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Evaluation of quality characteristics of meat and edible by products of indigenous native chicken: Uttarafowl and its cross

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Abstract
Present study aimed at evaluating carcass and meat quality characteristics of native Indian chicken breed Uttara and its cross. Purebred Uttarafowl (U_{PB}) and crossbred Uttarafowl (Uttarafowl × Rhode Island Red) (U_{CB}) of age group 16-20 weeks are compared with that of Kadaknath (K) chicken for dressing percentage, meat yield, meat:bone ratio, cut-up yield, giblet weight and fatty acid profile of edible by-products. The breast muscle and giblet were also evaluated for physico-chemical properties such as proximate composition, WHC (water holding capacity), cholesterol and pH value. Findings of the studies are suggestive of significantly higher ($P<0.05$) dressing percentage of crossbred Uttarafowl, while purebred Uttarafowl had the highest ($P<0.05$) meat: bone ratio. Results for by product yield revealed that giblet weight, blood yield and skin yield were higher ($P<0.05$) in Kadaknath chicken. Proximate composition analysis showed significantly ($P<0.05$) higher moisture and protein content in Kadaknath breast than U_{PB} and U_{CB} bird. The cholesterol content also differed significantly ($P<0.05$) among all the three groups with highest ($P<0.05$) value observed in U_{CB}. Omega-3 fatty acid (C22:6N3) value was highest in that of Purebred Uttarafowl whereas, Omega-9 (C22:1N9) fatty acid was highest in muscle and liver of Kadaknath. The study concluded that Uttarafowl pure as well as cross can serve as valuable indigenous species meat source and establishing market for the Uttara chicken to establish it as quality meat type chicken.

Keywords: Uttarafowl, Kadaknath, indigenous chicken, carcass quality, physico-chemical, fatty acid profile

Introduction
Chicken is one of the most popular sources of meat among all poultry species [1]. Archaeological studies have indicated that chicken has been domesticated around 5400 BC. Chicken meat is widely popular in India, mainly because it is not associated with any religious taboo. The input-output ratio of meat from chicken is also very favorable. It has lower content of cholesterol and saturated fat as compared to red. Meat and is considered a healthy food. Regular consumption of poultry meat has many positive factors [2].

Due to their characteristic flavor and acclaimed medicinal benefits, the indigenous breeds of chicken in India are slowly gaining popularity. These breeds have the ability to thrive in rough. Climatic conditions. Native chickens are preferred by local farmers as their rearing requires very little input with high tolerance level to diseases and they also thrive well in local forages. There is growing demand for local indigenous chicken considering it delicious, tasty, and chewy, as well as healthy [3]. However, to increase the productive efficiency of backyard farming, exotic or improved poultry breeds have been introduced to the local farmers which in turn led to development of crossbred. chicken. Hence, to determine genetic purity of these native breeds of chicken, there is a need of proper identification, conservation and characterization of meat quality of these native chickens.

Uttarafowl is a native breed of chicken found in northern hilly regions of Uttarakhand state in India. It is reared in backyard system and provides economic as well as nutritional security to the bird rearing families in those regions [4]. The breed is being recently recognized, having a rich black-colored plumage as well as a characteristic feathered shank. But very less information is available in literature about this native breed of chicken as limited research work has been conducted on meat quality characteristics of the breed. In the present study, Uttarafowl and its cross is compared with another native chicken breed of India, Kadaknath popularly known as Kalamashi, mainly reared by tribal communities of Jhabua and Dhar districts in Madhya Pradesh along with the adjoining areas in Gujarat and Rajasthan.

Four different sub-types of Kadaknath are available viz., Golden, Black, Pencil and Silver. They are famous for their black-coloured meat [6]. Although the meat is not very appealing, still it is delicious and the eggs and meat are rich source of protein and iron. It is also claimed that Kadaknath chicken meat has aphrodisiac properties, along with its medicinal value in treatment of nervous and haemopoeitic ailments.

As very less data are available regarding carcass and meat quality characteristics of indigenous hill breed Uttarafowl and their crosses, so the present study was conducted to establish carcass quality characteristics and physico-chemical characteristics of Uttarafowl and its cross as compared to another indigenous, well recognized breed of poultry i.e. Kadaknath.

