EFFECT OF FEEDING ASHWAGANDHA (*Withania somnifera*) ROOT POWDER ON THE GROWTH PERFORMANCE OF BROILER

by

MR. MOHAN SHRIKISAN DHANDE
(Reg. No. 14/122)

A thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722, DIST - AHMEDNAGAR
MAHARASHTRA STATE (INDIA)

In partial fulfilment of the
requirement for the
degree
of

MASTER OF SCIENCE (AGRICULTURE)

in

ANIMAL HUSBANDRY

DEPARTMENT OF ANIMAL HUSBANDRY AND DAIRY SCIENCE
MAHATMA PHULE KRISHI VIDYAPEETH,
POST GRADUATE INSTITUTE RAHURI, –413 722
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CANDIDATE'S DECLARATION

I hereby declare that the thesis or part thereof has not been submitted by me or any other person to any other University or Institute for a Degree or Diploma.

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CERTIFICATE

This is to certify that the thesis entitled, **"EFFECT OF FEEDING ASHWAGANDHA (*Withania somnifera*) ROOT POWDER ON THE GROWTH PERFORMANCE OF BROILER",** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra, India, in partial fulfillment of the requirements of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **ANIMAL HUSBANDRY,** embodies the result of the piece of bona-fide research work carried out by **Mr. MOHAN SHRIKISAN DHANDE** under my guidance and supervision and that no part of this thesis has been submitted for any other Degree or Diploma or publication in any other form.

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CERTIFICATE

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Date : / /2016

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Place: Rahuri

Date: / /2016 (Mohan Dhande)

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LIST OF ABBREVIATIONS

%	-	Per cent
/	-	Per
@	-	At the rate of
Adlib	-	Ad-libitum
°C	-	Degree Celsius
CD	-	Critical difference
d.f.	-	Degrees of freedom
Ed.	-	Edition
Kg	-	Kilogram
et al.	-	And others
Etc	-	etcetera (and other things)
Fig.	-	Figure
gm	-	Gram
Hrs	-	Hour(s)
i.e.	-	id est (that is)
SE	-	Standard error
SE(m)	-	Standard error of mean
Sig.	-	Significant
NS	-	Non significant
J.	-	Journal
Sci.	-	Science
viz.,	-	Namely
No.	-	Number
Rs.	-	Rupees
Lit	-	Liter
Unpub.	-	Unpublished
ARP	-	Ashwagandha Root Powder
IBD	-	Infectious bursal disease
FCR	-	Feed Conversion Ratio
SR	-	Standard Ration
A.I.	-	Artificial Insemination

ABSTRACT

"EFFECT OF FEEDING ASHWAGANDHA (*Withania somnifera*) ROOT POWDER ON THE GROWTH PERFORMANCE OF BROILER"

by

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A candidate for the degree

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2016

Research Guide	: Dr. Y. G. Fulpagare
Department	: Animal Husbandry and Dairy Science

The present investigation entitled "Effect of feeding Ashwagandha (*Withania somnifera*) root powder on the growth performance of broiler" was carried out to assess the effect of feeding Ashwagandha on Body weights, Feed consumption, Feed efficiency (FCR) of poultry birds production.

Eighty healthy day old, commercial broiler chicks of were purchased from Vyankateshwara hatchery, Pune, Maharashtra. They were randomly distributed into 4 treatment groups viz., T_0, T_1, T_2 and T_3 with a 20 chick in each group.

Ashwagandha root powder was added in experimental ration at different levels. The dietary treatments consisted of one basal control (T_0), supplemented with 1.0 %

(T_1), 2.0 % (T_2) and 3.0 % Ashwagandha root Powder (T_3) respectively. The experiment was continued upto 6 weeks.

The overall mortality in Vencobb poultry birds of various groups during the experimental period was zero.

The corresponding average live body weights at the end of 6 weeks of age were 2207.55, 2216.35, 2311.70 and 2182.70 g, in T_0, T_1, T_2 and T_3 treatment groups, respectively. The average weekly body weight gains at the 6th week of age were 495.40, 461.05, 502.60 and 477.30 g, in T_0, T_1, T_2 and T_3 treatments groups, respectively.

The average total weekly feed consumption during the experimental period were recorded as 1173.30, 1050.30, 1045.90 and 1115.30 g, for T_0, T_1, T_2 and T_3 treatments groups, respectively.

The average weekly feed efficiency at 6th week age were 2.37, 2.28, 2.08 and 2.34 in T_0, T_1, T_2 and T_3 treatments groups, respectively.

It is therefore concluded that supplementation of Ashwagandha root powder to basal ration at the rate of 2.0 % was beneficial in broilers to improve feed efficiency.

1. INTRODUCTION

Among different activities in the livestock sector, poultry farming is the fastest growing sector of livestock in terms of economy. Amongst the various animal husbandry enterprises, poultry production has secured number one position and attained industrial status in India. Poultry farming is labour-intensive, requires minimum capital and ensures quick returns. It has been recognised as a vital sector for the generation of employment and highly nutritious food for ever-growing human population.

The dynamic Indian poultry industry is growing at an estimated rate of 6-7 per cent per annum for egg and 15-20 per cent for meat, while the production of agriculture crops has been rising at a rate of 1.5 to 2 per cent per annum. India is World's fourth largest egg producer and fifth largest producer of broilers (Saran *et al.,* 2005). Poultry industry is a fast growing segment of Indian economy contributes about 8 % of the Gross National Income. Per capita availability of meat in India is 1.6 Kg/ annum, in which the broiler forms the major part being a cheapest source. Modern intensive poultry industry demands more rapid growth in a confined housing environment which leads to greater susceptibility to stress in broilers. At present per capita availability is 2.40 kg chicken meat and 42 eggs per annum. It is far below the ICMR recommended level of 180 eggs and 11 kg meat. India's contribution to world's egg and chicken production is nearly, 4

and 2 per cent, respectively whereas poultry sector contributes 3 per cent to national GDP which is 10 per cent of total livestock GDP (Anon.2011).

Broiler production is one of the best ways of supplying good quality animal origin protein for human consumption. It is the quickest, economic and most efficient food converter of plant material in to food of high biological value. Broilers are major source of poultry meat in India. About 140 million broilers are produced in each month. Tamilnadu, Andhra Pradesh, West Bengal, Maharashtra, Karnataka and Punjab are the major broiler producing states (Mohapatra and Misra, 2008). The whole success of broiler production is mainly based on rapid growth of birds. The growth leads to increase in body weight that is, if the cells grow tissue will grow and muscle developments occur. All these things mostly depend on genetic, physiological, environmental and nutritional factors. The nutritional factors are concerned with efficient feeding programme with maximum utilization of nutrients from available feedstuff.

Therefore, becomes necessary to have an efficient programme with maximum utilization of the nutrients from the available feedstuffs. The modern development of biotechnology ensures the availability of different growth promoters like enzymes, probiotics, organic acids, antibiotics, yeasts, algae, etc. These growth promoters are successfully used in broiler production to improve feed conversion efficiency and overall performance. However, use of synthetic growth promoters like antibiotics have some disadvantages

like high cost of production, toxicity and development of resistance and environmental and health hazards. Rapid growth rate in broiler birds accelerated the metabolic rate and make them vulnerable to oxidative stress owing to increased free radical generation.

Feed is a major component affecting net return from the poultry business, because 80 per cent of the total expenditure in terms of cash is spent on feed purchase (Asghar *et al.*, 2000). To ensure more net return and to minimize expenditure on feed, many research strategies such as introducing feed supplements and feed additives have been practiced (Pervez, 1992).

Numbers of feed additives are used to feed broiler birds for the purpose of increased body weight and to improve feed efficiency. In the past, the major growth promoters were antibiotics. Many of such growth promoters are expensive and acts as predisposing factor leading to immunodeficiency syndrome. Some feed additives like hormones and others have residual effect in meat and egg. However, the current research is looking for natural alternative to such feed additives because of their residual effect.

The history of herbs is as long as the story of mankind for people has used these plants since earliest times. Wars have been fought and lands conquered for the sake of plants, and even today, we continue to depend on exotic species for many of our newest medicines and chemicals (Richmond and Mackley, 2000). Recently, many countries tend to minimize or prohibit the chemical components for their

deleterious side effects on both animals and human. So it is important to use natural promoters. Some plants were found to have natural effects, e.g., tonics, antiparasitic, antibacterial, stimulant, carminative, anti-fungal, anti-microbial and antiseptic (Boulos, 1983a; El-Emary, 1993). In this respect, vegetable, herbs, spices and edible plants were suggested as non-traditional feed additive or growth promoters in broiler diets to improve the growth, feed conversion efficiency and reduce the cost of feed (Boulos, 1983b; Gill, 1999; Dickens *et al*, 2000; Al-Harthi, 2002).

Now a days, the natural ways of nourishment attract the attention of people and more emphasis is done on the natural ways of animal feeding which are suitable to the nature of these species. Studies regarding animal feeding based on aromatic plants parallel to their natural requirements became an interesting research topic particularly after antibiotic supplementation to diets was banned in Europe at the beginning of 2006. Plants are used for medical treatments since the prehistoric time (Dragland *et al.*, 2003).

In recent years, some herbal preparations are widely used as feed additives for enhancing growth, reducing feed cost by improving feed efficiency and for building better immunity. Herbal feed additives are better for no known side effect on the health of birds and human being through food chain .The dietary use of herbal growth promoter increases the performance of broiler by increasing live weight gain and feed conversion ratio (Samarth *et al.*, 2002). At present the

scientists are working to improve feed efficiency and growth rate of livestock using useful herbs (Bunyapraphatsara, 2007).

India with its rich traditional heritage is well known for Ayurvedic medicine system due to its therapeutic potential. It has been now practiced for human as well as animal health care. Though much information is available about the medicinal values of plants, very few of it is reported as a growth promoter.

Withania somnifera, commonly known as Ashwagandha, is an important medicinal plant that has been used in Ayurvedic and indigenous medicine for over 3,000 years. *Withnia somnifera* belonging to family Solanacae is an important medicinal plant used in tradition of a healthy balance of life forces (Sharma, 1983; Shukla and Thakur, 1991). Most of its biological activities have been attributed to the presence of group of compounds referred as withanolides. The roots and leaves of *withania* are used as drugs. Most of the herbal medicine available is derived from the roots of the plant Ashwagandha. Roots are a constituent of over 200 formulations in Ayruvedha, Siddha and Unani medicine, which are used in the treatment of various physiological disorders (Asthana and Raina, 1989).

Ashwagandha (*Withania somnifera*) is one of the well known medicinal plants. Number of active principles (Withanolides) have so far been isolated from *Withania somnifera* and have been reported to possess immunomodulatory effects. Ashwagandha (*Withania somnifera*) is reported to be general tonic, antistress, hepato-

protective, haematinic, growth promoter, antioxidant in human practice (Bhattacharya and Ghosal, 1994). The use of herbal medicines or medicinal plants as feed additives can avoid widespread of many diseases and disturbed occurrence of hormones, antibiotics etc. in humans and livestock. Similarly can restrict the abuse of synthetic growth hormones or antibiotic and their side effects in livestock and human being.

