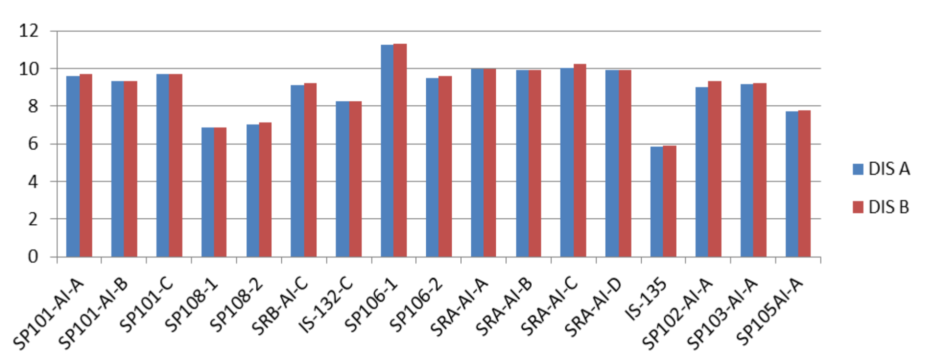

Figure 5. Effect of early setting inside Single Stage Incubator on dead in shell at Salman hatchery Chakri Rawalpindi Pakistan during April 2017**.** The column in blue and red colors presents dead in shell% of groups A and group B flocks respectively from 5.94 % to 11.8%. Both groups contain same number of eggs from every flock.

Table 1. The effect of early setting inside single stage incubator on hatchability, candling, water loss, chick yield, dead in shell, chick waste and hatch window at Salman Hatchery Chakri Rawalpindi, Pakistan (April, 2017)

Parameters	Group A	Group B
Hatchability	84.502±2.9221[a]	84.217±3.0279[b]
Candling	6.5418±0.5605[a]	6.7682±0.5705[b]
Water loss	11.556±0.1399[a]	11.545±0.1486[a]
Chick yield	68.835±0.0926[a]	68.818±0.0928[a]
Dead in shell	6.5418±2.3112[a]	6.7682±2.3702[b]
Chick waste	19.67±1.7213[a]	19.69±1.7653[a]
Hatch window	22-24±0.142[a]	26-28±0.1324[b]

[a-b] denote difference between parameters of group A and group B ($P < 0.05$)

CONCLUSION

Setting of stored eggs inside single stage incubator avoids further water loss from fertile eggs. The water loss from stored eggs retained inside incubator becomes a source of humidity for the growing embryos/single stage incubators cab be used to store eggs for short time by providing ideal condition for storage and may enhance hatchability by improving hatch window and avoiding candling and dead in shell.

DECLARATIONS

Author's contribution

All authors have equally contribution in this work.

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Competing 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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Effect of Technological Intervention on the Economics of *Vanaraja* Chicken Rearing in West Siang District of Arunachal Pradesh, India

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ABSTRACT

The present investigation was conducted to evaluate the comparative economics of two methods of *Vanaraja* chicken rearing under backyard system i.e. improved technologies demonstrated under Front Line Demonstration (FLD) and Farmer's Practice (FP) traditionally adopted by the farmers. All together 120 farmers from 12 randomly selected villages of West Siang district of Arunachal Pradesh having experience of poultry rearing for more than two years were selected for FLD. The study (from August, 2015 to July, 2017) reveals that, the technologies demonstrated in FLDs recorded higher body weight gain of male chickens (2300g) over FP (1800g) at 20 weeks of age, which was 27.78% higher than that of Farmers' Practice. Mean annual egg production under FLD was recorded as 110 numbers which was 37.50% higher than that of FP (80). The estimated technology gap in body weight gain was recorded as 200 g/bird, whereas for egg production it was 20 numbers/bird. The extension gap of body weight gains and egg production was recorded as 500 g/bird and 30 numbers/bird, respectively with a technology index of 8% in body weight gain and 15.38% in egg production. The benefit cost (B: C) ratio for *Vanaraja* chicken rearing under FLD and Farmers' Practice was recorded as 2.62:1 and 1.71:1, respectively which indicated that under improved rearing techniques demonstrated under FLD *Vanaraja* chicken gives much more profit than that of rearing techniques under FP. Non availability of improved germplasm of poultry (93.33%) was given the top ranking while weak market linkage to dispose the produce (35.00%) was given as bottom ranking in the constraints matrix ranking in poultry production. Under client satisfaction index over the performance of FLD analysis reveals 63.33% of high satisfaction index over the performance of FLDs while 27.50% respondent expressed medium level of satisfaction and only 9.17% respondent expressed low level of satisfaction index.

