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Effect of feeding of culled carrot on carcass quality of rabbit

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Abstract
The present study was conducted to evaluate the effect of incorporating culled carrots in diets of New Zealand White rabbits on carcass quality and on feeding economics. Twenty-one New Zealand White rabbits (*Oryctolagus cuniculus*) were divided into three groups of 7 rabbits in each. Rabbits in CON group were fed on a plane concentrate mixture, whereas, T1 and T2 were fed concentrate mixture mixed with culled carrots @ 10% and 20% (on DM basis) respectively. Green berseem was offered *ad lib* to fulfil the remaining nutritional requirements. The proximate composition, total phenolic contents and DPPH assay of the culled carrot were analysed prior to start of experimental feeding. At end of experimental period of 90 days, rabbits were slaughtered to study the carcass attributes and keeping quality of meat. There was no significant effect ($p>0.05$) of feeding culled carrot on pre-slaughter weight, dressing percentage, yield of wholesome cuts, edible and non-edible organ, meat to bone ratio. Similarly, proximate composition, pH & WHC of *Longissimus dorsi* muscle was found non-significant among all the groups. However, the concentration of TBARS (mg MDA/kg) was significantly ($p<0.05$) lower in culled carrot fed group as compared to control. From an economic perspective, the study revealed that incorporating culled carrots led to significant reduction ($p<0.05$) in daily feed costs and total feed costs per kilogram of gain. There was a substantial cost savings observed in T2 (20% culled carrot) compared to other two groups. Consequently, it is concluded that culled carrots can be included in rabbit diets up to 20% level without compromising overall performance. Further, this not only maintains carcass quality but also enhances meat quality while offering cost-effective benefits.

Keywords: TBARS, carcass quality, culled carrot, economics of feeding, rabbits

Introduction
In India, fruit and vegetable production stands at an impressive 314.6 million tonnes (Horticulture Statistics at a Glance, 2018) [1]. However, a concerning 16% of this bounty is lost as waste, as highlighted in a report by Indian Council of Agricultural Research-Central Institute of Post-Harvest Engineering and Technology (ICAR-CIPHET), (Jha *et al.*, 2015) [2]. Surprisingly, Various reports has explained importance of fruit and vegetable wastes when in fresh conditions indicating their high nutritive quality and potential usage in livestock feed. Carrot, a crucial biennial or annual herb with a thick fleshy tap root, is cultivated in both winter and summer or spring, depending on the region's climate (tropical or temperate). According to horticulture statistics (2018) [1], India produces 1648 MT of carrots, but during harvesting, processing, and marketing, 10-15% is wasted, waste that could serve as valuable fodder for livestock (Bakshi and Wadhwa, 2016) [3].

In the fruit and vegetable market, the sellers or vendors separate the damage and defective carrots which is further treated as culled carrot. The culled carrots are not suitable for human consumption; however, are good sources of energy (13.76 MJ ME/kg DM), crude protein (10-13%), fibre and carotenoid (Goby and Gidenne, 2008 [4]; Wadhwa and Bakshi, 2013) [5]. Besides, it is rich in antioxidants, vitamins such as vitamin E (513 ug/100g), vitamin C (7 mg/100g), thiamine, riboflavin, niacin and folic acid (Alasalvar *et al.*, 2001) [6]. These antioxidant micronutrients are known to reduce the risk of cardiovascular ailments, probably by protecting lipoproteins from peroxidation, quenching free radicals and arresting cellular damage. Consequently, series of studies were conducted by Salisu *et al.* (2012) [7] and Ngoshe *et al.* (2013) [8] on effect of feeding carrots and observed the inclusion of 10 to 20% carrot meal in diet of rabbits showed improved slaughter weight, dressing percentage, wholesome cut (shoulder, loin, hind legs) yield without any unfavorable effect on body physiology.

Livestock production systems has managed to effectively reduce the feed costs and avoid competition with human food sources (i.e. grains) by employing unconventional feeds, unsaleable fruit and vegetables into a ration (Das *et al.*, 2019) [9]. The culled carrots, not suitable for human consumption are readily available in the vegetable markets at nominal cost and there are no deleterious effects reported so far due to its feeding in livestock. Therefore, the present study was conducted to unravel the effect of feeding culled carrot (*Daucus carota*) on carcass quality and feeding economics in rabbits.