Indian poultry industry has made a tremendous and remarkable progress evolving from a small scale backyard venture to the status of commercial, full-fledged, self-sufficient and most progressive agro based industry. Indian poultry industry ranks 4th in egg production and 5th in broiler production with contribution of 2% to GDP (Gross Domestic Product) and provides employment to 1.5 million people. Though Indian poultry industry recorded faster growth; it is witnessing a series of problems due to high ambient temperature in the tropics, accompanied by high relative humidity is one of the most important stressor. The adverse effects of hot weather on the growth performance of broilers are overcome by using Ayurvedic formulation containing herbs (*Withania somnifera, Magnifera indica, Ocimum sanctum* etc.) and fortifying with synthetic amino acids and vitamins. Ashwagandha (*Withania somnifera*) possess antistress, adaptogenic, immunomodulatory and performance enhancing properties. Moreover, it has also been reported to play vital role in lowering blood sugar, serum cholesterol and stress

induced gastric indigestion and ulcers (Muhammad *et al.*, 2009).

An ideal growth promoter should be readily biodegradable, should not cause cross resistance, should be free from environment hazards and should be non-toxic to animals and human being. It should not be involved with transferable drug resistance. It should improve performance effectively and economically (Wolter, 1980). All these characteristics can be achieved by herbal growth promoter like Ashwagandha root powder. Therefore, an effort has been made to study the effect of feeding of *Withania somnifera* (Ashwagandha) root powder on the growth performance of broilers.

Thus, present study entitled "Effect of feeding of Ashwagandha (*Withania somnifera*) root powder on the growth performance of broilers" was planned with the following objectives:

1) To study the effect of Ashwagandha root powder on the growth performance of broiler
2) To assess the feed conversion ratio
3) To estimate the proximate composition of meat

2. REVIEW OF LITERATURE

Ashwagandha (*Withania somnifera*) root powder used by many researchers in laboratory animals and human beings to examine its haematinic, nervine tonic, diuretic and immunomodulatory and antistress activities. However, as reviewed from the literature, very few workers have conducted experiments to examine its effect on growth, haemato-biochemical parameters and immune status of broilers. Hence the references related with species other than birds were also included in the reviewed literature on the following parameters:

1. Growth performance of broilers.
2. Feed Consumption.
3. Feed Conversion Ratio.

Historically, the plant has been used as an antioxidant, adaptogen, aphrodisiac, liver tonic, anti-inflammatory agent, astringent and more recently to treat ulcers, bacterial infection, venom toxins and senile dementia.

2.1 Growth Performance

Pradhan (1995) studied the effect of stresroak (containing Mango, Tulsi, Amla and Ashwagandha) supplementation on 100 day old broiler chickens divided into five identical groups (A to E). Group A was kept as control while the group B to E were subjected to vaccination, debeaking, excitation, deworming and disease stress. Group B

was kept as untreated while the groups C, D and E were treated with stresroak from 1 to 49 days @ 4,5 and 6 ml per 100 birds, respectively for initial 21 days. The dose was doubled thereafter. It was observed that the weight gain was significantly higher in treated groups as compared to untreated and the healthy over control groups.

Mishra and Singh (2000) studied the effect of feeding root powder of *Withania somnifera* on performance of broilers. Group G_0, G_1, G_2 and G_3 were fed broiler mash supplemented with 0 per cent, 0.5 per cent, 1 per cent and 2 per cent *Withania somnifera* root powder, respectively. Feed conversion efficiency in treatment group G_1 and G_2 was better as compared to G_3 group and control (G_0). The cumulative feed conversion efficiency in treatment group was also better than control group (G_0).

Shelukar *et al.* (2000) reported that supplementation of Shatavari (*Asparagus racemosus*) with Ashwagandha (*Withania somnifera*) and probiotics increased haemoglobin, serum calcium, serum phosphorus, blood glucose as compared to control group animals.

Samarth *et al.* (2002) studied the effect of Ashwagandha root powder on performance of broilers. Gain in body weight revealed increasing trend in group (T_2) ranging between 44.25$\pm$1.74 to 423.00$\pm$22.60 g as compared to 47.00$\pm$1.79 to 391$\pm$25.50 g in group (T_1). Similarly, cumulative gain in body weight in group T_2 was 44.25$\pm$1.74 to 1659.25$\pm$25.67 g as compared to group T_1, the values being

47.00±1.79 to 1508.00±16.18 g. Average feed consumption of group T_2 was 631.92 g and for group T_1 was 611.47 g. The conversion of feed to live weigh gain was 2.10 for T_2 group whereas for group T_1 was 2.22. It was concluded that Ashwagandha root powder improved the gain in body weight as well as feed conversion ratio.

Bhoyar *et al.* (2003) studied the effect of Ashwagandha (*Withania somnifera*) root powder at rate of 5 g and 10g per kg of feed on egg production, feed efficiency and stress in layers. From the results obtained, it was concluded that Ashwagandha improved egg production, egg weight, body weight and can be used as antisterss agent.

Pedulwar (2004) studied the effect of supplementation of roots of Ashwagandha at the rate of 0.5 per cent and 1 per cent on the performance of broilers. Higher body weight and net profit per bird, improved weight gain and better feed conversion ratio was observed in Ashwagandha supplemented groups of broilers.

Narayanswamy *et al.* (2004) conducted the field trial to assess the beneficial effect of Geriforte (Vet liquid) as adaptogen in commercial broilers for summer stress. Two thousand healthy, one-day old, straight run commercial broiler chicks were obtained from a reputed hatchery and randomly divided into 2 equal groups, *viz.,* control and Geriforte (Vet liquid) supplemented group. Both the groups were fed with commercial broiler starter feed for 4 weeks and broiler finisher feed till the end of the experiment. The control

group had no supplementation whereas the birds of the supplement group was given at 2.5 ml, 5 ml and 10 ml Geriforte (Vet liquid) per 100 birds in drinking water, for 0-2 weeks, 2-4 weeks and 4-6 weeks, respectively. Parameters like average body weight of 25 birds from each group, feed consumption, feed conversion ratio and livability were monitored on a weekly basis. There was increase in average body weight of supplemented group, when compared to control group. The average weight in the control group was 1.55 kg whereas in the supplement group it was 1.70 kg and average FCR was 1.87 kg in the supplement group and 2.10 kg in control group.

Narayanswamy and Santoshkumar (2004) carried out an experiment on 200 (day old) broiler chicks in June and July when the temperature was above 37.0^0C. Broiler chicks were divided into two groups, *viz.*, control and Geriforte (antistress contains Ashwagandha) supplemented group. The birds from the Geriforte supplemented group were found to be the most efficient in terms of conversion of feed to live weight gain (1.87 kg).

Jadhao (2005) studied the effect of supplementation of Ashwagandha (*Withania somnifera*) at the rate of 1 per cent of feed on growth, haemato-biochemical and immunological status of broilers. He recorded higher body weight and weekly weight gain in Ashwagandha supplemented group.

Akotkar *et al.* (2007) studied the effect of different levels of *Withania somnifera* on performance and haemo-immune response of broilers. One hundred eighty broiler chicks of one day age were randomly distributed into five treatments having three replications comprising twelve chicks in each. The average body weight of all the groups was similar. The dietary treatments T_1, T_2, T_3, T_4 and T_5 contained *Withania somnifera* at the rate of 0 per cent, 0.5 per cent, 0.75 per cent, 1.0 per cent and 1.25 per cent respectively. The body weight gain, feed consumption and feed conversion efficiency revealed significant ($P < 0.05$) variations among the groups. It was concluded that supplementation of 1 per cent Ashwagandha (*Withania somnifera)* root powder significantly improved body weights and feed efficiency of birds.

Wanjari *et al.* (2007) conducted a study with supplementation of herbs like *Withania somnifera* and *Emblica officinalis* to broilers through feed showed significant increase in haemoglobin concentration, packed cell volume, total erythrocytes count and total leucocytes count. All the three treatment groups showed no significant increase in neutrophil, lymphocyte, monocyte and basophil count as compared to control group. However, eosinophil count showed the significant decrease in all the treatment groups.

Sharma *et al.* (2008) conducted an experiment in 180 day-old broiler chicks to evaluate efficacy of herbal liver tonic and growth promoter products on overall growth performance and carcass quality parameters. Day old chicks were randomly divided into three groups, control group I was

given no treatment while group II and III were administered herbal liver tonic and growth promoter products Superliv DS and Xlivpro, respectively, from 0 to 6 weeks. The results indicated significant ($P<0.05$) and notable improvement in overall carcass yield and carcass quality parameters. Dressing percentage for group I, II, III were 71.83, 77.38, 76.58 respectively. P^H of carcass for group I, II, III were 5.84, 5.6, 5.7, respectively. The administration of polyherbal liver tonic formulations enhanced nutrient utilization and boosted overall economy of broiler raising by reducing mortality, and carcass quality.

Shisodiya *et al.* (2008) carried out an experiment to study the effect of Ashwagandha and commercial synthetic compound on the growth performance on 225 broiler chicks for a period of 6 weeks. Group T_1 received standard broiler diet. However, Group T_2 and Group T_3 received Ashwagandha at the rate of 0.05 per cent and commercial synthetic compound at the rate of 0.05 per cent, respectively of standard broiler ration. Supplementation of Ashwagandha (T_2) and commercial synthetic compound (T_3) resulted in significant ($P<0.05$) increase in average mean body weight, weekly gain in body weight as compared with the control group (T_1). The control group (T_1) showed significantly ($P<0.05$) higher feed consumption as compared to T_2 and T_3 groups. The groups supplemented with Ashwagandha (T_2) and commercial synthetic compound (T_3) reported significantly ($P<0.05$) better FCR than the control group.

Jahan *et al.* (2008) conducted a study to determine the comparative efficacy of 6 medicinal plants including *Nigella sativa, Boerhavia diffusa, Withania somnifera, Ipomea digitata, Azadirachta indica* and *Corylusa vellena* at the rate of 4 g per kg of feed as growth promoter and their subsequent influence on the performance of broilers. 210 day old chicks were randomly divided into 21 experimental units of 10 chicks each. These experimental units were randomly allotted to seven treatments comprising of 3 replicates each. Commercially formulated broiler starter and finisher rations were offered *ad libitum* from 0-4 and 4-6 weeks of age. Authenticated samples of the plant materials were dried in shade, pulvarized and mixed each at the rate of 4 g per kg of feed and offered to the chicks of the respective treatment groups. Maximum gain in weight was observed with the *Withania somnifera* (1.819 kg) followed by *Nigella sativa* (1.805 kg) and *Azadirachta indica* (1.800 kg). The best cumulative FCR at the end of 6 week of age was for that of *Withania somnifera* (2.038) followed by *Nigella sativa* (2.054) and *Azadirachta indica* (2.083). The lowest results as regards FCR were recorded for *Ipomea digitata* (2.394) and *Boerhavia diffusa* (2.396). The results of the *Corylusa vellena* (2.209) and control (2.235) were statistically similar. It was concluded from the study that medicinal plants especially *Withania somnifera, Nigella sativa*and *Azadirachta indica*can be used as growth promoters in the poultry diets with better production performance.