Materals and Methods

Chicken

Purebred Uttarafowl (U_{PB}), Crossbred Uttarafowl (Rhode Island Red × Uttarafowl) (U_{CB}) and Kadaknath (K) male of age groups between 16-20 weeks were procured from Instructional Poultry Farm of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar. A total of 18 birds comprising 6 birds from each group were selected from a random flock and sacrificed for this study.

Experimental design

The birds were first weighed to determine the live weight and then slaughtered according to standard procedures of slaughter at Department of Livestock Products Technology. The birds were then dressed according to standard procedure and each cut up part, giblet and byproduct was then weighed separately.

Analytical procedure

Estimation of carcass quality characters: Yield estimation of meat, cut-up parts and giblet (liver, heart and gizzard) and other byproducts (head, skin, bone, feather and blood) were done immediately after slaughter using standard formulae.

Dressing % and meat: bone ratio were calculated using the following folmulae:

$$\text{Dressing \%} = \frac{\text{Carcass weight (in grams)}}{\text{Live weight (in grams)}} \times 100$$

$$\text{Meat bone ratio} = \frac{\text{Muscle weight(g)}}{\text{Bone weigt(g)}}$$

Proximate composition: Proximate composition of breast muscle and giblets were determined by the standard methods of AOAC [7].

Physicochemical characteristics: pH was then recorded using pH SINTIX 3030i meter by immersing the pH meter electrode into aliquot of the samples, until a stable value was observed. WHC content of breast muscle and the giblets were estimated by centrifugation method as described by Wardlaw *et al.* [8]. Cholesterol content was determined as described by Rajkumar *et al.* [9].

Fatty acid profile: The fatty acid profile of the samples was calculated using Gas–chromatography mass-spectrophotometer where the method of O'Fallon *et al.* [10] for preparation of fatty acid methyl ester of samples was used. The samples were then sealed with paraffin wax for further use and analyzed for GC- MS where fatty acids are compared for their retention time with fatty acid methyl standard and expressed as % fatty acid.

Statistical analysis

The whole experiment was repeated three times and each sample was evaluated in duplicates (n=6). Statistical analysis of the result obtained in the form of data was then done using ANOVA technique using completely randomized design (CRD). SPSS (Statistical Package for Social Sciences) 20.0 (SPSS Inc, Chicago, II USA) software was used for analyzing the data. Significant difference between the data was determined using Duncan's Multiple Range test (DMRT).

Results and Discussion

Carcass quality characteristics

Meat yield: Study revealed non-significant ($P<0.05$) difference in live weight of K, U_{CB} and U_{PB}. The live weight of Kadaknath was higher than reported by Haunshi and Prince [11], who observed that Kadaknath attains the body weight of 865 g at 20 weeks of age.

Significant ($P<0.05$) difference between mean defeathered weight of U_{PB}, U_{CB} and K was observed and highest ($P<0.05$) value was observed for U_{PB} followed by U_{CB}.

Significantly ($P<0.05$) higher values of dressing percentage were observed for U_{PB} followed by U_{CB} as compared to that of K (Table 1). Higher dressing percentage of hilly indigenous chicken breeds in present study might be related to better adaptability in different climatic conditions. Dyubele *et al.* [12] also observed higher dressing percentage of indigenous chicken breed as compared to broiler chicken. Despite a lower live weight, higher dressing percentage value was observed for Uttarafowl which might be because of its hardiness and diseases resistance characteristics contributing to its growth and muscular development during rearing period.

Uttarafowl (U_{PB}, U_{CB}) showed significantly ($P<0.05$) higher meat:bone ratio values as compared to that of K. Bai *et al.* [13] observed meat:bone ratio of backyard native chicken (BNC) procured from native breeding population of Tumkur district of Karnataka as 1.05 ± 0.01. Higher meat:bone ratio of Uttarafowl might be because of better adaptability and higher feed conversion ability of hilly chicken.

