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Effect of Dietary Supplementation of Sea Buckthorn Leaf Meal on Egg Production Performances by Coloured Breeder Birds During Summer Season

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Abstract

The present experiment was conducted to study the effect of sea buckthorn leaf meal (SBTLM) supplementation on hen house and hen day egg production in ninety coloured Chabro adult breeder hens and 18 viable cocks in 1:5 sex ratio were randomly distributed into three dietary treatment groups: Control (Basal), standard breeder diet (BIS, 2007); basal+ 0.5% and basal+1.0% SBTLM. The average egg production during 5th week were significantly higher ($p<0.01$) in basal diet+1.0% SBTLM supplemented group (72.86) as compared to basal diet+0.5% SBTLM and control or basal diet groups (56.67 and 62.3). However, during 11th and 12th week of experimental feeding, the weekly hen house egg production were significantly higher ($p<0.01$) in both the SBTLM supplemented groups than the control group. The overall egg production up to the 12th week of experimentation were significantly higher ($p<0.01$) in basal diet +1.0% SBTLM supplemented groups as compared tocontrol group. During the experimental study period, there was no mortality in any treatment group. Hence, the hen day egg production per week and phase wise hen day egg production per week was equal to the hen house egg production per week and phase wise egg production per week, respectively.

Keywords: Coloured chicken; Breeder; Chabro and sea buckthorn.

Introduction

Poultry meat and eggs are the cheapest and best source of quality animal protein. Impressive growth has been achieved in commercial poultry farming but the rural poultry sector remains unchanged. Due to limited feed resources and changing agro climatic conditions of our country, backyard poultry happens to be best viable alternative to ensure nutritional security and agricultural sustainability by utilizing locally available resources. The impressive growth in poultry industry is the result of

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technological breakthrough in feeding, breeding, management and health care (Pathak *et al.,* 2015). The World Health Organization estimated that approximately 80% of the earth's inhabitants rely on traditional medicines for their primary health care needs as well as to improve the productive and reproductive performances of poultry. Herbal medicines may serve as safer alternatives as growth promoters due to their suitability and preference, lower cost of production, improved feed efficiency, fast growth, reduced mortality, reduced risk of diseases, minimum health hazards and environmental friendliness. Sea buckthorn (*Hippophae rhamnoides* L.), a unique and valuable plant has gained worldwide attention, mainly for its medicinal and nutritional potential (Nazir *et al.,* 2017). Sea buckthorn is a thorny, dioecious, wind pollinated, multipurpose temperate bush plant bearing yellow or orange berries with nitrogen fixing abilities. It is commonly known as "cold desert gold" due to its various beneficial effects over plant, animal, human & soil health. Sea buckthorn is a small shrub comprising of fruit and leaves that are rich in nutrients and bioactive components such as vitamins (Kudritskaya *et al*., 1989), amino acids (Repyakh *et al*., 1990), lipids (Goncharova and Glushenkova, 1993), sugars and acids (Yang, 2009), and flavonoids (Häkkinen *et al*., 1999). Studies have shown that the leaves and fruit residues of sea buckthorn could be used to feed poultry and livestock without the accumulation of toxins, and that the feed also had a stimulating effect on growth and performance of poultry and livestock (Liu *et al.,* 1989). The leaves of SBT are very nutritious and can be fed to the livestock and poultry after value addition. As protein is the most expensive nutrient, by introducing new protein source in breeder diet, we can certainly decrease the cost of production and increase the profit per birds leading to socio-economic up-liftment of poultry farmers during intense summer season.

Materials and Methods

Ninety coloured chicken breeder (Chabro) hens and eighteen viable cocks were obtained from the Poultry farm of the U.P. Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go-Anusandhan Sansthan, Mathura. These birds were randomly distributed into three treatment groups having three replicates of 10 hens and 2 cock each of uniform age, production and in good health condition. The basal/control group was kept on standard breeder diet (BIS, 2007) and other two treatment groups were supplemented with 0.5% and 1.0% sea buckthorn leaf meal (SBTLM). These breeder birds were reared under deep litter system and standard managemental conditions. Throughout the experimental period the birds were offered fixed weighed quantity (110 g/day) feed (adequate in all nutrients) as per BIS (2007) and water *ad lib*.

Results

The average morning, afternoon and evening Temperature Humidity Index (THI) values ranged from 79.07 to 83.70, 84.83 to 88.79 and 82.72 to 87.14, respectively up to twelve weeks of experimentation. The average minimum and maximum temperature (^{o}C) up to twelve week of experimentation ranged from 21.21 to 25.07 and 36.86 to 41.23, respectively.

The average egg production during 1st week of experimentation was 63.33, 62.86 and 62.38, while at the end of 12th week of experimentation was recorded as 49.05, 58.09 and 57.62 in basal diet, basal diet + 0.5% SBTLM and basal diet + 1.0% SBTLM dietary groups respectively. There were no significant differences in average hen house egg production during 1st, 2nd, 3rd, 4th and 6th to 8th week of experimentation among various dietary treatment groups. However, during 11th and 12th week of experimental feeding, the weekly hen house egg production was significantly higher ($p<0.01$) in both the SBTLM supplemented groups than the control group fed the basal diet. The average hen house egg production during 5th week was 56.67, 62.38 and 72.86, during 11th week was 56.67, 62.38 and 72.86 while in 12th week of experimentation 49.05, 58.09 and 57.62, respectively in basal diet, basal diet + 0.5% SBTLM and basal diet + 1.0% SBTLM dietary groups dietary of breeder birds (Table 1).

The overall hen house egg production in basal diet + 1.0% sea buckthorn leaf meal supplemented groups (67.70) were significantly higher ($p < 0.05$)

Hen day egg production per week

During the experimental study period, there was no mortality in any treatment group. Hence, the hen day egg production per week and phase wise hem day egg production per week was equal to the hen house egg production per week and phase wise egg production per week, respectively.