Thange *et al.* (2009) studied the effect of different herbal preparations on the performance and immunomodulation on broilers for 6 weeks. 300 day old chicks were divided into six equal groups *viz*. A to F. Group A was control. Group B to F received feed containing Tulsi (*Ocimum sanctum*) dry leaf powder at the rate of 5 g per kg, Neem (*Azadirachta indica*) fruit powder at the rate of 3 g per kg, Shatavari (*Asparagus racemosus*) root powder at the rate of 10 g per kg, Ashwagandha (*Withania somnifera*) root powder at the rate of 10 g per kg, Garlic (*Allium sativum*) powder at the rate of 0.5 g per kg of feed respectively. The differences in the live weights of control and groups receiving Shatavari, Ashwagandha and Garlic were significantly lower than control. Herbal preparations used were not beneficial for improving gain in weight except Tulsi. Tulsi and Neem resulted in recording comparable feed consumption to that of control. However, supplementation of Shatavari, Ashwagandha reduced feed consumption. Birds receiving different herbal preparations recorded marginally better feed conversion ratio than control. Thus, it was concluded that use of different herbal preparations is not very useful for overall improvement in the growth.

Muhammad *et al.* (2009) studied the effect of *Zingiber officinale, Carumapticum, Withania somnifera, Trigonella Foenum Graecum, Silybumm arianum, Allium sativum* and *Berberis lyceum*, on the growth performance of broiler chicks. A total of 240 day old chicks were purchased and were reared for 35 days in summer month. Feed and

water were provided *ad libitum*. Total numbers of chicks were divided into four groups (A, B, C and D) each having 60 chicks. Each group was further subdivided into three groups (replicates) each having 20 chicks. Aqueous extract of these plants was mixed at the rate of 5, 10 and 15 ml/lit with water offered to group B, C and D, respectively while group A served as a control. Mean weight gain, dressing percentage, breast weight and leg weight were significantly higher ($P<0.05$) in group C with better FCR (Feed Conversion Ratio) while mean feed intake was significantly high in control group. It was concluded that these locally available plants if offered as supplement to broiler may result in improvement of broiler efficiency.

Biswas *et al*. (2012) conducted an experiment to investigate the effect of supplementing diets with Ashwagandha (*Withania somnifera*) in combination with ascorbic acid on production performance of broiler. Day old vaccinated commercial broiler chicks (n=240), were procured from a private hatchery. The chicks were distributed into 4 treatments having 4 replicates of 15 chicks in each replicate. Three diets i.e., T1, T2 and T3 were formulated to contain 1% Ashwagandha powder, 0.05% ascorbic acid and combination of 0.5% Ashwagandha powder + 0.025% ascorbic acid respectively. One control group (C) was also taken without supplementation of Ashwagandha powder and ascorbic acid. The birds in supplemented groups gained ($P<0.05$) more weight compared to the control group.

Rajashree *et al.* (2012) conducted an experiment on broiler chicks. Three herbal formulations viz., Amla, Ashwagandha and Shatavari capsules were examined for general test parameters at different production stages and a few basic nutritive test parameters. The general test parameters and assays were found to be satisfactory and the nutritive values were found to be quite significant. This proved that the three formulations could be used as herbal medicines and the significant nutritive values proved that they could be used as dietary supplements.

Mane *et al.* (2012) the trial was conducted for a period of six weeks on 240 day old broiler chicks uniformly distributed into four groups, three replicates of 20 chicks in each T1, T2, T3 and T4 groups. The chicks were fed with standard starter mash which contained crude protein 22.01 per cent and metabolizable energy 2985 Kcal / kg (calculated value) upto three weeks of age. For next 3 weeks *i.e.* from 4 to 6 weeks of age with finisher mash which contained crude protein 19.11 per cent and metabolizable energy 3030 Kcal / kg (calculated value). Group T1 (control) received standard broiler diet without any supplementation, T2, T3 and T4 received standard broiler diet with supplementation of Aswagandha powder @ 5 kg/t, Shatavari powder @ 10 kg/t and Ashwagandha and Shatavari @ 10 kg/t of feed, respectively. The chicks were kept in floor pens, water and feed were provided *ad libitum* throughout the experimental period of 42 days. The supplementation of Shatavari powder to basal diet showed significant ($P<0.05$) effect on body weight,

weekly gain in body weight and feed conversion ratio of broilers in group T3 as compared to those in T2, T4 and control T1 groups. The feed intake was significantly ($P<0.05$) higher in group T1 than in T2, T3 and T4 groups.

Mushtaq *et al.* (2012) studied the effect of aqueous Ashwagandha (*Withania somnifera*) on the performance of broiler chickens. For this purpose, 240 day old broiler chicks were divided into four groups i.e. T_0, T_1, T_2, T_3 receiving control, 10, 20, and 30 g/L of treatments, respectively. An experiment resulted in significant improvement in their feed intake, body weight gain, hematological profile and immunological status.

Joshi *et al.* (2015) conducted an experiment to evaluate the effects of dietary addition of Ashwagandha (*Withania somnifera*) root powder and guduchi (*Tinospora cordifolia*) stem powder on growth performance, feed conversion ratio and economics of feeding in broilers. In experiment 1, treatments were T1: basal diet; T2: basal diet + Ashwagandha (*Withania somnifera*) root powder @ 1 g/kg of feed; T3: basal diet + Ashwagandha (*Withania somnifera*) root powder @ 2 g/kg of feed. In experiment 2, treatments were T1: basal diet; T2: basal diet + guduchi (*Tinospora cordifolia*) stem powder @ 1 g/kg of feed; T3: basal diet + guduchi (*Tinospora cordifolia*) stem powder @ 2 g/kg of feed. The chicks were fed with standard basal diets in three different growth phases i.e. pre-starter (0–10d), starter (11–21d) and finisher (22–42d). Supplementation of *Withania somnifera* and *Tinospora cordifolia* significantly increased the overall body weights,

weekly gain in body weight of broilers compared to the control group.

Vasanthakumar *et al.* (2015) conducted an experiment to assess the effect of Ashwagandha on alleviating heat stress using 90 numbers of day old broiler chicks dividing into 3 treatment groups containing 3 replicates in each group during summer season. The dietary treatments included T1 (Control) without any herbal supplementation, T2 - 1.0 % Ashwagandha root powder and T3 - 0.15 % Ashwagandha root extract. At the end of 42 days of age, the body weight, feed intake, antioxidant level and immune status were significantly ($p<0.05$) better in Ashwagandha root powder and extract supplemented groups when compared to the control group.

Kale *et al.* (2016) conducted an experiment on one hundred eighty day old commercial broiler chicks (Ven Cob Strain) to study the effect of *Withania somnifera* (Ashwagandha) root powder as feed additive on the performance and blood biochemical profile in broilers during 0-6 weeks of age. The chicks were randomly divided into three groups 60 each. All the chicks were housed in deep litter system. The experimental diets were: no feed additive (T0), 0.25 per cent Ashwagandha root powder (T1) and 0.5 per cent Ashwagandha root powder (T2). Body weight gain of T1 (567.00 g) and T2 (581.67 g) was significantly ($P<0.05$) higher than T0 (424.17 g) at the end of trial, but the values were similar for T1 and T2. Average feed consumption did not differ among treatment. Feed conversion ratio at the end of sixth

week was significantly (P<0.05) better in T1 and T2 as compared to T0. It may be concluded that the inclusion of 0.25 and 0.5 per cent level of *Withania somnifera* root powder in broiler ration as a herbal feed additive was beneficial in improving average weekly body weight gain, feed conversion ratio and blood biochemical profile.

2.2 Feed Consumption

Samarth *et al.* (2002) carried out an experiment on 40 day old broiler chicks divided into 2 groups (T_1 and T_2). Group T_1 was maintained as control and T_2 was provided with Ashwagandha root powder @ 0.5 per cent as feed mix. The total average feed intake recorded for T_2 group was 831.92 g whereas 811.47 g for T_1 group.

Deka and Dutta (2003) conducted an experiment on 120 day old White Leghorn chicks divided into three groups. Group 1 was fed with AD1 (the extract of *Withania somnifera*, *Ocimum sanctum* and *Mangifera indica*) whereas group 2 was provided with Levamisole (hydrochloride of yecemic 2,3,5,6 phenol midozo (2,1-6) thiazole) and group 3 was kept as untreated (control). They recorded feed consumption, 1517g, 1526g and 1600g for group 1, 2 and 3, respectively. From this it was concluded that the extract of *Withania somnifera*, *Ocimum sanctum* and *Mangifera indica in poultry diet reduced the feed intake.*

Wanjari (2004) conducted an experiment on day old broiler chicks divided into four groups *viz.* To-Control, T_1-fed with Ashwagandha, T_2- fed with Amla and T_3- fed with

combination of Ashwagandha and Amla during the 6 weeks period. It was found that feed consumption did not differ significantly between treated groups.

Shisodiya *et al.* (2008) conducted 6 weeks trial on 225 day old broiler chicks, uniformly distributed into 3 groups of 75 chicks in each T_1, T_2 and T_3 group and fed with standard starter mash Group T_1 received standard broiler diet. Group T_2 and T_3 received standard broiler diet supplemented with Ashwagandha and commercial synthetic compound @ 0.05 per cent of feed, respectively. The supplementation of Ashwagandha and commercial synthetic compound recorded significant improvement in feed conversion ratio. However, in control group it was significantly higher than supplemented group.

Mane *et al.* (2012) the trial was conducted for a period of six weeks on 240 day old broiler chicks uniformly distributed into four groups, three replicates of 20 chicks in each T1, T2, T3 and T4 groups. The chicks were fed with standard starter mash which contained crude protein 22.01 per cent and metabolizable energy 2985 Kcal / kg (calculated value) upto three weeks of age. For next 3 weeks *i.e.* from 4 to 6 weeks of age with finisher mash which contained crude protein 19.11 per cent and metabolizable energy 3030 Kcal / kg (calculated value). Group T1 (control) received standard broiler diet without any supplementation, T2, T3 and T4 received standard broiler diet with supplementation of Aswagandha powder @ 5 kg/t, Shatavari powder @ 10 kg/t and Ashwagandha and Shatavari @ 10 kg/t of feed,

respectively. The chicks were kept in floor pens, water and feed were provided *ad libitum* throughout the experimental period of 42 days. The supplementation of Shatavari powder to basal diet showed significant ($P<0.05$) effect on body weight, weekly gain in body weight and feed conversion ratio of broilers in group T3 as compared to those in T2, T4 and control T1 groups. The feed intake was significantly ($P<0.05$) higher in group T1 than in T2, T3 and T4 groups.