Key words: Backyard poultry, Front line demonstration, *Vanaraja*, Benefit cost ratio

INTRODUCTION

The state Arunachal Pradesh of India is ethnically and culturally akin to South East Asia and agriculture is the prime source of livelihood for the rural population in this region. Although, cereals dominate the cropping pattern in this region, livestock and poultry also plays an important role in the mixed farming systems adopted traditionally by the farmers. Poultry are the birds that include fowl, turkey, duck, goose, ostrich, guinea fowl and etc. which render not only economic amenities but also contribute significantly to human food as a primary supplier of meat and egg (Sarma et al., 2017). Among various poultry species backyard poultry plays an important economic, nutritional and socio-cultural role in the rural livelihood of this region. For this region without backyard poultry farming it is quite impossible meet up the demand and production gap of meat and eggs. As most of the farmers of this region is either landless or marginal, therefore commercial poultry farming cannot provide the required protein at affordable rate to the people (Singh et al., 2016). Though, backyard poultry contributes many livelihood indicators of rural people, but it is reared with a little or no bushiness motive. Farmers used to keep a very small flock size of birds managed as a supplementary enterprise with zero or negligible input investment (Awasthi et al., 2015). To uplift this situation of backyard poultry farming a Front Line Demonstration (FLD) was conducted by Krishi Vigyan Kendra West Siang on backyard poultry production with improved strain *Vanaraja* developed by project directorate of poultry, Hyderabad especially meant for rural backyard poultry production. FLD is a concept of field demonstration evolved by the Indian council of agricultural research, with an objective of demonstrating newly released production technologies and their management practices in the farmers' field under different agro-climatic regions and farming situations. By keeping the above point in view, the present study was designed to explore the contribution of FLD on backyard poultry farming in terms of income generation along with its economic structure and to determine the effectiveness and satisfaction level of the farmers in terms of their traditional farming practices.

MATERIALS AND METHODS

FLD with improved package of practices were conducted from August, 2015 to July, 2017 at 12 randomly selected villages of West Siang district of Arunachal Pradesh, India, namely Sago, Lipunamchi, Gori I, Gori II, Gori III, Regi, Pagi, Disi, Bam I, Bam II, Nyodu and Dali with 5 farm family from each village, covering 60 farm family altogether. Twenty numbers of Day Old Chicks (DOC) of *Vanaraja* were provided to the each of those 60 farm families from the hatchery unit of Indian council of agricultural research complex for North Eastern Hill region, Arunachal Pradesh centre. Another 60 farmers using their own practice (farmer's practice) for rearing *Vanaraja* poultry taken from the same hatchery unit were randomly contacted for collecting data to study the comparative performance of FLD and Farmer's Practice (FP). Prior to the distribution of DOC where FLD was conducted, vocational training was given to the selected farmers regarding scientific rearing techniques of *Vanaraja* chicken and demonstrated improved package of practices which has been illustrated in Table 1. Under FLD programme, day old Vanaraja chicks were kept in brooding up to 6 weeks of age and simultaneously vaccinated with Ranikhet disease vaccine (F strain/ La Sota strain) on 7th day and booster dose on 28th day of age. Infectious bursal disease vaccine (MB strain) was done on 14th day and booster dose on 35th day of age. Multivitamin suspension was given to all the chicks during the first 10 days. Up to 6 weeks of age, chicks were fed with broiler chicken starter diet with a provision of *ad libitum* fresh and clean water. After brooding, chicks were let loose at backyard environment after proper acclimatization. The primary data were collected for day old to 18 months of age of the birds. The body weights for both male and female birds were estimated separately at the age of 20 weeks. Similarly, average annual egg production was estimated by calculating the numbers of eggs produced by the female birds up to one year. Performance of *Vanaraja* chicken under FLD and FPs were estimated by taking the average for both body weight and egg production for estimating the growth performance and economic returns. Finally, the technology gap, extension gap and technology index for *Vanaraja* poultry rearing were calculated by using the formula defined by Samui et al. (2000).