Table 1: Comparison of Meat Yield between Uttarafowl (U_{PB}, U_{CB}) and Kadaknath (K)

Parameters	U_{PB}	U_{CB}	K	Overall Mean
Live wt (kg)	1.04±29.840	1.06±46.874	1.13±53.101	1.07±25.706
Defeather wt(g)	849.02±5.999^{c}	908.52±4.501^{b}	1020.31±11.481^{a}	925.95±17.253
Carcass wt (g)	573.45±6.491^{c}	618.37±5.668^{b}	689.59±4.231^{a}	627.13±11.931
Dressing%	57.00±0.531^{a}	57.57±0.500^{a}	50.80±0.265^{b}	55.12±0.781
meat:bone ratio	0.94±0.009^{a}	0.84±0.013^{b}	0.79±0.017^{c}	0.86±0.016

n = 6, Data represents Mean ± S.E. values bearing different superscript in each row by small alphabets (a, b, c) differ significantly ($P<0.05$)

Cut-up yield: The Mean ± S.E. values of cut-up yield of U_{PB}, U_{CB} and K have been presented in Table 2. The highest neck weight was observed in U_{CB}, followed by K and U_{PB}. Thutwa *et al.* [14] observed higher values for neck weight of some indigenous local chicken (two strains of Tswana chickens). There was a significant ($P<0.05$) difference between the values of wing weight of U_{PB} and the other two groups. A significant ($P<0.05$) difference was observed between mean back weight value of U_{PB} and the other two groups. The highest value of thigh weight was observed in K, followed by U_{PB} and U_{CB}. The results of the present study were in agreement with that of Singh and Tanwar [15], who observed mean thigh weight values of 118.44g and 149.80g in 16 week old Kadaknath chicken and Pearl Guinea fowl respectively. U_{CB} showed a non-significantly ($P>0.05$) higher mean drumstick weight value than the other two groups.

Table 2: Comparison of Cut-up yield (g) between Uttarafowl (U_{PB}, U_{CB}) and Kadaknath (K)

Parameters	U_{PB}	U_{CB}	K	Overall Mean
Neck wt	36.84 ± 1.040^{c}	40.28 ± 1.214^{a}	38.19 ± 0.704^{ab}	38.43±0.645
Wing wt	86.65 ± 0.437^{a}	76.50 ± 0.961^{b}	77.09 ± 1.075^{b}	80.08±1.223
Breast wt	146.32 ± 3.499^{b}	150.37 ± 1.543^{b}	210.27 ± 5.575^{a}	168.98±7.390
Back wt	111.46 ± 4.188^{b}	146.63 ± 2.419^{a}	139.02 ± 3.496^{a}	132.37±4.117
Thigh wt	107.38 ± 3.998^{b}	105.14 ± 6.696^{b}	117.59 ± 3.839^{a}	110.03±3.018
Drumstick wt	105.49±6.431	108.58±3.575	99.21±4.073	104.42±2.772

n = 6, Data represents Mean ± S.E. values bearing different superscript in each row by small alphabets (a, b, c) differ significantly ($P<0.05$)

Giblet yield: The highest mean heart weight value was observed in K, followed by U_{CB} and U_{PB} (Table 3). The mean liver weight of K was also significantly ($P<0.05$) higher than that of U_{PB} and U_{CB}. The results of the current study were similar to the findings obtained by Taha *et al.* [16] in case of local Egyptian and Canadian chicken strains**.** K had a significantly ($P<0.05$) higher giblet weight value than U_{PB} and U_{CB}.

Table 3: Comparison of Giblet Yield(g) between Uttarafowl (U_{PB}, U_{CB}) and Kadaknath (K)

Parameters	U_{PB}	U_{CB}	K	Overall Mean
Heart	4.58 ± 0.168^{c}	5.60 ± 0.091^{b}	6.23 ± 0.147^{a}	5.47±0.181
Liver	25.22 ± 1.376^{b}	24.87 ± 0.993^{b}	32.11 ± 1.625^{a}	27.40±1.093
Gizzard	26.10 ± 1.013^{a}	24.11 ± 1.125^{ab}	22.13 ± 0.684^{b}	24.11±0.652
Giblet	56.37 ± 0.984^{b}	53.20 ± 1.489^{b}	61.67 ± 0.980^{a}	57.08±1.061

n = 6, Data represents Mean ± S.E. values bearing different superscript in each row by small alphabets (a, b, c) differ significantly ($P<0.05$)