Mushtaq *et al.* (2012) studied the effect of aqueous Ashwagandha (*Withania somnifera*) on the performance of broiler chickens. For this purpose, 240, day old broiler chicks were divided into four groups i.e. T_0, T_1, T_2, T_3 receiving control, 10, 20, and 30g/L of treatment respectively. An experiment resulted in significant improvement in their feed intake, body and immunological status.

Vasanthakumar *et al.* (2015) conducted an experiment to assess the effect of Ashwagandha on alleviating heat stress using 90 numbers of day old broiler chicks dividing into 3 treatment groups containing 3 replicates in each group during summer season. The dietary treatments included T1 (Control) without any herbal supplementation, T2 - 1.0 % Ashwagandha root powder and T3 - 0.15 % Ashwagandha root extract. At the end of 42 days of age, the body weight, feed intake, antioxidant level and immune status were significantly ($p<0.05$) better in Ashwagandha root powder and extract supplemented groups when compared to the control group.

2.3 Feed efficiency (FCR)

Samarth (2002) calculated 2.10 kg F.C.R for Ashwagandha root powder treated group whereas, 2.22 kg for control group in broilers.

Deka and Dutta (2003) conducted an experiment on 120 day old White Leghorn chicks fed with AD1 (the extract of *Withania somnifera*, *Ocimum sanctum* and *Mangifera indica*). It was observed that FCE (Feed Conversion Efficiency) was better in treated group as compared to control group.

Narayanswamy and Santoshkumar (2004) carried out an experiment on 200 day old broiler chicks. Chicks were divided into 2 groups, *viz.* control and Geriforte (antistress contains Ashwagandha) supplemented group. The birds from the Geriforte supplemented group were found to be the most efficient in terms of conversion of feed to live weight gain (1.87kg).

Mane *et al.* (2012) the trial was conducted for a period of six weeks on 240 day old broiler chicks uniformly distributed into four groups, three replicates of 20 chicks in each T1, T2, T3 and T4 groups. The chicks were fed with standard starter mash which contained crude protein 22.01 per cent and metabolizable energy 2985 Kcal / kg (calculated value) upto three weeks of age. For next 3 weeks *i.e.* from 4 to 6 weeks of age with finisher mash which contained crude protein 19.11 per cent and metabolizable energy 3030 Kcal / kg (calculated value). Group T1 (control) received standard broiler diet without any supplementation, T2, T3 and T4

received standard broiler diet with supplementation of Ashwagandha powder @ 5 kg/t, Shatavari powder @ 10 kg/t and Ashwagandha and Shatavari @ 10 kg/t of feed, respectively. The chicks were kept in floor pens, water and feed were provided *ad libitum* throughout the experimental period of 42 days. The supplementation of Shatavari powder to basal diet showed significant ($P<0.05$) effect on body weight, weekly gain in body weight and feed conversion ratio of broilers in group T3 as compared to those in T2, T4 and control T1 groups. The feed intake was significantly ($P<0.05$) higher in group T1 than in T2, T3 and T4 groups.

Dwivedi *et al.* (2015) the study was conducted to assess the Ashwagandha (*Withania somnifera*) as a phytogenic growth promoter in broiler chickens. Day-old commercial broiler chicks (n=250) were distributed equally in five groups of 50 chicks each and further subdived in 5 replicates. The chicks were placed into 5 dietary treatments– basal diet without any supplementation (NCON) or with antibiotic (PCON), Ashwagandha at 0.5% (WS-0.5), 1.0% (WS-1.0) and 1.5% (WS-1.5) levels. The effect of these supplements on feed intake, weight gain, FCR, hemato-biochemical parameters, carcass characteristics and on economic returns was assessed in a six week study. After six week WS-0.5 and PCON groups showed significantly ($P<0.05$) higher weight gain and growth rate than NCON groups. The FCR of PCON and WS-0.5 groups broiler were incomparable, while weight gain, growth rate and PI were highest in WS-0.5 group broilers.

Kale *et al.* (2016) conducted an experiment on one hundred eighty day old commercial broiler chicks (Ven Cob Strain) to study the effect of Ashwagandha (*Withania somnifera*) root powder as feed additive on the performance and blood biochemical profile in broilers during 0-6 weeks of age. The chicks were randomly divided into three groups 60 each. All the chicks were housed in deep litter system. The experimental diets were: no feed additive (T0), 0.25 per cent Ashwagandha root powder (T1) and 0.5 per cent Ashwagandha root powder (T2). Feed conversion ratio at the end of sixth week was significantly ($P<0.05$) better in T1 and T2 as compared to T0. It may be concluded that the inclusion of 0.25 and 0.5 per cent level of *Withania somnifera* root powder in broiler ration as a herbal feed additive was beneficial in improving average weekly body weight gain, feed conversion ratio and blood biochemical profile.

3. MATERIALS AND METHODS

The present research work entitled as "Effect of Feeding Ashwagandha (*Withania somnifera*) root powder on the growth performance of broiler", was carried out at Poultry Unit, Veterinary Polyclinic and A.I. Centre, Department of Animal Husbandry and Dairy Science, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra State. The materials used and methodology adopted during the course of experimentation are detailed in this chapter.

3.1 Procurement of Ashwagandha Root Powder

The Ashwagandha root powder was procured from Medicinal Plant Unit, Department of Agricultural Botany, MPKV, Rahuri, Ahmednagar (M.S.) as feed supplement for the conducting feeding trial on broilers.

3.2 Selection of experimental chicks

For the present study 80 healthy day old, commercial straight run broiler chicks of Vencobb strain were purchased from Vyankateshwara hatchery, Pune, Maharashtra.

On arrival, chicks were weighed and distributed randomly in 4 treatment groups *viz.*, T_0, T_1, T_2 and T_3 with 20 chicks in each treatment as replicates, on equal weight basis (Table 1).

Table 1. Average body weight of day old chicks

Sr. No.	Treatment	Average body weight (g) of Chicks
1.	T_0	46.50
2.	T_1	46.85
3.	T_2	46.60
4.	T_3	46.60

All the experimental chicks were vaccinated with Marek's disease vaccine on the first day of life at hatchery and subsequent vaccination schedule was carried out as depicted in Table 2.

Table 2. Vaccination schedule of experimental birds

Sr. No.	Disease	Vaccine	Age of vaccination	Dose / route
1.	Ranikhet	Lasota vaccine (F1 Strain)	7th day	One drop in eye (intraocular)
2.	Gumboro (IBD)	Gumboro vaccine	14th day	One drop in eye (intraocular)
3.	Ranikhet Booster dose	Lasota vaccine (booster)	21st day	Through drinking water
4.	Gumboro (IBD)	Gumboro vaccine (booster)	28th day	Through drinking water

3.3 Housing and Management

Before arrival of broiler chicks the pens, waterers, feeders, brooders and floor were cleaned, washed, disinfected and fumigated. All the experimental chicks were reared on deep litter system i.e. rearing on rice husk as a litter material in a well-ventilated house with identical managemental, nutritional and environmental conditions. Proper brooding of chicks was done by providing sufficient heat and light by using electric bulbs in each replication for first three weeks of age. Afterwards, sufficient artificial light was provided during night hours throughout the experimental period.

Fresh, clean and cool drinking water was provided to the experimental birds *ad-libitum*. All the precautionary measures against diseases were taken throughout the experimental period of 6 weeks.

Ashwagandha (*Withania somnifera*) root powder was used as an herbal feed additive and the dietary treatments were as follows:

Table 3. Details of dietary treatment and feeding

Treatment	Details of treatment
T_0	Standard broiler ration without Ashwagandha root powder (Control)
T_1	Standard broiler ration with 1 per cent Ashwagandha root powder (1 kg per 100 Kg of feed)
T_2	Standard broiler ration with 2 per cent Ashwagandha root powder (2 kg per 100 Kg of feed)
T_3	Standard broiler ration with 3 per cent Ashwagandha root powder (3 kg per100 Kg of feed)

All the broiler chicks were fed with crumbled maize grains for first 2 days of age followed by the experimental ration. Commercial poultry ration mixed with Ashwagandha root powder as per treatment. The diets were fed *ad-libutum* to experimental birds.

3.4 Experimental Period

The experiment was conducted from 13-10-2015 to 16-11-2015.

3.5 Observations recorded

3.5.1 Body Weight (Growth Performance)

The live body weights of all birds were recorded accurately on the electronic weighing machine replicates wise at weekly interval in morning hours by withdrawing feeding troughs. From these data, the average weekly body weight and weight gain per bird were calculated for various treatment groups.

3.5.2 Feed Intake

Daily feed consumption was calculated from the amount of feed consumed by each group in a day. The average feed consumption was calculated from the total feed offered and the feed left over on the next day morning. Weekly feed consumption was calculated by adding up the daily average feed consumption of the particular week. Cumulative feed consumption of particular week was calculated by adding up the weekly average feed consumption of the previous weeks with the feed consumption of that particular week.

$$\textbf{Weekly feed intake (g/bird)} = \frac{\text{Total feed intake by all birds in treatment during a week}}{\text{No. of live chicks in the treatment during that week}}$$

3.5.3 Feed Conversion Ratio

Weekly feed conversion ratio was calculated by dividing the weekly feed consumption by weekly weight gain. The weekly cumulative feed conversion ratio was estimated by dividing the cumulative feed consumption or total amount of feed consumed up to that particular week by the body weight gain recorded upto that week.

$$\textbf{FCR} = \frac{\text{Total feed consumed (g)}}{\text{Gain in body weight (g)}}$$

3.5.4 Proximate composition of meat

The birds were slaughter at the end of 6th week of age. After removal of skin the dressing percentage were calculated.

Meat proximate analysis was done by following standard procedure of AOAC (2005).

3.6 Chemical Analysis

The chemical analysis of the experimental broiler rations were carried out as per A.O.A.C. (1995) for all the proximate principles.

3.7 Statistical analysis

The data generated during the experimental period was statistically analyzed by CRD given by Snedecor and Cochran (1994).

4. RESULTS AND DISCUSSION

The present study entitled "Effect of feeding Ashwagandha (*Withania somnifera*) root powder on the growth performance of broiler" was carried out to access the effect of Ashwagandha root powder.

The details of different parameters studied and result obtained under the investigation are discussed.

4.1 Proximate composition of experimental broiler ration

The proximate chemical composition of experimental broiler starter and finisher rations are presented in Table 4. It was observed that experimental broiler rations contained adequate nutrients for growth as per BIS (1992).