Table 1: Effect of dietary supplementation of sea buckthorn leaf meal on the average weekly hen house egg production (HHEP) of breeder birds during summer season

Treatments	Weeks												
	1	2	3	4	5	6	7	8	9	10	11	12	0-12
Basal diet	63.33	60.95	62.86	79.05	56.67a	55.71	55.24	55.24	53.33	57.14	56.67a	49.05a	57.10a
Basal diet + 0.5% SBTLM	62.86	64.76	67.14	66.67	62.38a	60.95	61.90	62.38	61.90	64.29	66.19b	58.09b	63.29ab
Basal diet + 1.0% SBTLM	62.38	66.67	70.48	72.38	72.86b	65.72	69.52	68.57	64.76	68.57	72.86b	57.62b	67.70b
SEM	1.21	2.16	2.15	2.48	2.62	2.81	2.96	3.01	2.74	2.18	2.66	1.69	1.89
Sig. Level	NS	NS	NS	NS	P<0.01	NS	NS	NS	NS	NS	P<0.01	P<0.01	P<0.05

Means bearing different superscripts within a column differ significantly ($p < 0.01$)

NS: Not significant ($p > 0.05$) SEM: Pooled standard error of means

SBTLM: Sea buckthorn leaf meal

Discussion

The basal diet + 1.0% SBTLM supplemented group had significantly better ($p < 0.05$) hen house egg production as compared to control group during phases of 4-8 weeks, 8-12 weeks and 0-12 weeks (Overall). In addition, it was also observed that basal diet + 1.0% SBTLM supplemented group had significantly better ($p < 0.05$) response in phase wise hen house egg production as compared to basal diet + 0.5% SBTLM group, while it was lowest in control group. The increase in hen house egg production could be due to the supplementation of sea buckthorn leaves, rich in nutrients and bioactive components such as vitamins, amino acids, lipids, flavonoides, higher content of essential oils and have as anti oxidant properties.

The results obtained in the present study fall in line with the findings of Wang (2007), Dumbrava *et al.* (2006), Singh and Sharma (2008), Ambatkar (2009), Biswas *et al.* (2010) Chand *et al.* (2018) and Shaker *et al.* (2018). Hasanuzzaman (2011) observed that egg production of layers were higher after replacing CP content of ration up to 20% by sea buckthorn cake. On contrary Rao *et al.* (2011), Latshaw and Zhao (2011) reported that changes in the level of protein in diet did not affect the rate of egg production and egg mass.

Conclusion

The leaves, seeds and fruit residues contains high crude protein, amino acid, calcium and phosphorus, they have advantages as basic materials for feed formulations for poultry. Due to presence of several nutritional and bio active compounds in fruit, leaves, seed oil and cakes of sea buckthorn, it serves as good growth promoter as well as enhance egg productivity. It was found that the basal diet + 1.0% SBTLM supplemented group had significantly higher ($p < 0.05$) hen house and hen day egg production as compared to control group during different weeks and overall experimental period.

Acknowledgement

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Conflict of interest

The authors declare no conflicts of interest

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Original Article

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Herd Structure of Kankrej Cattle at Cattle Breeding Farm

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Abstract

An analysis was performed to study the herd structure of Kankrej cattle at Cattle Breeding Farm of Gujarat State. The data were collected from Cattle Breeding Farm, Thara (Gujarat). Data were collected from Livestock records from January 2003 to December 2013. The herd strength ranged between 118.00 to 195.67.00 with a mean of 149.02 ± 08.38 units. The average herd composition includes cow, heifer (above two year), heifer (1-2 year), heifer calf, male (above two year), male (1-2 year), male calf, breeding bull and bullock/teaser was 71.00 ± 4.19, 33.70 ± 2.54, 06.12 ± 0.49, 04.93 ± 0.18, 07.61 ± 1.51, 05.39 ± 1.11, 05.21 ± 0.67, 06.32 ± 0.61 and 08.73 ± 2.80 units, respectively. The average proportion of animals against respective categories was 47.65, 22.61, 04.11, 03.31, 03.62, 03.50, 04.24, 05.11 and 05.86 per cent. Female: male ratio was found to be 71: 29.

Keywords: Herd structure; Kankrej; LRS.

Introduction

Management decision related to the composition of cattle on the farm has impact on the long-term profitability. Herd strength is one of the important factors affecting milk production, labour management and overall economy of the farm. Culling decisions are important part for management of herd composition. Increase in herd strength through productive animals (Milking cows) and breedable heifers is likely to increase total milk production of herd; whereas, uncontrolled increase in non-productive animals (dry animals, male calves and females with inferior growth) in the herd directly leads to additional burden to available resources like housing, feeds and fodders and thereby reduce the profitability and efficiency of the farm. Therefore, the herd strength of the organized farm has been evaluated in terms of total strength and compositions of herd structure in accordance to total herd strength over a period of eleven years.

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Material and Methods

The data for this study were collected over the period from January-2003 to December-2013, from Cattle Breeding Farm, Thara, District-Banaskantha, and State- Gujarat. The average strength of the different classes of the herd, viz., cows, heifers, female calves, male calves, breeding bulls, bullocks/ teasers excluding those disposed were compiled from the herd roll-call registers for every month of respective years of study. Finally average annual strength of the respective classes was calculated for all the years. Adult units for each year were worked out on the basis of criteria (Table 1) described by Burte (1995). Data collected were analyzed by frequency, mean and per cent basis as.

Results and Discussion

Information furnished in Table 2 and 3 denotes the details of herd strength of different categories of animals in terms of adult unit and head basis, respectively for Kankrej cattle at Cattle Breeding Farm, Thara (Gujarat).

It is visualized from the Table 2 that the average number of cows, heifers (above 2 years to upto calving), heifers (1-2 year), heifer calves, males (above 2 years to upto breeding), males (1-2 year, including growing bull and castrated male), male calves, breeding bulls and bullock/teaser units were ranged from 54.00 to 95.00, 22.67 to 50.00, 03.33 to 9.67, 04.25 to 06.00. 01.25 to 15.00, 00.67 to 12.00, 01.67 to 09.99, 03.00 to 10.00 and 2.00 to 31.00 units, respectively with mean values 71.00 ± 4.19, 33.70 ± 2.54, 06.12 ± 0.49, 04.93 ± 0.18, 07.61 ± 1.51, 05.39 ±

Table 1: Criteria for estimating Adult units (Burte, 1995)

4 Calves (below 1 yr.)	=	1 A. U.
3 Heifers & growing bulls (above 1 to 2 yr.)	=	1 A.U.
1.5 Above 2 yrs to up to calving / breeding	=	1 A.U.
1 Cow	=	1 A. U.
1 Breeding Bull	=	1.25 A. U.
1 Bullock	=	1 A. U.
1 Teaser	=	1 A. U.