By-Product yield: The Mean±S.E. values of by-product yield of U_{PB}, U_{CB} and K have been presented in Table 4. K showed a non-significantly ($P > 0.05$) higher head weight value than U_{CB} and U_{PB}. A significant ($P<0.05$) difference was observed between mean shank weight and mean blood yield value of U_{PB}, U_{CB} and K. Similar studies were conducted by Munira *et al.* [17], who reported shank weight value of 58.00g in case of RIR. The mean value for skin yield was significantly ($P<0.05$) higher for K in comparison to U_{PB} and U_{CB}. The higher value of skin yield in indigenous breeds of chicken in comparison to crosses might be due to higher subcutaneous fat in case of indigenous chicken. The highest mean inedible viscera weight was observed in K. Present study revealed a non-significant ($P>0.05$) difference between mean bone weight values of K and the other two groups.

Table 4: Comparison of By-Product Yield(g) between Uttarafowl (U_{PB}, U_{CB}) and Kadaknath (K)

Parameters	U_{PB},	U_{CB}	K	Overall Mean
Head	40.24±1.686	42.27±1.308	42.91±1.869	41.81±0.930
Shank	46.90 ± 1.303^{a}	45.58 ± 0.801^{ab}	41.94 ± 1.715^{b}	44.80±0.881
Blood	26.79 ± 1.004^{b}	29.01 ± 0.922^{b}	35.96 ± 1.608^{a}	30.58±1.154
Feather yield	233.31 ± 2.185^{a}	219.05 ± 4.347^{ab}	213.26 ± 6.319^{b}	221.87±3.219
Skin	63.54 ± 1.606^{b}	62.05 ± 1.928^{b}	80.91 ± 2.467^{a}	68.83±2.350
Inedible viscera wt	77.42 ± 1.686^{ab}	74.93 ± 2.841^{b}	82.56 ± 1.301^{a}	78.30±1.352
Bone	277.37 ± 6.445^{b}	296.46 ± 4.983^{a}	280.68 ± 5.887^{ab}	284.83±3.791

n = 6, Data represents Mean ± S.E. values bearing different superscript in each row by small alphabets (a, b, c) differ significantly ($P<0.05$)

Proximate composition

Proximate composition of breast muscle: Study revealed a highly significant ($P<0.01$) difference between mean value for moisture content of breast meat of U_{PB}, U_{CB} and K. The present study revealed higher moisture content for breast muscle as compared to the results obtained by Jaturasitha *et al.* [18]**.** Also a highly significant ($P<0.01$) difference was observed between mean value of protein content in breast meat of U_{PB}, U_{CB} and K (Table 5). K had higher ($P<0.01$) protein content than U_{CB} and U_{PB} which maybe as a result of better conversion of feed into muscle protein. The highest fat content was observed in breast meat of U_{CB} and the highest total ash value was observed in $U_{PB.}$ Breast muscle of all treatments showed lower fat content as compared to the giblet as also observed in the findings of Razmaitė *et al*. [19]**.**

Proximate composition of giblet: A highly significant ($P<0.01$) difference was observed between mean value of moisture content in heart of U_{PB}, U_{CB} and K. The highest protein content of heart was observed in K (Table 5). The protein content in Kadaknath liver in the present study was in accordance with that of Singh and Pathak [20]**,** who observed 19.02% protein content in liver of Kadaknath chicken. The highest fat content was observed in liver of U_{CB}. The value of

moisture content of U_{PB} differed significantly ($P<0.05$) with that of U_{CB} and K. K had the highest ($P<0.05$) protein content, followed by U_{PB} and U_{CB} (Table 5).