4.1.1 Starter ration

The proximate composition of experimental starter ration is given in Table 4. The crude protein and calculated metabolizable energy (ME) of the diet was 23.00 per cent and 2863.811 Kcal/kg, respectively.

4.1.2 Finisher ration

The proximate composition of finisher ration is given in Table 4. The crude protein and calculated metabolizable energy (ME) of the diet was 20.00 per cent and 2939.75 Kcal/kg, respectively.

Table 4. Per cent chemical composition of experimental broiler ration on dry matter basis

Nutrients	Broiler ration	
	Starter	Finisher
Crude protein	23.00	20.00
Crude fiber	4.60	3.78
Ether extract	4.80	4.30
Total ash	7.20	6.85
Nitrogen free extract	60.40	65.15
Acid insoluble ash	1.25	1.44
ME (Kcal/kg)	2863.811	2939.75

4.2 Growth performance

4.2.1 Cumulative body weights

The growth performance was assessed by recording the weekly body weight of experimental birds and weekly gain in weight. The data pertaining to average weekly body weight is presented in table 5 and depicted in Fig.1 and the ANOVA is given in table 5.1.

The mean initial body weights of day old broiler chicks were 46.50, 46.85, 46.60 and 46.60 g for treatments T_0, T_1, T_2 and T_3 respectively.

The average cumulative body weight at first week of age for T_0, T_1, T_2 and T_3 were 148.35, 148.25, 148.65 and 148.10 g, respectively. The highest weight was observed in treatment group T_2 (148.65 g) followed by T_0, T_1 and T_3. Average weekly cumulative body weight of chicks at first week of age in all treatments T_0, T_1, T_2 and T_3 were non-significant.

Table 5. Average weekly cumulative body weight (g) per bird

Age in weeks	Treatment groups				CD	S.E.
	T_0	T_1	T_2	T_3		
Initial	46.50	46.85	46.60	46.60	NS	0.38
1st week	148.35	148.25	148.65	148.10	NS	0.99
2nd week	375.40	374.75	372.80	371.85	NS	1.03
3rd week	718.85[b]	712.85[a]	714.25[a]	712.10[a]	4.04	1.43
4th week	1183.00[a]	1204.15[b]	1234.25[c]	1181.40[a]	5.02	1.79
5th week	1712.15[b]	1755.30[c]	1809.10[d]	1705.40[a]	5.43	1.93
6th week	2207.55[b]	2216.35[c]	2311.70[d]	2182.70[a]	5.33	1.89

NS- Non significant.

The average cumulative body weights at second week of age were 375.40, 374.75, 372.80 and 371.85 g, respectively for treatment T_0, T_1, T_2 and T_3. The highest weight was observed in treatment group T_0 (375.40 g) followed by T_1, T_2 and T_3. Average weekly cumulative body weight of chicks at second week of age in all treatments T_0, T_1, T_2 and T_3 were non-significant.

The average cumulative body weight at third week of age for treatments T_0, T_1, T_2 and T_3 were 718.85, 712.85, 714.25 and 712.10 g, respectively. The higher body weight was observed in T_0 treatment (718.85 g) followed by T_2, T_1 and T_3 group. Statistically, (ANOVA Table 5.1) the treatment T_0 was significantly ($P < 0.01$) superior over T_1, T_2 and T_3 upto 3rd week of growth.

The average cumulative body weight at fourth week of age for treatments T_0, T_1, T_2 and T_3 were, 1183.00, 1204.15, 1234.25 and 1181.40 g, respectively. The highest body weight observed in T_2 (1234.25 g) followed by T_1, T_0 and T_3 groups. The ANOVA (Table 5.1) showed that the treatment T_2 was significantly ($P < 0.01$) superior over other treatments. However treatment T_0 and T_3 was at par with each other.

The mean cumulative body weight at fifth week of age for T_0, T_1, T_2 and T_3 were 1712.15, 1755.30, 1809.10, 1705.40 g, respectively. The treatment differences were significant. The higher weight was observed in treatment T_2 (1809.1 g) followed by T_1, T_0 and lowest in T_3. The ANOVA (Table 5.1) showed that the treatment T_2 was significantly ($P < 0.01$) superior over other treatments.

The mean cumulative body weight at sixth week of age for T_0, T_1, T_2 and T_3 were 2207.55, 2216.35, 2311.70 and 2182.70 g, respectively. The treatment differences were significant to each other. The higher body weight observed in T_2 (2311.70 g) followed by T_1, T_0 and T_3 group. From ANOVA it was observed that treatment T_2 was significantly ($P < 0.01$) superior over other treatment. Same trend of weight gain was observed for fifth week also.

Table 5.1 Analysis of variance for the weekly cumulative body weight (g) per bird

Source	df	Initial		1st week		2nd week		3rd week	
		MSS	'F' value	MSS	'F' value	MSS	'F' value	MSS	'F' value
Treat-ment	3	0.44	0.15	1.07	0.05	54.83	2.60	183.11	4.45**
Error	76	2.90		19.58		21.05		41.14	

Source	df	4th week		5th week		6th week	
		MSS	'F' value	MSS	'F' value	MSS	'F' value
Treat-ment	3	12155.23	191.21**	45741.55	616.22**	64011.85	893.64**
Error	76	63.56		74.22		71.63	

** P < 0.01

On the perusal of the Table 5, it could be seen that highest cumulative body weight of 2311.70 g was obtained in broiler receiving 2.00 per cent Ashwagandha root powder (T_2) followed by 2216.35 g with 1.00 per cent Ashwagandha root powder in treatment T_1 and body weight of 2207.55 g was obtained with 0.0 per cent Ashwagandha root powder in T_0 and lowest body weight (2182.70 g) was observed in (T_3) receiving 3.00 per cent Ashwagandha root powder at end of 6th week.

The growth pattern indicated that optimum beneficial effect of Ashwagandha root powder could be achieved at 2.00 per cent level of inclusion. The other levels (1.00 per cent and 3.00 per cent) could not show any advantage over 2.00 per cent level of inclusion.

From the first week of age up to second weeks non-significant differences were observed in treatment groups T_1,

T_2, T_3 and control T_0. However from third week broilers in T_2 group grew substantially faster than the birds in other groups i.e. T_0, T_1, and T_3 resulting into higher weight gain. Therefore from the third week significant ($p<0.01$) difference in cumulative body weight gain was recorded in T_2 group as compared to T_1, T_3 and control group T_0. From the table 5 it may be observed that at the end of sixth weeks, the average cumulative body weights for treatment group T_0, T_1, T_2 and T_3 were 2207.55, 2216.35, 2311.70 and 2182.70 g, respectively. The average weekly cumulative body weight of experiment birds in T_2 group was recorded more as compare to birds in T_0, T_1, and T_3 group.

The results indicated that the experimental birds did not respond to the dietary treatments in form of herbal feed additives such as Ashwagandha during starter phase. However, the response to the herbal feed additive Ashwagandha at 2.00 per cent was better during finisher phase. Other treatment like Ashwagandha (1.00%) and control group gain more weight than the Ashwagandha (3.00%).

The present optimum level of inclusion of Ashwagandha is higher that reported earlier by Pedulwar (2004) who studied the effect of supplementation of roots of Ashwagandha at the rate of 0.5 per cent and 1.00 per cent on the performance of broilers. Higher body weight and net profit per bird, improved weight gain and better feed conversion ratio was observed in Ashwagandha supplemented groups of broilers.

4.2.2 Body weight gain

The data on the average weekly weight gain is presented in Table 6 and depicted in Fig.2 and the ANOVA is given in table 6.1.

The mean weight gain for T_0, T_1, T_2 and T_3 treatments were 101.85, 101.40, 102.50 and 101.50 g, respectively for first week of age. The highest weight gain was observed for T_2 (102.50 g) followed by T_0, T_3 and T_1 groups. The analysis of variance for mean weekly body weight gain at first week of age showed that treatment group T_0, T_1, T_2 and T_3 were non-significant.

Table 6. Average Weekly gain in body weight (g) per bird

Age in weeks	Treatment groups				CD	S.E
	T_0	T_1	T_2	T_3		
1st week	101.85	101.40	102.50	101.50	NS	1.10
2nd week	227.05	226.50	224.15	223.75	NS	1.33
3rd week	343.45	338.10	341.45	340.25	NS	1.92
4th week	464.15^a	491.30^b	520.00^c	469.30^a	6.08	2.16
5th week	529.15^a	551.15^b	574.85^c	524.00^a	7.03	2.50
6th week	495.40^c	461.05^a	502.60^c	477.30^b	7.97	2.83

NS- Non significant

The mean body weight gain for T_0, T_1, T_2 and T_3 treatment were 227.50, 226.50, 224.15 and 223.75 g, respectively at second week of age. The highest body weight gain was observed in treatment T_0 (227.05) followed by T_1, T_2 and T_3 groups. The analysis of variance for mean body weight gain at second week of age showed that control (T_0), T_1, T_2 and T_3 were non-significant.

Table 6.1 Analysis of variance for weekly gain in body weight (g) per bird

Source	df	1st week		2nd week		3rd week	
		MSS	'F' value	MSS	'F' value	MSS	'F' value
Treatment	3	1.83	0.075	54.74	1.54	100.24	1.36
Error	76	24.20		35.39		73.57	
Source	**df**	**4th week**		**5th week**		**6th week**	
		MSS	**'F' value**	**MSS**	**'F' value**	**MSS**	**'F' value**
Treatment	3	12935.08	139.02**	10805.91	86.77**	6983.21	43.65**
Error	76	93.03		124.52		159.95	

** P < 0.01

The mean body weight gains for T0, T1, T2 and T3 at third week of age were 343.45, 338.10, 341.45 and 340.25 g, respectively. The higher weight gain was observed in treatment T_0 (343.45 g) followed by T_2, T_3 and T_1. The analysis of variance showed that treatment group T_0, T_1, T_2 and T_3 were non-significant.

The mean body weight gain at fourth week of age for treatment T_0, T_1, T_2 and T_3 were 464.15, 491.30, 520.00 and 372.90 g, respectively. The higher body weight gain was observed in T_2 treatment (520.00 g) followed by T_1, T_3 and T_0 group. From the analysis of variance it is observed that the treatment T_2 was significantly ($P< 0.01$) superior over T_1, T_0 and T_3 whereas T_0 and T_3 were at par.

The mean body weight gain at fifth week of age for T_0, T_1, T_2, and T3 were 529.17, 551.15, 574.85 and 524.00, respectively. The higher weight gain was observed in T_2

(574.85 g) followed by T_1, T_0 and T_3 group. The ANOVA (Table 6.1) showed that the treatment T_2 was significantly ($P < 0.01$) superior over other treatments. Remaining for treatments were at par to each other.

The body weight gain at sixth week of age for T_0, T_1, T_2 and T_3 groups were 495.40, 461.05, 502.60 and 477.30 g, respectively. The higher weight gain was observed in treatment T_2 (502.60 g) followed by T_0, T_3, and T_1. The ANOVA (Table 6.1) showed that treatment T_2 was significantly ($P < 0.01$) superior over others. While T_1 and T_3 were at par to each other.