Table 2: Average composition and strength of Kankrej cows (on adult unit basis) at CBF-Thara

Year	Cows	Heifers above 2 yrs. upto calving	Heifers 1-2 yr.	Heifer calves	Male above 2 yrs. upto breeding.	Male 1-2 yr.	Male calves	Breeding Bulls	Bullocks / Teaser	Total
2003	93.00	50.00	9.67	5.00	10.00	9.00	9.00	5.00	5.00	195.67
	(47.53)	(25.55)	(4.94)	(2.56)	(5.11)	(4.60)	(4.60)	(2.56)	(2.56)	
2004	95.00	46.67	5.67	6.00	6.67	8.00	10.00	11.25	5.00	194.25
	(48.91)	(24.02)	(2.92)	(3.09)	(3.43)	(4.12)	(5.15)	(5.79)	(2.57)	
2005	77.00	34.00	6.33	5.75	7.33	5.00	7.75	12.50	5.00	160.67
	(47.93)	(21.16)	(3.94)	(3.58)	(4.56)	(3.11)	(4.82)	(7.78)	(3.11)	
2006	65.00	30.00	6.33	4.50	2.67	3.00	7.00	6.25	9.00	133.75
	(48.60)	(22.43)	(4.74)	(3.36)	(1.99)	(2.24)	(5.23)	(4.67)	(6.73)	
2007	70.00	33.33	5.00	5.00	2.00	4.33	5.25	1.25	31.00	157.17
	(44.54)	(21.21)	(3.18)	(3.18)	(1.27)	(2.76)	(3.34)	(0.80)	(19.72)	
2008	73.00	34.00	5.67	4.25	2.00	5.00	5.25	13.75	20.00	162.92
	(44.81)	(20.87)	(3.48)	(2.61)	(1.23)	(3.07)	(3.22)	(8.44)	(12.28)	
2009	54.00	35.33	5.67	5.00	7.33	3.33	4.50	15.00	13.00	143.17
	(37.72)	(24.68)	(3.96)	(3.49)	(5.12)	(2.33)	(3.14)	(10.48)	(9.08)	
2010	54.00	33.33	7.33	4.25	2.67	4.67	3.00	10.00	2.00	121.25
	(44.54)	(27.49)	(6.05)	(3.51)	(2.20)	(3.85)	(2.47)	(8.25)	(1.65)	
2011	62.00	27.33	5.00	5.50	6.00	1.67	6.00	2.50	2.00	118.00
	(52.54)	(23.16)	(4.24)	(4.66)	(5.08)	(1.41)	(5.08)	(2.12)	(1.69)	
2012	77.00	24.00	7.33	4.50	0.67	7.00	5.75	3.75	2.00	132.00
	(58.33)	(18.18)	(5.56)	(3.41)	(0.51)	(5.30)	(4.36)	(2.84)	(1.52)	
2013	61.00	22.67	3.33	4.50	12.00	6.33	6.00	2.50	2.00	120.33
	(50.69)	(18.84)	(2.77)	(3.74)	(9.97)	(5.26)	(4.99)	(2.08)	(1.66)	
Mean ± S. E.	71.00 ± 04.19	33.70 ± 02.54	6.12 ± 00.49	4.93 ± 00.18	5.39 ± 01.11	5.21 ± 00.67	6.32 ± 00.61	7.61 ± 01.51	8.73 ± 02.80	149.02 ± 08.38
Overall	(47.65)	(22.61)	(4.11)	(3.31)	(3.62)	(3.50)	(4.24)	(5.11)	(5.86)	(100.00)

Figures in parenthesis indicate per cent.

1.11, 05.21 ± 0.67, 06.32 ± 0.61 and 08.73 ± 2.80 units, respectively over the period of 2003 to 2013.

Trend of change in strength of cow and heifer (above one year) units corresponds the trend of average herd strength. The overall average proportion of different categories of animals like cow, heifer (above 2 year to upto calving), heifer (1-2 year), heifer calf, male (above 2 year to upto breeding), male (1-2 year, including growing bull and castrated male), male calf, breeding bull and bullock/teaser was 47.65, 22.61, 04.11, 03.31, 03.62, 03.50, 04.24, 05.11 and 05.86 per cent, respectively. The mean value for the average herd strength in terms of adult unit was 149.02 ± 08.38 for the period under study. It was found that the mean herd strength at CBF, Thara (149.02 A. U.) was lower than the findings of Bettini et al. (1962); Patel (1971) for Anand (178.09) and Charodi farm (282.45); Chaudhary (1999) and Ankuya (2017).

Proportion of all categories of Kankrej animals decreased gradually till 2013. This was might be due to lack of facilities, lack of managerial (administrative and technical) staff forcing them to increase culling rate.

Proportion of cows and heifers above 2 years of age was higher in 2003 and 2004, but thereafter it was maintained with mean value throughout study period. In the male line, proportion of male of 1 to 2 year of age and male calves were maintained throughout study period. But proportion of male above 2 year of age and breeding bull was uneven throughout study period. This was might be due to uneven culling based on requirement of growing and breeding bulls by the institute or farmers. Proportion of bullocks was also reduced to lower numbers might be due to reduction in total numbers of Kankrej herd which need lower quantum of fodder for feeding.

Average composition of Kankrej herd for different categories of animals on head basis is presented in Table 3. The herd strength ranged between 182.00 to 304.00 with a mean value 223.45 ± 12.63 over the period under study. The cows contributed the highest (31.77%) of herd strength and followed by heifers (above two year), male calves, heifer calves, heifers (1-2 year), males (1-2 years), bullocks/teasers, male (above two year) and breeding bulls with 22.62, 11.31, 08.83, 08.22, 07.00, 03.91, 03.62 and 02.73 per cent of the herd strength, respectively.