Materials and Methods

Animal and diet: Twenty-one male New Zealand White (NZW) rabbits (average age 45±3 d and average body weight 711±33 g) were divided into three groups of 7 animals each. Group I was CON group, wherein rabbits only fed with a concentrate mixture, whereas, those in T1 and T2 were fed with a concentrate mixture mixed with culled carrots @ 10% and 20% (on DM basis) respectively. Green berseem was offered *ad lib* to rabbits in all study groups. The experimental diet was prepared to be iso-nitrogenous and iso-fibrous diet (concentrate mixture) (Table 1) to provide 18% crude protein and 12% crude fibre to all experimental rabbits as per ICAR. (2013) [10]. Every day, fresh carrots were purchased from nearby vegetable market, chopped into small pieces and fed to rabbits. The rabbits were individually offered weight quantity of diet at 09:00h and the residue was measured next morning to record daily feed intake.

Slaughtering: At the end of 6 weeks experimental feeding, all the rabbits were slaughtered after starving them for 12 hours ET by Halal method (Ramayyan *et al.*, 1980) [11]. Bleeding, skinning and evisceration were done as per the standard techniques at ICAR-IVRI experimental slaughter-house. The carcass was split into four primal cuts-two shoulder or fore legs, thorax or chest, loin and two legs. The two legs were separated by sharply cutting across the carcass immediately in front of hip joint. The lion was separated from the chest at the last rib. Two shoulders were removed from the chest by separating muscles between scapula and ribs (Hiner, 1962) [12]. The primal cuts were further separated into lean and bones to arrive at bone: meat ratio of total carcass (Blasco *et al.*, 1984) [13]. The weight of primal cuts was expressed as percentage of empty hot carcass weight. The weight of inedible offal's (blood, skin, feet and tail, lung and trachea, spleen and GI tract) and edible organs (liver, heart, kidney, head and giblet) were recorded soon after slaughter and expressed as percentage of liveweight. The dressing percentage of empty carcass, carcass with pluck and carcass with pluck and dressed head were expressed on fasted pre-slaughter weight (Lukefahr *et al.*, 1982). [14].

Chemical analysis, pH, Water holding capacity and TBARS: The representative meat sample collected from all primal cuts of sacrificed rabbits were mixed and minced thoroughly after removing visible fat for various parameters i.e. moisture, crude protein, ether extract and ash (AOAC, 2005) [15]. The pH of homogenised meat sample was estimated by digital pH meter (HI98127, pHep®4). Water holding capacity were determined by press method after applying pressure on meat sample kept in between two filter paper (Grau and hamm, 1956) [16]. Secondary lipid oxidation products were quantified by Thiobarbituric acid reactive substance (TBARS) analysis according to Vyncke (1970) [17] and Sørensen and Jørgensen (1996) [18] and expressed as malondialdehyde (MDA) equivalents.

Economics of feeding culled carrot: At the end of the study, the economics of feeding culled carrots was calculated. The calculation was done as per the available market price of feed ingredients at time of the experiment. The total feed cost Rs.day and feed cost Rs.kg live weight gain (kg) were calculated.

Statistical Analysis: Data generated from the study were subjected to the analysis of variance (ANOVA) as per the standard statistical procedures Snedecor and Cochran (2004) [19] using SPSS (version 20.0) software. The means of different treatment groups were compared by using Tukey's posthoc test (1953) [20].

Results and Discussion

Carcass attributes: The preslaughter weight (g), dressed weight (g), dressing percentage, carcass length (cm), meat to bone ratio) of experimental rabbit were found non-significant ($p>0.05$) among the groups (Table 1). The different parameters showed an increasing trend in T1 and T2 group. In this study, the non-significant difference observed in dressing percentage indicated that dietary protein level has no significant influence on the carcass traits (Ledin, 1982 [21]; Abou-Ashour and Ahmed, 1983 [22]; Deshmukh 1989 [23]). The body weight was positively correlated with dressing percentage, as heavier rabbits had higher dressing percentage (Milisits *et al.*, 2000) [24]. Furthermore, it is known that a lower growth rate affects the development of specific tissue so the development of the tissue depends upon body weight gain (Metzger *et al.*, 2003) [25]. The body weight gain was similar among groups resulting in similar dressing percentage. Similar meat to bone ratio were also reported by Dal Bosco *et al.* (2000) [26] in caged and pen-based rabbits.