The value of weekly gain in body weight indicate that broiler chicks receiving 2.00 per cent Ashwagandha root powder feed grew significantly ($P < 0.01$) faster as compared to control followed by T_3 (3.00 per cent Ashwagandha root powder) and T_1 (1.00 per cent) Ashwagandha root powder.

The mean weekly weight gains showed significant ($p<0.01$) differences in T_0, T_1, T_2 and T_3 groups from fourth week of age. The average gain in body weight at sixth week for treatment T_0, T_1, T_2 and T_3 were 495.40, 461.05, 502.6 0 and 477.30 g respectively. It may be seen from Table 6 and ANOVA Table 6.1 that the average gain in body weight of treatment group T_2 was significantly higher ($p< 0.01$) as compared to treatment group and T_0 (control) from fourth week.

From table 6 it may be observed that the average weekly gain in body weight (g) per bird followed the trend of non-significant effect of dietary treatment among the experimental birds up to third week. However, the significant effect of dietary treatment was revealed from fourth week

indicating anabolic property of Ashwagandha which might have enhanced utilization of nutrients resulting in to growth promotion.

4.2.3 Feed consumption

The feed consumption of experimental broiler chicks was recorded at weekly interval throughout the experimental period of 6 weeks. The average weekly feed consumption of broiler chicks presented in Table 7 with its statistical analysis in Table 7.1 The pattern of feed intake depicted in Fig.3.

Table 7. Average weekly feed consumption (g) per bird

Age in weeks	Treatment groups				CD	S.E.
	T_0	T_1	T_2	T_3		
1st week	121.60	121.10	119.10	120.30	NS	1.39
2ndweek	314.60	310.4	307.00	312.60	NS	2.87
3rd week	516.10	504.70	501.70	512.70	NS	4.72
4th week	842.20^{c}	821.80^{b}	812.90^{a}	825.20^{b}	8.27	2.93
5thweek	1131.70^{c}	1043.70^{a}	1030.50^{a}	1105.80^{b}	14.44	5.12
6th week	1173.30^{c}	1050.30^{a}	1045.90^{a}	1115.30^{b}	13.00	4.61

NS- Non significant

The average feed consumption at first week of age for T_0, T_1, T_2 and T_3 were 121.60, 121.10, 119.10 and 120.30 g, respectively. The higher feed consumption was observed in T_0 (121.60 g) followed by T_3, T_1 and T_2. The analysis of variance table 7.1 showed that feed consumption in T_0, T_1, T_2 and T_3 were non-significant.

Table 7.1 Analysis of variance for weekly feed consumption (g) per bird

Source	df	1st week		2nd week		3rd week	
		MSS	'F' value	MSS	'F' value	MSS	'F' value
Treatment	3	23.95	0.62	215.20	1.31	909.68	2.04
Error	76	38.55		164.60		446.39	
Source	**df**	**4th week**		**5th week**		**6th week**	
		MSS	**'F' value**	**MSS**	**'F' value**	**MSS**	**'F' value**
Treatment	3	3009.52	17.47**	47316.1	90.07**	73004.75	171.46**
Error	76	172.23		525.30		425.79	

** P < 0.01

The average feed consumption at second week of age for T_0, T_1, T_2 and T_3 were 314.60, 310.40, 307.00 and 312.60 g, respectively. The higher feed consumption was observed in T_1 (314.60 g) followed by T_3, T_1 and T_2. The analysis of variance, table showed that feed consumption in T_0, T_1, T_2 and T_3 were non-significant.

The average feed consumption at third week of age for treatment T_0, T_1, T_2 and T_3 were 516.10, 504.70, 501.70 and 512.70 g, respectively. The higher feed consumption was observed in T_0treatment followed by T_3, T_1 and T_2. Statistically ANOVA (Table 7.1) showed that treatment differences in T_0, T_1, T_2 and T_3 were non-significant.

The average feed consumption at fourth week of age for treatment T_0, T_1, T_2 and T_3 were 842.20, 821.80, 812.90 and 825.20 g, respectively. The numerical higher feed consumption was observed in T_0 (842.20g). From ANOVA Table, it was indicated that average weekly feed consumption

in treatment T_2 was significantly (P< 0.01) less than all other treatments.

The average feed consumption at fifth week of age for treatment T_0, T_1, T_2 and T_3 were 1131.70, 1043.70, 1030.50 and 1105.80 g, respectively. The numerical higher feed consumption was recorded in T_0 treatment (1131.70 g) followed by T_3, T_1 and T_2. The analysis of variance showed that in treatment T_2 less feed was consumed as compare to other treatments. However T_1 and T_2 at par to each other.

The average feed consumption at sixth week of age for treatment T_0, T_1, T_2 and T_3 were 1173.30, 1050.30, 1045.90 and 1115.30 g, respectively. The higher feed consumption was observed in treatment T_0 followed by T_3, T_1 and T_2. ANOVA (Table 7.1) indicated that in treatment T_2 was significantly (P< 0.01) less feed was consumed than other treatments. Similarly, as during fifth week, the same trend of treatment i.e. T_1 and T_2 were found at par to each other.

Broiler chicks receiving 0.00 per cent level of Ashwagandha root powder consumed more quantity of feed (4099.50 g) as compared to supplemented group. The birds in T_1 receiving 1.00 percent Ashwagandha root powder consumed 3851.80 g of feed. Treatment T_3 receiving 3.00 percent Ashwagandha root powder required 3991.80 g of feed. Those in T_2 receiving 2.00 percent Ashwagandha root powder consumed 3816.9 g of feed, which was found lower than other treatments.

Similar findings were reported by Shisodiya *et al.* (2008) who conducted six weeks trial on 225 day old broiler

chicks, uniformly distributed into three groups of 75 chicks in each T_1, T_2 and T_3 group and fed with standard starter mash Group T_1 received standard broiler diet. Group T_2 and T_3 received standard broiler diet supplemented with Ashwagandha and commercial synthetic compound @ 0.05 per cent of feed, respectively. The supplementation of Ashwagandha and commercial synthetic compound recorded significant improvement in feed conversion ratio. However, in control group it was significantly higher than supplemented group.

4.2.4 Feed conversion ratio (FCR)

The mean weekly feed conversion ratio and their standard error at different weeks of age are presented in Table 8 and graphically representation of FCR upto sixth week of age is depicted in Fig. 4. The ANOVA is given in 8.1.

The average feed conversion ratio for first week of age, for T_0, T_1, T_2 and T_3 were 1.19, 1.19, 1.17 and 1.18, respectively. Better feed conversion ratio was observed in T_2 (1.17) treatment followed by T_3, T_1 and T_0. The analysis of variance showed that the all treatments were non-significant during 1st week period.

The average feed conversion ratio for second week of age for T_0, T_1, T_2 and T_3 were 1.39, 1.37, 1.37, and 1.40, respectively. The statistically better FCR was observed in T_1 and T_2 treatment than other treatments. From ANOVA, it was observed that, the all treatment were non-significant.

Table 8. Average weekly feed conversion ratio of experimental birds

Age in weeks	Treatment groups				CD	S.E
	T_0	T_1	T_2	T_3		
1st week	1.19	1.19	1.17	1.18	NS	0.02
2nd week	1.39	1.37	1.37	1.40	NS	0.01
3rd week	1.53^{b}	1.53^{b}	1.47^{a}	1.48^{a}	0.04	0.01
4th week	1.79^{c}	1.67^{b}	1.56^{a}	1.78^{c}	0.03	0.01
5th week	2.14^{d}	1.89^{b}	1.79^{a}	2.11^{c}	0.03	0.01
6th week	2.37^{c}	2.28^{b}	2.08^{a}	2.34^{c}	0.05	0.02

NS- Non significant.

Table 8.1 Analysis of variance for weekly feed conversion ratio of experimental birds

Source	df	1st week		2nd week		3rd week	
		MSS	'F' value	MSS	'F' value	MSS	'F' value
Treatment	3	0.0033	0.41	0.005	0.82	0.017	4.14**
Error	76	0.0079		0.004		0.004	
		4th week		5th week		6th week	
Source	df	MSS	'F' value	MSS	'F' value	MSS	'F' value
Treatment	3	0.23	119.45**	0.57	188.97**	0.33	53.44**
Error	76	0.002		0.004		0.0054	

** $P < 0.01$

The average feed conversion ratio for third week of age for treatment T_0, T_1, T_2 and T_3 were 1.53, 1.53, 1.47 and 1.48, respectively. The better FCR was recorded in T_2 treatment as compared to other treatments. However, T_0 with T_1 and T_2 with T_3 were at par to each other.

The average feed conversion ratio for fourth week of age for treatment T_0, T_1, T_2 and T_3 were 1.79, 1.67, 1.56 and

1.78, respectively. The analysis of variance showed that treatment T_2 was significantly ($P < 0.01$) superior over others. However, T_1 and T_3 were at par to each other.

The average feed conversion ratio for fifth week of age for treatment T_0, T_1, T_2 and T_3 were 2.14, 1.89, 1.79 and 2.11, respectively. The analysis of variance showed that treatment T_2 was significantly ($P < 0.01$) superior over others.

The average feed conversion ratio for sixth week of age for control, T_1, T_2 and T_3 treatments were 2.37, 2.28, 2.08 and 2.34, respectively. From ANOVA (Table 8.1) it was observed that, treatment T_2 was significantly superior ($P < 0.01$) for FCR over control, while T_1 and T_3 treatments were at par to each other.

It was seen from table 8 that feed conversion ratio of T_2 (2.00 % ARP) was significantly ($P < 0.01$) better than other Ashwagandha root powder fed groups and control group. It was observed that FCR was better in treated group as compared to control group.

The ultimate aim of broiler farmers is to have better FCR thereby reducing the feed cost and increased cost: benefit ratio. As evidence from the significantly improved FCR in present research with T2 (2.00 per cent ARP) treatment group and findings of research workers suggest and support the beneficial effects of Ashwagandha (*Withania somnifera*) root powder for improving utilization of all feed ingredients.

Similar findings were reported by Deka and Dutta (2003) who conducted an experiment on 120 day old White Leghorn chicks fed with AD1 (the extract of *Withania somnifera*, *Ocimum sanctum* and *Mangifera indica*). It was

observed that FCE (Feed Conversion Efficiency) was better in treated group as compared to control group.

4.2.5 Proximate meat composition

Table 9. Proximate composition of meat in different treatments

Treatment/ Parameter (%)	T_0	T_1	T_2	T_3	CD	S.E.
Moisture	72.95	72.55	74.15	72.30	NS	0.38
Dry Matter	27.05	27.45	25.85	27.70	NS	0.38
Ash	1.70	2.05	2.29	1.75	NS	0.47
Crude protein	19.40	19.05	20.30	19.70	NS	0.50
Crude fat	3.50	3.50	3.75	2.47	NS	0.27
NFE	48.45	50.05	48.85	49.85	NS	0.47

NS- Non significant.