Proportion of heifers above two year of age was quite higher than heifers of 1-2 years age and

Table 3: Average composition and strength of Kankrej cows (on head unit basis) at CBF-Thara

Year	Cows	Heifers above 2 yrs. upto calving	Heifers 1-2 yr.	Heifer calves	Male above 2 yrs. upto breeding.	Male 1-2 yr.	Male calves	Breeding Bulls	Bullocks/ Teaser	Total
2003	93 (30.59)	75 (24.67)	29 (9.54)	20 (6.58)	15 (4.93)	27 (8.88)	36 (11.84)	04 (1.32)	05 (1.64)	304
2004	95 (32.31)	70 (23.81)	17 (5.78)	24 (8.16)	10 (3.40)	24 (8.16)	40 (13.61)	09 (3.06)	05 (1.70)	294
2005	77 (31.82)	51 (21.07)	19 (7.85)	23 (9.50)	11 (4.55)	15 (6.20)	31 (12.81)	10 (4.13)	05 (2.07)	242
2006	65 (32.18)	45 (22.28)	19 (9.41)	18 (8.91)	04 (1.98)	09 (4.46)	28 (13.86)	05 (2.48)	09 (4.46)	202
2007	70 (31.25)	50 (22.32)	15 (6.70)	20 (8.93)	03 (1.34)	13 (5.80)	21 (9.38)	01 (0.45)	31 (13.84)	224
2008	73 (32.02)	51 (22.37)	17 (7.46)	17 (7.46)	03 (1.32)	15 (6.58)	21 (9.21)	11 (4.82)	20 (8.77)	228
2009	54 (25.96)	53 (25.48)	17 (8.17)	20 (9.62)	11 (5.29)	10 (4.81)	18 (8.65)	12 (5.77)	13 (6.25)	208
2010	54 (29.51)	50 (27.32)	22 (12.02)	17 (9.29)	04 (2.19)	14 (7.65)	12 (6.56)	08 (4.37)	02 (1.09)	183
2011	62 (34.07)	41 (22.53)	15 (8.24)	22 (12.09)	09 (4.95)	05 (2.75)	24 (13.19)	02 (1.10)	02 (1.10)	182
2012	77 (37.93)	36 (17.73)	22 (10.84)	18 (8.87)	01 (0.49)	21 (10.34)	23 (11.33)	03 (1.48)	02 (0.99)	203
2013	61 (32.45)	34 (18.09)	10 (5.32)	18 (9.57)	18 (9.57)	19 (10.11)	24 (12.77)	02 (1.06)	02 (1.06)	188
Mean ± S. E.	71.00 ± 4.19	50.55 ± 3.80	18.36 ± 1.47	19.73 ± 0.73	8.09 ± 1.66	15.64 ± 2.00	25.27 ± 2.42	6.09 ± 1.21	8.73 ± 2.80	223.45 ± 12.63
Overall	(31.77)	(22.62)	(8.22)	(8.83)	(3.62)	(7.00)	(11.31)	(2.73)	(3.91)	(100.00)

Figures in parenthesis indicate per cent.

heifer calves. This was might be due to inclusion of heifers of 3 years and above age and that too due to late maturity of indigenous cattle. The age of first calving is more than 1000 days in Kankrej cattle. The present findings are in agreement with the results of Burte (1995) and Chaudhary (1999) with slight lower values of the herd strength. Proportion of heifers above two years occupies second position next to cows. As they are the second lines of herd going to occupy first line of cows in the future as replacement stock.

It was also seen from the Table 3 that the proportion of male above one year upto breeding (10.62%), was higher than heifer calves (8.83%). This might be due to the reason that, older males might have been retained for distribution to for breeding purpose.

Proportion of female and male was 71: 29 at CBF, Thara (Table 4). Proportion of male was higher than the herd of China cattle (Matassino *et al.* 1965) and Kankrej herd of Anand (Tripathi, 1970).

Proportion of cows (31.71%) as compared to other category of female followers was higher at Cattle Breeding Farm. The result was similar to Burte (1995). However, proportion of heifers above 2 years of age (22.67%) was higher at CBF as compared to the findings of Ankuya (2016) for CBF, Bhuj and Ankuya (2017) for LRS, Sardarkrushinagar. This was might be due to more longevity of cows and restriction of herd strength as well as better replacement rate from heifers to cow. Proportion of cows to the total herd strength at CBF was lower than the findings of Tripathi (1970) and similar to the findings of Ankuya (2016). Proportion of heifers (1–2 yrs.) at CBF were higher as compared to the findings of Ankuya (2016) for CBF, Bhuj and lower than Ankuya (2017) for LRS, Sardarkrushinagar.

Proportion of heifer calves (8.83%) was lower than the findings of Ankuya (2017) for LRS, Sardarkrushinagar (12.13%) and CBF, Bhuj (10.19%) Ankuya (2016). This was might be due to more mortality in younger calves.

Male above 2 years to breeding was much lower than the finding of Ankuya (2017) for CBF, Bhuj and slightly lower than LRS, Sardarkrushinagar. This is attributed to the cause of selling older indigenous male calves for distribution to district and village panchayats for breeding.

Proportion of male (1-2 years) and male calves was more or similar at all three stations. Proportion of bullock was higher than the finding of Ankuya (2017) for LRS, Sardarkrushinagar and CBF, Bhuj might be due to more irrigated land for fodder production and less mechanization as compared to LRS, Sardarkrushinagar.

Proportion of cows at CBF was lower than the findings of earlier workers (Bettini *et al.* 1962, Quadri and Proto, 1964, Matassino *et al.* 1965 and Nowicki and Jaczewski, 1974). However, proportion of female calves was more or less similar at CBF, Thara as compared to the findings of Bettini *et al.* (1962); whereas, proportion of female calves was higher at LRS as compared to findings of earlier workers (Quadri and Proto, 1964 and Matassino *et al.* 1965).

Proportion of cows (44.78%) in female stock was higher than other category of animals followed by heifers above 2 years of age (31.66%) whereas, strength of male calves (39.60%) was higher in male department (Table 5).