Yield of wholesome cut, edible and non-edible organ: The yield of wholesome cut (two shoulder, thorax, loin and two legs), edible organ and non-edible organ were comparable among all three groups. In general, the weight of some internal organs i.e. liver and kidney are measured to evaluate toxicity effects inflicted due to the dietary component as reported by Bone (1979) [27]. The abnormalities will arise due to higher metabolic rate of the particular organs in order to convert the toxic elements into non-toxic compound. The normal liver and kidney weight in the rabbits in the present experiment suggested that the test diet was devoid of any harmful component or toxin. Deshmukh (1989) [23] reported no significant difference in yield of inedible organ except yield of blood which was higher in rabbits fed high protein (20% CP) diet. Similarly, Vasanthakumar *et al.* (2001) [28] reported the non-significant differences in yield of edible organs in rabbits fed neem seed kernel cake.

Chemical composition of longissimus dorsi muscle, pH and water holding capacity: The dry matter (DM), crude protein (CP), ether extract (EE), total ash (TA), water holding capacity (WHC) percentage and pH of *longissimus dorsi* muscle was similar ($p>0.05$) among the groups (Table 2). Results of several reports studying feeding of carrots in

rabbits (Bhosale, 1994[29]; Gowda, 1994[30]; Vasanthakumar *et al.*, 2001[28]; Dal Bosco *et al.*, 2000[26]) are in line with the present study. Besides, pH and WHC of *longissimus dorsi* muscle was found in agreements with the finding of Daszkiewicz *et al.* (2012) [31] and Dal Bosco *et al.* (2002) [32] in the rabbits.

Keeping quality: The TBARS (Thio barbituric acid reacting substances) concentrations (mg MDA/kg meat) was significantly ($p<0.05$) lower in T1 & T2 compared to CON and decreased linearly from CON to T2 (Table 2) (Fig.1). The reaction of MDA with 2-thiobarbituric acid is frequently thought to be a reliable indicator for determining the degree of lipid peroxidation (Havsteen, 2002) [33]. The TBARS value in the carcass is an important parameter for assessing the keeping quality as it indicates lipid peroxidation. Low TBARS values are preferred in carcasses. Polyphenols present in the diet of livestock are known to function as antioxidants and reported to lower the TBARS value (Wong *et al.*, 1995[34]; Aderao, 2017[35]). The present findings of TBARS were in accordance with reported range of 0.43 to 0.67 mg MDA/kg (Daszkiewicz *et al.*, 2012) [31]. While Dal Bosco *et al.* (2002) [32] reported a higher value of TBARS (1.08 to 3.56 mg MDA/kg) in rabbits reared in caged vs floor system. It is possible that in living animal, cell metabolism counteracts free radical production, whereas the stressors during pre-slaughter treatments (handling) enhance pro-oxidant factors (Dal Bosco *et al.*, 2002) [32]. Lower value of TBARS found in the treatment group suggests potential role of carrot consumption for enhancing antioxidant status and reducing lipid peroxidation (Nicolle *et al.*, 2003) [36] indicating the benefits of carrot feeding in rabbits.

Economics of feeding: The average total feed cost (Rs. /day) was significantly ($p<0.05$) lower in T1 and T2 compared to CON (Table 3) (Fig.2). The average feed cost (Rs.) per kg gain was statistically ($p<0.05$) lower in T2 as compared to CON; however, cost per kg gain in T1 was comparable with both CON & T2 (Fig.3). The average saving of Rs. 6.64 and 13.71 per kg gain was estimated that occurred due to replacing 10 and 20% of concentrate mixture with culled carrot respectively (Table 3). The observations regarding reduced feeding cost are in agreement with a study conducted by Salisu *et al.* (2012) [7] in growing rabbits fed on carrot meal. Rust and Buskirk (2008) [37] also reported lower feed cost per Mcal of ME when corn was replaced with carrot in cattle. Similarly, Bhosale (1994) [29] and Gowda (1994) [30] reported lower feed cost per unit gain in rabbits fed urea ammoniated neem seed kernel cake and water-soaked neem seed kernel meal, respectively.

Conclusion

From present study, it can be concluded that culled carrots can be included in rabbit diet up to 20% level without compromising overall performance. Besides, culled carrot feeding enhances meat quality while offering cost-effective benefits.

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