Technology gap = Potential yield – Demonstration yield.

Extension gap = Demonstration yield – Yield of FP.

Technology index (%) = {(Potential yield - Demonstration yield) / Potential yield} × 100

Table 1. Package of practices followed in the FLDs and FP for *Vanaraja* chicken in West Siang district of Arunachal Pradesh, India

Serial Number	Inputs/Package of practices provided to the farmers	Front Line Demonstration	Farmers' Practice
1.	Vanaraja chicks (Day Old Chicks)	Twenty numbers of *Vanaraja* Day Old Chicks.	Farmers procured Day Old Chicks of *Vanaraja* chicken by own.
2.	Technological knowledge of poultry rearing	Through training and demonstration.	Untrained, traditional knowledge.
3.	Vaccinations	As per schedule.	Not followed as per schedule.
4.	Medication	Mostly as preventive doses.	Indiscriminate used.
5.	Housing	Scientific design with locally available materials.	Not scientific, overcrowded, improper ventilation.
6.	Feeds	Commercial balanced feeds up to 6 weeks of age.	Not balanced, mostly broken rice and sometime little quantity of broiler starter feeds mixed with broken rice.

The estimated cost of rearing was calculated by adding the variable cost i.e. cost of DOC, feed cost, vaccine cost, medicine cost, labour cost and fixed cost i.e. land, poultry shed and equipment cost. The return was calculated by adding the incomes from the sale of eggs, sale of cocks and spent hens. Unit wise economic analysis was also done for FLD and FP. To determine the cost and returns from backyard poultry production gross margin analysis was used as per the method described by Oladunni and Fatuase (2014). The Gross Margin (GM) was estimated with the help of following equations:

GM = TVP – TVC Where, TVP = Total value of production, TVC = Total variable cost

If GM > 0, the backyard poultry enterprise is considered profitable. Based on the above facts, to know the economic viability benefit cost ratio was calculated by dividing the gross income/bird by net cost of production/bird. After that matrix ranking techniques was utilized to identify the constraints faced by the farmers in poultry farming. Farmers were also asked to rank the constraints they perceived as limiting factor for poultry farming in order of preference. An interview schedule was also prepared to know the farmers' satisfaction level for the technology demonstrated through FLD and based on that, client satisfaction index was calculated by the following formula.

Client satisfaction index = (Individual score obtained/ Maximum score possible) ×100.

All the data generated were tabulated and subjected to statistical analysis (wherever required) as per the method of Snedecor and Cochran (1994).

Zoonotic diseases management

Exposure to zoonotic diseases is always persist for the backyard poultry owner or handler if proper hygiene practices are not followed in the farm. Hygienic practices, such as avoiding of consumption of food or water within the farm premises, hand washing after handling the birds or their excrement were strictly followed throughout the study.

Ethical approval

The study was conducted without affecting the birds' general wellbeing. Approval was taken from concern authority.

RESULTS AND DISCUSSION

Rearing expenditure of Vanaraja chicken under FLD and FP are presented in table 2. The estimated cost of rearing of 20 *Vanaraja* chickens under FLD and FP for 18 months of age are presented in table 2.