Table 4: Comparison of overall composition of the herd (per cent) on the head basis of total herd strength

Sr. No.	Name of farm	Cows	Heifers above 2 yrs. upto calving	Heifers 1-2 Year	Heifer calves	Total female	Male above 2 yrs. upto breeding	Male 1-2 years	Male calves	Breeding Bulls	Bullocks / Teaser	Total male	Reference
1.	CBF-Thara	31.77	22.62	8.22	8.83	71.44	3.62	7.00	11.31	2.73	3.91	28.56	
2.	LRS-SKN	32.34	15.37	10.89	12.13	70.73	4.25	7.46	12.33	2.88	2.35	29.27	Ankuya (2017)
3.	CBF-Bhuj	30.82	20.68	7.82	10.19	69.51	9.01	8.37	11.67	0.42	1.01	30.49	

Table 5: Comparison of overall composition of Female / Male population (per cent) of the herd on the head basis

Sr. No.	Name of farm	Cows	Heifers above 2 yrs. upto calving	Heifers 1-2 Years	Heifer calves	Total female	Male above 2 yrs. upto breeding	Male 1-2 years	Male calves	Breeding Bulls	Bullocks / Teaser	Total male	Reference
1.	CBF-Thara	44.48	31.66	11.50	12.36	100.00	12.68	24.50	39.60	9.54	13.68	100.00	
2.	LRS-SKN	45.72	21.73	15.40	17.15	100.00	14.53	25.47	42.12	9.83	8.04	100.00	Ankuya (2017)
3.	CBF-Bhuj	44.34	29.74	11.25	14.66	100.00	29.54	27.46	38.28	1.39	3.33	100.00	

Conclusions

Based on results, it can be concluded that the composition of herd structure at CBF, Thara is in a balanced manner i.e. the different category of animals in particular cows, heifers for replacement stock and breeding bull is ideal. However, there was declining trend for total herd strength during the period under study.

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Indian Journal of Ancient Medicine and Yoga	Quarterly	8000	7500	625	586
Indian Journal of Law and Human Behavior	Semiannual	6000	5500	469	430
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Indian Journal of Biology	Semiannual	5500	5000	430	391
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In Vitro Propagation Studies in Gymnema (*Gymnema Sylvestre* R. Br.)

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Abstract

Tissue culture technology is used for selection and rapid multiplication. In India the micro propagation technique has gained momentum to reoccupy the monopoly in Gymnema tissue culture at global level. It is able to regenerate millions of copies to ensure in a decade of time with high yielding with shorter duration. There is a tremendous demand for natural anti diabetic agents, because it have reducing blood sugar and are used as an anti diabetic agent in Indian medicine, improvement of cultivation is carried out by the in-vitro culturing or tissue culture technique. In-vitro studies or micro propagation of Gymnema were conducted at Agricultural College & Research institute, Killikulam at 2001. The shoot tip and nodal segments were collected and used as explants. These explants of Gymnema were inoculated in MS medium (Murashige and Shoog, 1962) supplemented with Kinetin (2.5 mg/lit), NAA (1 mg/lit), and GA3 (2.0 mg/lit) gave the better results for callus induction and shoot formation.

Keywords: Gymnema; Tissue culture; Kinetin; NAA.

Introduction

Gymnema sylvestris R.Br. belongs to the family Asclepiadaceae known as Sirukurujan and Gurmar. It is a woody climber and the leaves possess active principles like gymnemic acid, which are reported to have properties of reducing sugar and are used as an antidiabetic agent in Indian systems of medicine. So there is a tremendous demand for gymnema production. In India micro propagation technique has gained momentum to reoccupy the monopoly in gymnema production at global level. It is able to regenerate million of genetically identical copies of high yielding types in a shorter time and space, and the tissue cultured plants from different explants perform uniformly.

Materials and Methods

The successful *in-vitro* culture results depend on the interplay of the plant material (explants),

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medium in use and the culture environment. Two different explants namely shoot tip and nodal segments are involved in this study. The explants were surface sterilized with 0.1 per cent mercuric chloride for 10 minutes followed by washed with distilled water. Then it is rinsed with 70% ethanol for 3 times then it is washed with distilled water. Now the explants were ready for inoculation. The medium contained sucrose and solidified with 0.8% agar, p^H of the media was adjusted to 5.7 before autoclaving at 121^0C for 20 minutes. For callus growth and direct regeneration required quantity of auxins (NAA), cytokinin (BAP) and GA_3 were added in MS medium. Cultures were maintained at 27 ± 2^0C temperature, 75% relative humidity and with 16 hours photoperiod.

Treatments involved

T_1 - Normal MS media + BAP (2.0 mg /lit) + NAA (1.0 mg/lit)

T_2 - Normal MS media + Kinetin (2.5 mg/lit) + NAA (1.0 mg/lit)

T_3 - Normal MS media +BAP (2.0 mg/lit) + NAA (1.0 mg/lit) + GA_3 (2.0 mg/lit)

T_4 - Normal MS media + Kinetin (2.5 mg/lit) + NAA (1.0 mg/lit) + GA_3 (2.0 mg/lit)

Results and Discussion

In the present investigation, growth regulator combination of kinetin (2.5 mg/lit) + NAA (1.0 mg/ lit) and Kinetin (2.5 mg/lit), NAA (1.0 mg/lit) and GA_3 (2.0 mg/lit) gave the better result for callus induction and shoot proliferation. The use of kinetin in the culture medium has been reported by Anu *et al.* [1] and Somany *et al*. [3]. The shoot tip explant gave the maximum callus establishment (64.5%) and shoot regeneration in the T_4 treatment followed by T_2 treatment. (Table 1). The nodal segment also gave the better establishment of callus induction in T_2 treatment. The higher proportion of shoot proliferation from nodal segment followed by shoot tip was obtained on ms medium supplemented with Kinetin (2.5 mg/lit) and NAA (1.0 mg/lit) and GA_3 (2.0 mg/lit) (Table 2). These results are in agreement with the findings of Lakshmisita *et al*. [2].