Table 5: Comparison of proximate composition (%) of breast meat, heart, liver and gizzard in Uttarafowl (U_{PB}, U_{CB}) and Kadaknath (K)

Parameters	U_{PB}	U_{CB}	K	Overall Mean
Breast Moisture	76.50±0.141^{b}	76.65±0.209^{b}	79.51±0.124^{a}	77.55±0.348
Breast Protein	16.50±0.099^{c}	17.27±0.068^{b}	18.55±0.152^{a}	17.44±0.213
Breast Fat	2.89±0.099^{b}	3.56±0.092^{a}	2.39±0.040^{c}	2.95±0.125
Breast Ash	1.71±0.012^{a}	1.53±0.016^{b}	1.42±0.013^{c}	1.55±0.029
Heart Moisture	72.40±0.134^{b}	75.36±0.315^{a}	75.21±0.469^{a}	74.32±0.377
Heart Protein	10.68±0.014^{b}	10.28±0.023^{c}	11.59±0.021^{a}	10.85±0.133
Heart Fat	9.86±0.017^{b}	10.87±0.014^{a}	7.32±0.015^{c}	9.35±0.362
Heart Ash	0.29±0.007^{c}	0.67±0.011^{a}	0.45±0.015^{b}	0.47±0.038
Liver Moisture	76.23±0.049^{b}	77.40±0.126^{a}	76.36±0.088^{b}	76.66±0.136
Liver Protein	18.29±0.017^{b}	17.63±0.014^{c}	19.05±0.011^{a}	18.31±0.137
Liver Fat	4.72±0.022^{c}	5.67±0.015^{a}	4.81±0.019^{b}	5.06±0.103
Liver Ash	0.93±0.011^{b}	0.82±0.012^{c}	1.03±0.017^{a}	0.93±0.021
Gizzard Moisture	77.30±0.106^{b}	78.56±0.098^{a}	78.53±0.120^{a}	78.13±0.154
Gizzard Protein	18.26±0.023^{b}	17.67±0.015^{c}	19.24±0.015^{a}	18.39±0.157
Gizzard Fat	2.93±0.024^{b}	3.28±0.023^{a}	2.74±0.017^{c}	2.98±0.055
Gizzard Ash	1.21±0.022^{a}	0.92±0.020^{b}	0.82±0.013^{a}	0.98±0.040

n = 6, Data represents Mean ± S.E. values bearing different superscript in each row by small alphabets (a, b, c) differ significantly ($P<0.05$)

Physico-chemical characteristics

Water holding capacity (WHC): A highly significant ($P<0.01$) difference was observed between mean WHC value of raw breast meat of U_{PB}, U_{CB} and K (Table 6), where lowest values were observed for U_{PB}. K showed the highest value of water holding capacity whereas, U_{CB} showed the lowest. Good WHC value indicates improved meat quality probably due to intact structure of protein [21].

Cholesterol content: Results of the current study revealed a highly significant ($P<0.01$) difference between mean cholesterol content value of raw breast meat of U_{PB}, U_{CB} and K with U_{CB} showing the highest ($P<0.01$) cholesterol content, followed by U_{PB} and K (Table 6). The results of the present study were in accordance with Jaturasitha *et al.* [22], who observed that the cholesterol content in indigenous chicken was lower in comparison to broiler chicken.

pH of breast meat and giblet: A non-significant ($P>0.05$) difference was observed between mean pH value of raw breast meat of U_{PB}, U_{CB} and K. Similar findings were obtained by El-Attrouny *et al.* [23] for pH of breast meat of two Egyptian indigenous breeds of chickens (Benha line and Golden Montazah). A highly significant ($P<0.01$) difference was seen between mean pH value of heart of U_{PB}, U_{CB} and K. U_{CB} had the highest pH value of heart and U_{PB} had the lowest value (Table 6). Highest pH value of liver was observed in K whereas, the lowest pH value was observed in U_{PB}. The present study revealed a highly significant ($P<0.01$) difference between mean pH value of gizzard of U_{PB}, U_{CB} and K.