Table 2. Estimated rearing cost of 20 Vanaraja chickens under Front Line Demonstration and Farmers' Practice for *Vanaraja* chicken in West Siang district of Arunachal Pradesh, India

S. No.		Particulars	Cost of rearing (Rupees)	
			Front Line Demonstration	Farmers' Practice
	1	**Variable cost**		
a.		Cost of a day old chicks (Per chick cost is rupees 40.00)	800.00 (15.26%)	800.00 (17.76%)
b.		Cost of feed up to 42 days of age		
	i	Under front line demonstration 1.2 kg of broiler starter/bird i.e. 24 kg @ Rupees 40.00 per kg	960.00 (18.31%)	-
	ii	Under farmers' Practice 10 kg of broken rice mixed with little broiler starter @ Rupees 25.00 per kg for 20 numbers chicks	-	250.00 (5.55%)
c		Cost of vaccine @ Rupees 1.60 per chick	32.00 (0.61%)	32.00 (0.71%)
d		Under front line demonstration cost of medicine, feed supplement @ Rupees 3.75 per chick	75.00 (1.43%)	-
e		Under farmers' practice cost of medicine, feed supplement @ Rupees 2.40 per chick	-	48.00 (1.07%)
f		For both the flock (Front Line Demonstration and Farmers' Practice) cost of labour @ 20 hours per month = 2.5 Man-days × 18 months = 45 man-days × Rupees 150.00 per Man-day = Rupees 6750.00	3375.00 (64.38%)	3375.00 (74.91%)
		Total variable cost	5242.00	4505.00
	2	**Fixed cost**		
a		Land	Available with the farmers	Available with the farmers
b		Low cost poultry shed made with locally available material	1000.00	1000.00
c		Depreciation cost on poultry shed @ 33.33 % per year	499.95 (8.71%)	499.95 (10.63%)
d		Drinker/ Feeder	Locally made	Locally made
		Total fixed cost	499.95	499.95
3		Total cost/value of production	5741.95	5004.95
4		Cost of production per bird (D/20)	287.10	250.25

Table 3. Growth performance of *Vanaraja* chicken under front line demonstration and farmers' practice in West Siang district of Arunachal Pradesh, India

Numbers of demonstration	Numbers of birds/ demonstration	Mortality rate after 21 weeks (%)		Body weight of male at 20 weeks (g)		Average annual egg production (Numbers)		% Increase in		Technology gap in		Extension gap		Technology index (%)	
		FLD	FP	FLD	FP	FLD	FP	Body weight over FP	Egg production over FP	Body weight gain (g/bird)	Egg production (numbers/bird)	Body wt. gain (g/bird)	Egg production (numbers/bird)	Body weight gain	Egg production
120	20	15	40	2300	1800	110	80	27.78	37.50	200	20	500	30	8.0	15.38

FLD: Front Line Demonstration, FP: Farmers Practice

Table 4. Per unit return from *Vanaraja* chickens under front line demonstration and farmers' practice in West Siang district of Arunachal Pradesh, India

S. No.	Particulars	Front line demonstration	Amount (Rupees)	Farmers' practice	Amount (Rupees)
1	Income from sale of eggs (from 9 females under FLD and 7 females under FP)	Average annual egg production 110 eggs/hen i.e. 990 numbers of eggs @ Rupees 8/egg	7920.00	Average annual egg production 80 eggs/hen *i.e.* 560 nos. of eggs @ Rupees 8/egg	4480.00
2	Sale of cocks (8 under FLD and 5 under FP)	Average weight: 2.23Kg. Total weight: 17.84Kg @ Rupees 300/Kg	5352.00	Average weight: 1.80 Kg. Total weight: 9.0 Kg @ Rs. 300/Kg	2700.00
3	Sale of spent hens (9 females under FLD and 7 females under FP)	Rupees 200/ hen	1800.00	Rs. 200/ hen	1400.00
4	Total gross return	-	15072.00	-	8580.00
5	Gross income/bird	-	753.60	-	429.00
6	Net return (Gross income- production cost)	-	9330.05	-	3875.05
7	Net return / bird	-	466.50	-	193.75
8	Gross Margin	-	499.95	-	499.95
9	Benefit: cost Ratio	-	2.62:1	-	1.71:1