Table 1: Response of explants of Gymnema in different treatments of MS media

Callus induction medium	Response of explants to callus induction and shoot proliferation	
	Shoot tip	Nodal segment
T_1	C (57.2%)	-
T_2	C (63.3) and S	C (57.5%)
T_3	C (52.4%)	-
T_4	C (64.5%) and S	C (48.7%)

- : No callus production C : Callus production
CS : Callusing and shoot proliferation

Table 2: Shoot regeneration responded by explants

Callus induction medium	Response of explants to shoot regeneration	
	Nodal segment	Shoot tip
T_1	✓	*
T_2	✓	*
T_3	✓	*
T_4	✓	**

✓-Shoot regeneration
*- Shoot proliferation
**- Proliferation is abundant

Summary

In the present investigation of gymnema the shoot tip explant shows good callus growth and shoot proliferation in ms media supplemented with Kinetin (2.5 mg/lit) , NAA (1.0 mg/lit) and GA_3 (2.0 mg/lit), hence the above said treatment will be used for tissue culture in gymnema.

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Effect of Dietary Inclusion of Probiotics on Performance and Serum Parameters of Layers in Post Peak Production

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Abstract

The present study was carried out with a view to investigate the production performance of layers fed with probiotic in diets at different concentration 0 (T1), 50 (T2), 100 (T3) and 150 g (T4) per ton of basal diets during post peak production (47 to 58 weeks of age). The basal diet was formulated with commonly available feed ingredients like maize, soybean meal, sunflower meal, de-oiled rice bran, fish meal as per the specifications of BIS, (1992) suitable for Indian conditions. The chemical composition (%) of the basal diet was 90.0 (DM), 18.09 (CP), 2.82 (EE), 7.65 (CF), 55.22 (NFE), 17.22 (TA) and 3.81 (AIA). The calculated ME content of the basal diet was 2654 Kcal/Kg. One hundred and eighty Single Comb White Leghorn layers were used in the experiment and divided into four dietary treatments with three replicates of fifteen birds each. During the experimental period feed intake, feed efficiency and body weights were recorded in three periods of 28 days each (47 to 50, 51 to 54 and 55 to 58 weeks). Serum parameters like total serum proteins and serum cholesterol levels were recorded at the start and at the end of the experiment. There was no significant difference observed in feed intake (g) during overall experimental laying period (47-58 weeks) and feed intake ranged from 118.53 (T4) to 120.18 g (T1). There was no significant difference in feed efficiency (kg feed consumed for dozen eggs) during 47-58 weeks of age. Better feed efficiency (kg feed consumed for dozen eggs) was observed in T2, T3 and T4 groups (1.68 Kg) over T1 (1.69 Kg). Similarly non-significant differences were observed in birds fed with experimental diets with regard to feed efficiency expressed as Kg feed consumed for Kg egg produced. The total protein was reduced by 7.33% in control (T1) but increased in T2, T3 and T4 by 2.60, 1.19 and 2.58% respectively. There was no significant difference observed among the treatment groups. The serum cholesterol increased by 0.56% in control (T1) but reduced in T2, T3 and T4 by 2.39, 6.22 and 8.82% respectively. During 47-58 weeks of age significantly ($p \leq 0.05$) higher body weights (g) were observed in T1 (1296) and lower body weight was observed in T4 (1234) group. There was no significant difference in feed consumption and income over feed cost per 12 eggs produced among different treatments. Income over feed cost/12 eggs in T1, T2, T3 and T4 were 4.91, 5.13, 5.09 and 5.06 respectively. Percent improvement in income over the control (T1) was T2 (4.51), T3 (3.83) and T4 (3.14). There was no mortality observed in all the groups during the experimental period and birds did not show any illness on probiotic addition. Better performance of the birds, reduced cholesterol contents and improved relative economics over control suggest that 50g of probiotic addition to one ton of layer diet is beneficial without any adverse effects during post peak production. The inclusion of probiotics can replace the usage of antibiotics in poultry feeds.

Keywords: Probiotic; Layers; Post peak production; Feed efficiency; Serum cholesterol; Serum protein.

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Introduction

Due to continuous demand from consumers for low cost chicken meat and egg resulted in the intensification of poultry production system and extensive administration of antimicrobials as growth promoters (NRC, 1980; Fuller, 1992). The antibiotics as growth promoters appear to act by reducing the pathogenic bacteria and modifying the microflora in the gut of the animals (Radostits *et al*., 1994). Continuous use of sub-therapeutic level of antibiotics in animal feeds may result in not only bacterial resistance (Adams, 2004) but also accumulation of antibiotic residues in various tissues of the birds resulting in development of drug resistant microorganisms in humans upon consumption of such poultry products (Jin *et al*., 1996). The adverse effect of antibiotic feeding has encouraged a shift in favor of feeding probiotics to boost up productive performance of chicken.

Probiotics were introduced as an alternative to antibiotics. Probiotics are defined as live microbial feed supplements, which beneficially affect the host animal by improving the intestinal microbial balance (Fuller, 1989). The mechanism by which probiotics improve feed conversion efficiency include alteration in intestinal flora, inhibition of growth of pathogenic microorganisms and enhancement of growth of non pathogenic, facultative anaerobic and gram positive bacteria. The probiotics will enhance digestion, nutrient utilization, improve feed conversion efficiency, improved growth rate, reduction in mortality and maintain health status of birds.

Mohan *et al*., (1995) reported that probiotic supplementation can depress serum/yolk cholesterol and improve egg production by 5% in layers. Nahashon *et al*., (1996) observed increased egg size upon supplementation of *Lactobacillus* @110 mg/kg diet. Panda *et al*., (2008) reported that addition of probiotics significantly increased the egg production, shell weight, shell thickness and serum calcium and reduced the cholesterol content in serum and yolk. Yoruk *et al*., (2004) reported that supplementation of humate and probiotics increased egg production, reduced mortality, improved feed conversion efficiency in Hisex brown layers during late laying periods (54 weeks of age). The egg production starts declining after reaching the peak egg production. The ever increasing cost of production may marginally be compensated by improving the production and feed efficiency during this declining phase of production by using probiotic supplements. Therefore the present research work was taken up to study the effect of probiotic supplementation on feed intake, feed efficiency, serum parameters and cost economics in layers during post peak production.