Table 9.1 Analysis of variance for proximate composition of meat of experimental birds

Source	df	Moisture		Dry Matter		Ash	
		MSS	'F' value	MSS	'F' value	MSS	'F' value
Treatment	3	1.34	4.57	1.34	4.57	0.14	0.33
Error	4	0.29		0.29		0.45	
		Crude protein		Crude fat		NFE	
Source	df	MSS	'F' value	MSS	'F' value	MSS	'F' value
Treatment	3	0.56	1.13	0.65	4.37	1.19	2.68
Error	4	0.49		0.14		0.44	

** $P < 0.01$

The per cent moisture, dry matter, ash, protein, fat, and nitrogen free extract content under each treatment were 72.95, 72.55, 74.15 and 72.30 per cent moisture, 27.05, 27.45, 25.85 and 27.70 per cent dry matter, 1.70, 2.05, 2.29

and 1.75 per cent ash, 19.40, 19.05, 20.30 and 19.70 per cent protein, 3.50, 3.50, 3.75 and 2.47 per cent fat, 48.45, 50.05, 48.85 and 49.85 per cent NFE in T_0, T_1, T_2 and T_3 group, respectively were present.

Statistically the differences in proximate composition of meat were non-significant, which indicated that though the Ashwagandha improved FCE but it does not affect the meat quality.

4.2.6 Fatty acid profile of broiler meat

4.2.6.1 Effect of Ashwagandha root powder on Fatty acid Profile of Broiler breast meat (gm/100gm)

Table 10. Saturated fatty acids (%) profile of broiler breast meat

Parameter	Treatment				PSE
Fatty acids	**T_0**	**T_1**	**T_2**	**T_3**	
Myristic acid (C14:0)	0.63	0.61	0.57	0.66	0.02
Pentadcanoic acid (C15:0)	0.12	0.14	0.19	0.20	0.03
Palmitic acid (C16:0)	19.59	22.71	25.05	24.80	1.31
Heptadecanoic acid (C17:0)	0.25	0.20	0.28	0.20	0.03
Stearic acid (C18:0)	12.01	12.64	11.19	9.54	1.66
Arachidic (C20:2)	0.08	0.13	0.27	0.50	0.08
Total saturated fatty acids	32.68	36.43	37.55	35.9	

PSE= pooled standard error given in table.

Table 11. Monounsaturated fatty acids (%) profile of broiler breast meat

Parameter	Treatment				PSE
Fatty acids	**T_0**	**T_1**	**T_2**	**T_3**	
Palmitoleic acid (C16:1n-7)	1.99	3.43	3.01	4.05	0.41
Oleic acid (C18:1n-9)	34.84	34.43	28.31	29.44	1.26
Cis-11-Eicosenoic acid (C20:1)	0.41	0.42	0.37	0.50	0.03
Myristoleic acid (C14:1)	0.15	0.10	0.19	0.15	0.01
Total monounsaturated fatty acids	37.39	38.38	31.38	34.14	

PSE= pooled standard error given in table.

Table 12. Polyunsaturated fatty acids (%) profile of broiler breast meat

Parameter	Treatment				PSE
Fatty acids	**T_0**	**T_1**	**T_2**	**T_3**	
Linoleic acid (C18:2n-6)	16.22	8.83	13.58	17.04	1.63
α-linolenic acid (C18:3n-3)	0.90	0.90	0.75	0.65	0.08
Arachidonic acid (C:20:4n-6)	3.39	2.63	2.36	4.86	0.43
Eicosapentaenoic acid (C20:5n-3)	0.58	0.59	0.52	0.04	0.12
Cis-8,11,14-Eicosatrienoic (C20:3n-6)	0.15	0.18	0.24	0.22	0.02
Total polyunsaturated fatty acids	21.24	13.13	17.45	22.81	

PSE= pooled standard error given in table.

4.2.6.2 Effect of Ashwagandha root powder on Fatty acid Profile of Broiler Thigh meat (gm/100gm)

Table 13. Saturated fatty acids (%) profile of broiler thigh meat

Parameter	Treatment				PSE
Fatty acids	T_0	T_1	T_2	T_3	
Myristic acid (C14:0)	0.56	0.52	0.59	3.53	0.74
Pentadcanoic acid (C15:0)	0.17	0.30	0.14	0.18	0.04
Palmitic acid (C16:0)	22.56	10.63	23.39	23.26	3.12
Heptadecanoic acid (C17:0)	0.41	0.33	0.42	0.51	0.04
Stearic acid (C18:0)	12.64	10.25	11.16	11.42	0.49
Arachidic (C20:2)	0.34	15.79	0.69	0.33	3.83
Total saturated fatty acids	36.68	37.82	36.39	39.23	

PSE= pooled standard error given in table.

Table 14. Monounsaturated fatty acids (%) profile of broiler thigh meat

Parameter	Treatment				PSE
Fatty acids	T_0	T_1	T_2	T_3	
Palmitoleic acid (C16:1n-7)	3.27	2.94	3.61	3.01	0.15
Oleic acid (C18:1n-9)	32.31	33.12	31.10	31.31	0.47
Cis-11-Eicosenoic acid (C20:1)	0.39	0.23	0.38	0.36	0.04
Myristoleic acid (C14:1)	0.27	0.25	0.29	0.31	0.01
Total monounsaturated fatty acids	36.24	36.54	35.38	34.99	

PSE= pooled standard error given in table.

Table 15. Polyunsaturated fatty acids (%) profile of broiler thigh meat

Parameter	**Treatment**				**PSE**
Fatty acids	**T_0**	**T_1**	**T_2**	**T_3**	
Linoleic acid (C18:2n-6)	11.76	4.67	13.52	10.84	1.92
α-linolenic acid (C18:3n-3)	1.16	2.27	1.00	1.24	0.29
Arachidonic acid (C:20:4n-6)	3.23	1.59	2.29	1.65	0.38
Eicosapentaenoic acid (C20:5n-3)	0.27	4.05	0.17	0.46	0.94
Cis-8,11,14-Eicosatrienoic	0.19	0.28	0.24	0.19	0.02
Total polyunsaturated fatty acids	16.61	12.86	17.22	14.38	

PSE= pooled standard error given in table.

The data related to fatty acid profile of breast meat and thigh meat presented in tables 10 to 15. The fatty acid profile of either breast or thigh meat did not shown any specific trend as per the level of addition of Ashwagandha root powder.

Therefore, it was concluded that Ashwagandha is effective only to improve growth rate and feed efficiency in broiler. It does not have any effect on fatty acid profile of breast and thigh meat.

5. SUMMARY AND CONCLUSION

The present investigation entitled "Effect of Feeding Ashwagandha (*Withania somnifera*) root powder on the growth performance of broilers" was carried out to assess the effect of feeding Ashwagandha Root Powder (ARP) on body weights, body weight gain, feed consumption, feed efficiency (FCR) and proximate composition of meat.

Eighty day old, commercial broiler chicks of Vencobb strain were distributed into four treatments group of 20 chicks in each group. Each dietary treatment was having twenty replicates. The experimental broiler chicks were reared on deep litter system in well ventilated shed from 0-6 weeks. The Ashwagandha (*Withania somnifera*) root powder was added in experimental ration at the rate of 1.00 per cent, 2.00 per cent and 3.00 per cent to treatments T_1, T_2 and T_3 respectively. The control group (T_0) was without Ashwagandha (*Withania somnifera*) root powder.

5.1 Body weights

The average body weights at the end of sixth week for treatment group T_0, T_1, T_2 and T_3 were 2207.55, 2216.35, 2311.7 and 2182.7 g, respectively. This indicates that there was significant increase in body weight of birds in group T_2 over the control group.

The significant difference in weekly body weight was found from third week onward. The trend of significantly better growth was recorded in T_2 (2311.7 g) and T_1 (2216.35 g)

groups during fourth to sixth week. This indicates beneficial effect of feeding ARP (1.0%) and ARP (2.0%) than ARP (3.0%).

5.2 Weekly body weight gain

The initial body weight gain of broilers for all treatment groups were almost similar showing statistically non-significant difference up to third week of age.

The gain in body weight at sixth week for treatment groups viz., T_0, T_1, T_2 and T_3 were 495.4, 461.05, 502.6 and 477.3 g, respectively. At the end of sixth week average gain in body weight of the broiler chicks under group T_0 and T_2 was significantly ($P< 0.01$) higher as compared to those in group T_1 and T_3.

5.3 Weekly feed consumption

The average total weekly feed consumption gram/bird during the experimental period at end of 6^{th} week was recorded as 1173.30, 1050.3, 1045.9 and 1115.30 for T_0, T_1, T_2, and T_3, treatment groups, respectively.

The feed intake of all the chicks receiving Ashwagandha @ 2.00 % was lower as compared to other treatments.

5.4 Weekly feed efficiency

The feed conversion ratios during the sixth week were 2.37, 2.28, 2.08 and 2.34 for treatment group T_0, T_1, T_2 and T_3 respectively. The FCR was found to be statistically significant for different treatment groups from 3^{rd} week onwards.

5.5 Mortality percentage

The overall mortality in broilers of various groups during the experimental period was within the normal range (1%).

5.6 Conclusion

The effect of feeding of Ashwagandha root powder on growth performance of broiler indicated that 2.00 % of Ashwagandha root powder had significantly higher body weight and weekly gain in body weight along with better feed efficiency from the 4^{th} week onwards the treatment T_2 (2.00% ARP) had superior feed conversion ratio than other treatments. Similarly, the chemical composition of meat indicated that treatment T_2 had higher crude protein and fat.

It was concluded that for better feed efficiency and growth of broilers feeding of 2.00 % Ashwagandha root powder is beneficial.