Table 5. Matrix ranking of constraints of poultry farming in West Siang district of Arunachal Pradesh, India

S. No.	Constraints	Respondent (n=120)	(%)	Matrix ranking
1.	Non availability of improved germplasm of poultry	112	93.33	I
2.	Mortality due to disease outbreak	105	87.50	II
3.	Non availability of quality feeds	100	83.33	III
4.	High cost of concentrate feeds	96	80.00	IV
5.	Low productive performance of native birds	89	74.17	V
6.	Early chick mortality due to cold stress	82	68.33	VI
7.	Lack of investment capacity of the farmers	65	54.17	VII
8.	Weak market linkage to dispose the produce in right price	42	35.00	VIII

Table 6. Client satisfaction index over the performance of *Vanaraja* chicken under Front Line Demonstration (n=120) in West Siang district of Arunachal Pradesh, India

Number	Percent	Satisfaction level
76	63.33	High
33	27.50	Medium
11	9.17	Low

During the study it was found that under FLD, the cost of labour accounted the highest (64.38%) of rearing cost followed by cost of feed (18.31%), chicks (15.26%), depreciation cost on poultry shed (8.71%), cost of medicine, feed supplement (1.43%) and cost of vaccine (0.61%). Similarly, in case of FP the expenses for the labour is also highest (74.91%) among the other expenses of rearing. The expenses for the cost of feed, chicks, poultry shed depreciation cost, cost of medicine and feed supplement, cost of vaccine accounted 5.55, 17.76, 10.63, 1.07 and 0.71 % respectively.

This finding was in accordance with the findings of Uddin et al. (2013) and Islam et al. (2015) who also reported that labour cost estimated to be the highest in backyard poultry rearing. Present finding is contradictory with the finding of Nath et al. (2013), where he reported that feed cost (90.95%) constituted the highest expenditure for *Vanaraja* chicken under backyard rearing condition. In the present study the total production cost under FLD was found to be higher (Rupees 5741.95) than that of the production cost under FP (Rupees 5004.95) which might be due to the higher cost of feed and medicine, feed supplement. Growth performance of *Vanaraja* chicken under FLD and FP are presented in table 3.

The mortality after 21 weeks of age was recorded as 15% under FLD while in PF it was recorded as 40%. Average body weight of male birds under FLD was observed as 2300g which was 27.78% higher than that of FP (1800g). The average annual egg production was found to be 110 numbers, which was 37.50% higher than that of FP (80 numbers). These results are in close conformity with the results of Paul et al. (2005) and Singh et al. (2018). The lower mortality, higher production of meat and eggs under FLD might be due to the adoption of better and scientific management practices than that of FP (Das et al., 2014). On an average in the present study, the technology and extension gap for body weight gain were recorded as 200g/bird and 500g/bird, respectively while in case of egg production these values were 20 and 30 numbers/bird, respectively.

To minimize the extension gap, during the period of FLD emphasis was given to educate the farmers through trainings, demonstration for the adoption of scientific backyard poultry production techniques. The technology gap observed both in body weight gain and egg production may be due to primarily the dissimilarity in the awareness among the farmers regarding scientific poultry farming and secondarily the farming situation of the study area. Hence, location specific recommendation appears to be the prime need to minimize the technology gap of production level of a particular technology in different climatic situations.