Materials and Methods

Maize (ground), soybean meal, fish meal, sunflower meal, de-oiled rice bran (DORB), mineral mixture and shell grit were obtained from local market. Commercial probiotic supplement (Lactoplus) comprising of mixed cultures of *Lactobacillus acidophilus*. *Lactobacillus bulgaricus, Lactobacillus casei*, *Lactobacillus returi , Lactobacillus lactis, Streptococcus faecium, Asperigillus oryzae* and *Saccharomyces cervisiae* at the concentration of 32 billion CFU/100 g was procured from local market. Representative samples of feed ingredients and layer diets were analysed for proximate composition as per AOAC (2005). Representative samples of feed ingredients and layer diets were analysed for calcium and phosphorus as per method of Talapatra *et al*., (1940).

One hundred and eighty Single Comb White Leghorn layers of same hatch were used in the experiment. A 12-week feeding trial (March 2013 to May 2013) was conducted from 47th week of age and continued for 3 laying periods of 28 days each. The birds were weighed individually and randomly divided into 4 treatments of 3 replicates of 15 birds each (with uniform average body weight per replicate) housed in individual cages of California two tier system in completely randomized design. In the biological trial probiotic was included at 0, 50, 100 and 150 g/ ton in T_1, T_2, T_3 and T_4 experimental diets respectively. These iso-caloric and iso-nitrogenous layer diets were formulated according to BIS (1992) specifications.

All the birds were housed in cages with optimum floor space per bird and adequate ventilation throughout the experiment. The hens had free access to feed and water throughout the experiment. All birds were dewormed one week before commencement of experiment and the other managemental practices like vaccination were adopted uniformly for all the treatments. The birds were provided with 16 hours of light/day. Feed intake was recorded for every 28 days period replicate wise and based on this feed efficiency was calculated as the feed required in kilos to produce one dozen eggs/ one kg eggs.

Serum samples were collected from 2 birds in each replicate twice during the experiment i.e. at the beginning and at the end of the experiment. Serum

total proteins were estimated by using diagnostic kit (M/s Span Diagnostics Limited) by Biuret method (Varley *et al*., 1980). Serum cholesterol was estimated by using diagnostic kit (M/s Excel Diagnostics Private Limited) by enzymatic method of Allian (1974) for *in vitro* estimation. Individual body weights of all birds were recorded in grams at the beginning and also at the end of the every 28 day period during the experiment. Income over feed cost per dozen eggs in different treatments and relative economy of each dietary regimen were worked out based on the prevailing prices of various inputs and outputs. All the data obtained in the experiment were subjected to standard statistical analysis (Snedecor and Cochran 1994).

Results and Discussion

The results obtained with regard to chemical composition of feed ingredients and experimental diets, performance of layers during post peak production fed on diets with different levels of probiotics in terms of feed intake, feed efficiency, serum parameters and economics are discussed in conjunction with the available literature.

The chemical composition of the feed ingredients used in the experiment is given in the Table 1. The percent DM, CP, EE, CF, TA, NFE and AIA of maize, soybean meal, sunflower cake, fish meal, and de-oiled rice bran were 88.9, 10.59, 4.12, 2.74, 6.87, 75.68 and 0.72; 90.89, 42.9, 0.97, 6.13, 10.01, 39.99 and 1.32; 91.13, 27.18, 0.51, 24.49, 10.4, 37.42 and 0.94; 91.76, 42.23, 6.2, 3.12, 21.9, 26.55 and 8.61; 88.86, 15.0, 1.51, 15.79, 15.94, 51.76 and 8.42, respectively.

The CP content of the maize in the present study was 10.59% which is as per the values reported by Arora and Harjit kaur (2010). The CP content of soybean meal, sunflower cake, fish meal, and de-oiled rice bran used in the present study were lower than the values given by Arora and Harjit kaur (2010), which were 51.0, 35.3, 71.4 and 16.1, respectively. This may be due to variations in soil texture, season of harvesting and other variable factors.

The experimental diets were formulated based on the recommendations of BIS, (1992) suitable for Indian conditions (Table 2). The feed ingredients like maize, soybean meal, sunflower meal, de-oiled rice bran, fish meal were used in formulating the diets, as these are the most commonly used and available in this region. The chemical composition of layer diets along with probiotic supplementation at different levels used in the experiment is given in Table 3. The protein : energy ratio of T_1, T_2, T_3 and T_4 diets were 1:147, 1:147, 1:147 and 1:148, respectively which were nearer to the protein : energy ratio of 1:150 as recommended by BIS, (1992).

The feed intake during experimental period was not significantly affected in layers fed on experimental diets compared to control diet (Table 4). The feed intake (g/d) in T_1, T_2, T_3 and T_4 were 120.18, 119.36, 119.10 and 118.53, respectively.

Table 1: Chemical composition+ (%) of feed ingredients used in experimental diets

Constituent	Ingredient				
	Maize	Soybean meal	Sunflower cake	Fish meal	De-oiled rice bran
Dry matter	88.9	90.89	91.13	91.76	88.86
Crude protein	10.59	42.9	27.18	42.23	15.0
Ether extract	4.12	0.97	0.51	6.2	1.51
Crude fibre	2.74	6.13	24.49	3.12	15.79
Total ash	6.87	10.01	10.4	21.9	15.94
Nitrogen free extract	75.68	39.99	37.42	26.55	51.76
Acid insoluble ash	0.72	1.32	0.94	8.61	8.42
Calcium	0.24	0.34	0.4	5.39	0.33
Phosphorus	0.4	0.87	0.3	1.67	1.79
Lysine*	0.18	2.57	1.95	4.17	0.44
Methionine*	0.15	0.76	1.56	1.42	0.29
ME (Kcal/kg)	3309**	2300**	2230*	2500**	2235*

+On dry matter basis except for DM; * Values from Ramasubba Reddy and Bhosale (2001)