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7. VITA

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of

MASTER OF SCIENCE (AGRICULTURE)

in

ANIMAL HUSBANDRY

2016

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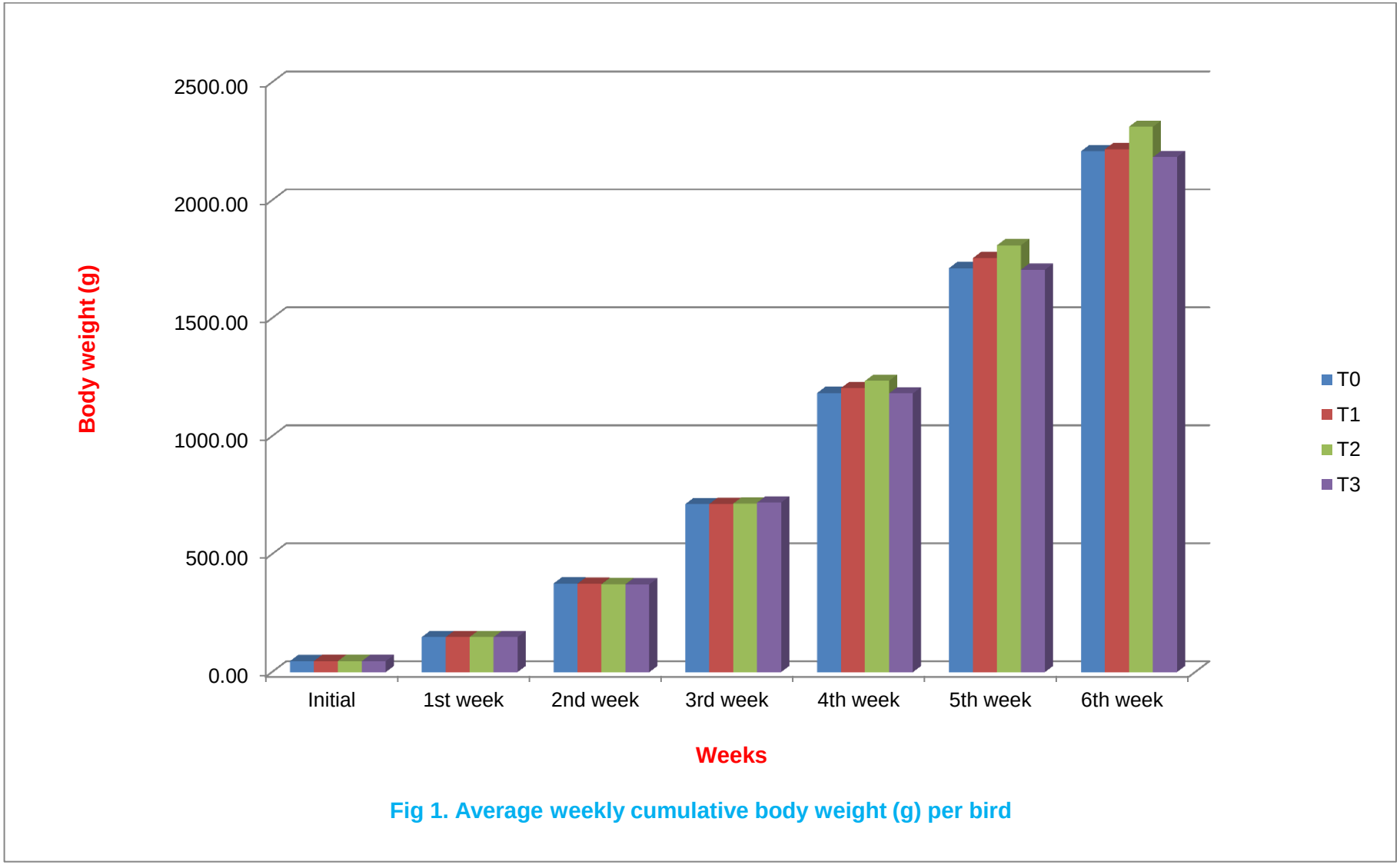

Fig 1. Average weekly cumulative body weight (g) per bird

Fig 2. Average weekly gain in body weight (g) per bird

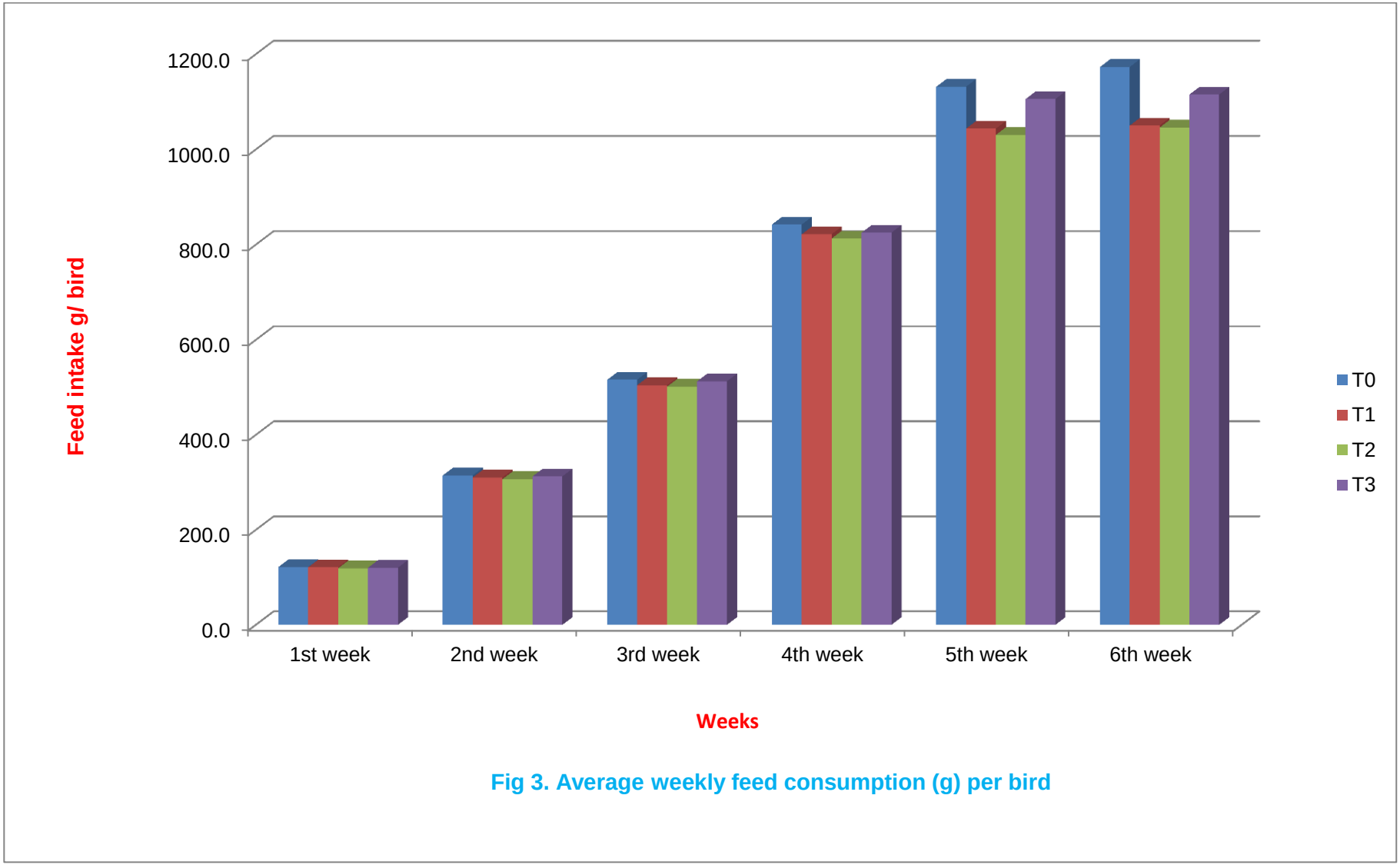

Fig 3. Average weekly feed consumption (g) per bird

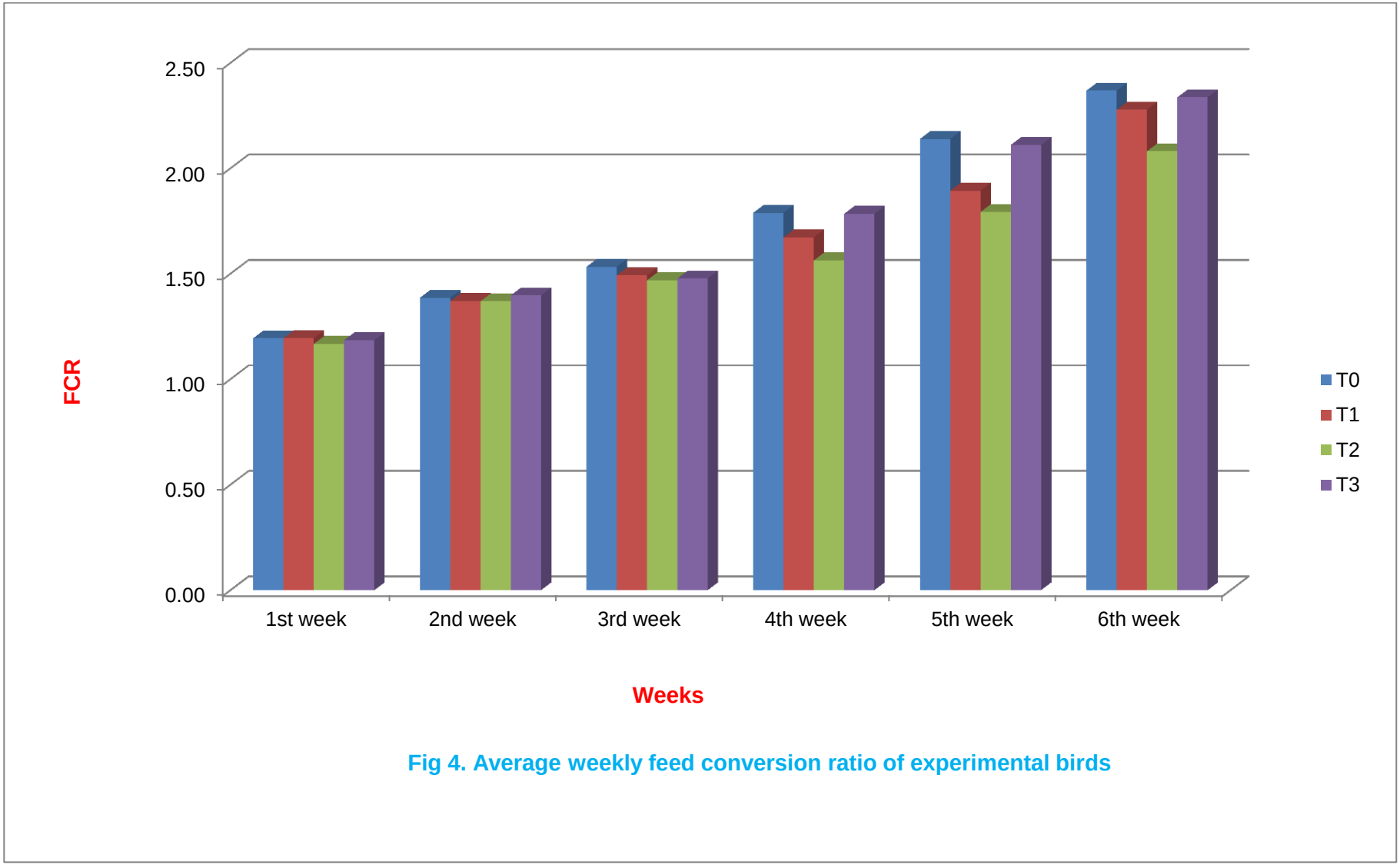

Fig 4. Average weekly feed conversion ratio of experimental birds