The technology index value for body weight gain and egg production were recorded as 8.00% and 15.38%, respectively. The technology index recorded in the recant study indicates the feasibility of the demonstrated technology at the farmers' level. The lower technology index value indicates more feasibility of the technology. Similar type of observation was also reported by Kant (2017). The average per unit return from *Vanaraja* chickens under FLD and FP were presented in Table 4.

The chickens under FLD fetched higher net return (Rupees 466.50) with higher benefit cost ratio (2.62:1) as compared to the net return (Rupees 193.75) and benefit cost ratio (1.71:1) under FP. Singh et al. (2015) also reported the similar type of observation of higher returns in FLDs on improved technologies. Higher profitability and economic viability of the poultry birds in FLD might be due to the fact that farmers under FLD adopted almost all the scientific technologies demonstrated under FLD for which inherent genetic potential of the *Vanaraja* birds were almost expressed which was mostly missing in traditional farming practices adopted by the farmers. Throughout the study constraints faced by the farmers were studied and were presented in the form of matrix ranking in Table 5. From the table 5 it is indicated that non availability of improved germplasm of poultry (93.33%) was given the top ranking followed by mortality due to disease outbreak (87.50%), mortality due to disease outbreak (87.50%), non-availability of quality feeds (83.33%), high cost of concentrate feeds (80.00%), low productive performance of native birds (74.17%), early chick mortality due to cold stress (68.33%), lack of investment capacity of the farmers (54.17%) and weak market linkage to dispose the produce at right price (35.00%) were the major constraints in poultry production. Similar trends of ranking have also been reported by Sarkar (2005).

Client satisfaction index over the performance of FLD was calculated based on the response received from the farmers and presented in Table 6. Majority (63.33%) of the respondents expressed their high level of satisfaction regarding the performance of FLDs, while 27.50% expressed medium level of satisfaction and only 9.17% expressed low level of satisfaction index. Farmers under higher and medium level of satisfaction with respect to performance of demonstrated technology indicate stronger persuasion, physical and mental involvement in the FLD which in turn would led to higher adoption. Similar observation was also recorded by Kant (2017).

DECLARATIONS

Author`s contributions

Sarmah Baruah M. performed the experiment and wrote the paper. Singh Raghav C. and Kalita H. analysed the data.

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Competing interests

The authors declare that they have no competing interests.

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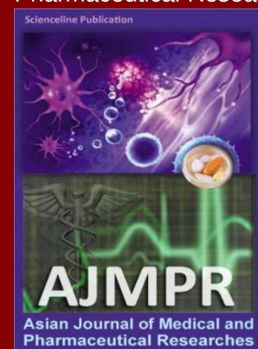

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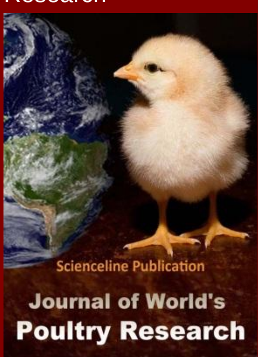

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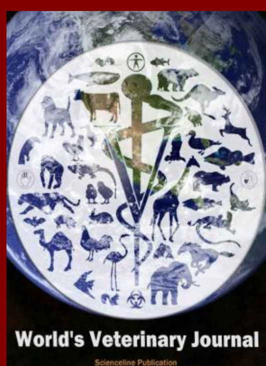

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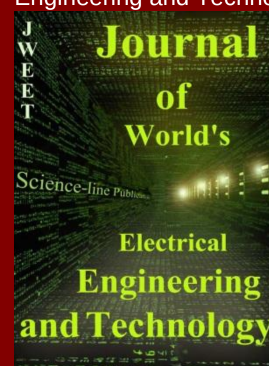

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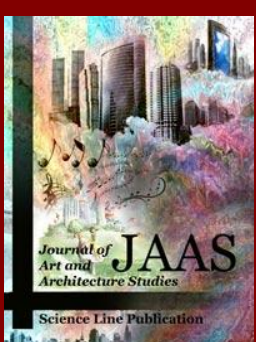

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