Table 6: Comparison of Cholesterol content, WHC and pH of breast meat and giblets of Uttarafowl (U_{PB}, U_{CB}) and Kadaknath (K)

Parameters	U_{PB}	U_{CB}	K	Overall Mean
WHC (%)	33.43±0.098^{b}	29.45±0.150^{c}	37.30±0.109 ^{a}	33.39±0.779
Cholesterol (mg%)	62.57±0.130^{b}	72.35±0.102^{a}	58.44±0.133^{c}	64.45±1.415
pH Breast Meat	5.88±0.026	6.07±0.042	5.90±0.128	5.95±0.047
pH Heart	6.61±0.027^{c}	6.88±0.009^{a}	6.74±0.026^{b}	6.74±0.028
pH Liver	6.69±0.021^{a}	6.71±0.027^{a}	6.56±0.047^{b}	6.65±0.024
pH Gizzard	6.47±0.021^{b}	6.59±0.030^{a}	6.61±0.029^{a}	6.56±0.021

n = 6, Data represents Mean ± S.E. values bearing different superscript in each row by small alphabets (a, b, c) differ significantly ($P<0.05$)

Fatty acid profile of breast muscle, liver and heart: Results of fatty acid profile (Table 7) indicated that breast muscle of U_{CB} had significantly ($P<0.05$) higher Palmitic acid (C16:0) content in comparison to the other two. Whereas, the level of Lauric acid (C12:0) was significantly ($P<0.05$) higher in the liver of K. Highest content of Oleic *acid* (*C18:1n9c*) was found in breast muscle and heart of U_{PB} liver of U_{PB}. Saturated fatty acid, unsaturated fatty acid, omega-6 and omega-9 content can be highly affected by the source of meat [24]. C18:2N6C (Linoleic acid) was found in highest quantity in breast muscle as well as liver of U_{CB}. Omega-3 fatty acid (C22:6N3) value was highest in the breast muscle of U_{PB} while Omega-9 (C22:1N9) fatty acid was highest in muscle and liver of K. Higher PUFA content was also reported by Sokolowicz *et al.* [25] in native breeds.

Table 7: Fatty acid profile of Uttara (U_{PB}, U_{CB}) and Kadaknath (K) chicken

Fatty Acid	U_{PB}- Muscle	U_{CB} Muscle	K Muscle
C4:0	98.657^{ab}	95.2646^{de}	97.3733^{bcd}
C6:0	0.0005	.	.
C8:0	0.0001	0.0001	.
C10:0	0.0012^{d}	0.004^{b}	0.0009^{e}
C12:0	0.0005^{f}	0.0027^{b}	0.001^{d}
C14:0	0.0057^{g}	0.0276^{b}	0.0079^{d}
C14:1	.	0.002	.
C15:1	0.0042^{d}	0.0077^{b}	0.0024^{ef}
C16:0	0.0478^{d}	0.0848^{b}	0.0726^{c}
C16:1	0.0152^{d}	0.0790^{i}	0.347^{f}
C17:0	.	0.0082	0.0306
C17:1	.	0.0479	0.0114
C18:0	0.0295^{de}	0.0539^{b}	0.0427^{c}
C18:1N9C	0.4273	.	0.7077
C18:2N6C	0.3541	1.657	.
C18:3N6C	0.0243	0.0023	.
C20:0	0.0076	0.9513	0.508
C21:0	.	.	.
C20:2	0.0082	0.0106	0.0109
C22:1N9	.	0.193	0.2772
C20:4N6	.	.	.
C22:2	0.0125^{i}	0.0648^{ef}	0.0769^{e}
C24:0	.	0.1463	0.1162

n = 6, Data represents Mean ± S.E. values bearing different superscript in each row by small alphabets differ significantly (P<0.05)

The findings of the present study indicated that carcass yield characteristics of purebred and cross bred Uttarafowl were comparable to that of Kadaknath indicating the potential use of the breed to establish as good quality meat type chicken breed to provide nutritional and economical security to the society. Higher dressing percentage as well as meat: bone ratio of purebred and crossbred Uttarafowl in addition to better adaptability of the breed to a wide range of climatic condition opens up the opportunity of the chicken to establish its meat market for the consumer preferring the meat of native chicken breed.

Plate 1: Dressed carcass and edible by-products of Purebred Uttarafowl (UPB)

Plate 2: Dressed carcass and edible by-products of Crossbred Uttarafowl (UCB)

Plate 3: Dressed carcass and edible by-products of Kadaknath (K)

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