**Values from Narahari (1996)

Table 2: The ingredient composition (%) of experimental diets

Ingredient	T_1	T_2	T_3	T_4
Maize	49	49	49	49
Deoiled rice bran	16	16	16	16
Soybean meal	9	9	9	9
Sunflower cake	12	12	12	12
Fish meal	8	8	8	8
Shell grit +	5	5	5	5
Mineral mixture *	1	1	1	1
Additives				
Probiotic (g)	0	5	10	15
Other feed additives **	+	+	+	+

+Contained *Ca,* 38%

*Contained *Ca,*32%; *P,*6%; *NaCl;* 2.5%; *Cu,* 100 ppm; *Mn,* 200 ppm, *Co,*50 ppm; *Zn,* 50 ppm and *I,* 100 ppm

**Meriplex DS @ 10g/100 kg: *Vit* B_1 8 mg, B_6 16 mg, B_{12} 80 mcg, *Niacin* 120 mg and *Ca* 88 mg

**Hyblend – AB_2D_3K @10g/100 kg: *Vit A* 82,500 IU, *Vit* B_2*-50 mg, Vit* D_3 12,000 IU, Vit K 10 mg.

Table 3: Chemical composition * (%) of experimental diets

Constituent	Layer diet			
	T_1	T_2	T_3	T_4
Dry matter	90.0	88.91	91.85	90.42
Crude protein	18.09	18.0	17.94	17.96
Ether extract	2.82	2.91	2.79	2.96
Crude fibre	7.65	7.37	7.51	7.27
Nitrogen free extract	54.22	54.62	54.03	54.44
Total ash	17.22	17.10	17.73	17.37
Acid insoluble ash	3.81	3.95	3.89	3.72
Calcium	3.78	3.54	3.81	3.69
Phosphorus	1.12	1.17	1.08	1.21
Lysine**	0.96	0.96	0.96	0.96
Methionine**	0.49	0.49	0.49	0.49
ME (Kcal/Kg)**	2654	2654	2654	2654

* On dry matter basis except for DM

** Calculated values.

Table 4: Effect of feeding probiotic supplemented diets on feed intake (g/hen/day)

Treatment	Age (weeks)			Mean for treatments
	47-50	51-54	55-58	
T_1	120.93 ± 0.92	121.03 ± 2.31	118.56 ± 0.97	120.18 ± 0.72
T_2	120.84 ± 0.82	118.71 ± 0.79	118.54 ± 1.05	119.36 ± 0.32
T_3	119.91 ± 0.82	117.79 ± 1.01	119.60 ± 1.26	119.10 ± 0.54
T_4	119.30 ± 1.19	117.99 ± 1.00	118.30 ± 1.91	118.53 ± 0.63
Mean for periods	120.25 ± 0.45	118.88 ± 0.72	118.75 ± 0.59	

Table 5: Effect of feeding probiotic supplemented diets on feed efficiency (kg feed consumed for dozen eggs)

Treatment	Age (weeks)			Mean for treatments
	47-50	51-54	55-58	
T_1	1.65 ± 0.009	1.70 ± 0.038	1.74 ± 0.021	1.69 ± 0.012
T_2	1.64 ± 0.009	1.64 ± 0.003	1.77 ± 0.049	1.68 ± 0.015
T_3	1.65 ± 0.019	1.66 ± 0.007	1.74 ± 0.024	1.68 ± 0.012
T_4	1.63 ± 0.010	1.67 ± 0.012	1.75 ± 0.045	1.68 ± 0.013
Mean for periods	1.64 ± 0.45	1.67 ± 0.011	1.75 ± 0.016	

Table 6: Effect of feeding probiotic supplemented diets feed efficiency (kg feed consumed for kg eggs)

Treatment	Age (weeks)			Mean for treatments
	47-50	51-54	55-58	
T_1	2.57 ± 0.03	2.62^{a} ± 0.02	2.70 ± 0.07	2.64 ± 0.01
T_2	2.57 ± 0.01	2.54^{c} ± 0.01	2.72 ± 0.07	2.61 ± 0.02
T_3	2.60 ± 0.01	2.56^{bc} ± 0.01	2.66 ± 0.04	2.61 ± 0.01
T_4	2.56 ± 0.01	2.61^{ab} ± 0.03	2.66 ± 0.04	2.61 ± 0.01
Mean for periods	2.58 ± 0.01	2.58 ± 0.01	2.69 ± 0.03	

Table 7: Effect of feeding probiotic supplemented diets on total serum protein (g/dl)

Treatment	At the start of experiment	At the end of experiment
T_1	6.73 ± 0.13	6.27 ± 0.31
T_2	6.73 ± 0.22	6.91 ± 0.16
T_3	6.61 ± 0.14	6.69 ± 0.10
T_4	6.78 ± 0.13	6.96 ± 0.12
Mean for periods	6.71 ± 0.08	6.71 ± 0.11

Table 8: Effect of feeding probiotic supplemented diets on serum cholesterol (mg/dl)

Treatment	At the start of experiment ^{NS}	At the end of experiment*
T_1	137.98 ± 4.5	138.76^{a} ± 2.3
T_2	132.43 ± 2.0	129.26^{b} ± 1.6
T_3	130.81 ± 1.7	122.67^{b} ± 2.6
T_4	136.67 ± 1.3	124.61^{b} ± 3.1
Mean for periods	134.47 ± 1.4	128.83 ± 1.7

Means with similar superscripts in a column do not differ significantly

NS: Non significant

* Significant at P≤0.01

Table 9: Effect of feeding probiotic supplemented diets on body weight (g)

Treatment	Age (weeks)			Mean for treatments*
	47-50*	51-54*	55-58^{NS}	
T_1	$1,353^{a}$ ± 11.28	$1,297^{a}$ ± 19.90	1,238 ± 18.77	$1,296^{a}$ ± 14.87
T_2	$1,290^{b}$ ± 28.17	$1,264^{ab}$ ± 18.81	1,249 ± 11.31	$1,268^{ab}$ ± 14.39
T_3	$1,286^{b}$ ± 12.25	$1,247^{ab}$ ± 11.47	1,215 ± 24.53	$1,249^{b}$ ± 10.11
T_4	$1,268^{b}$ ± 14.48	$1,234^{b}$ ± 7.23	1,200 ± 15.95	$1,234^{b}$ ± 2.81
Mean for periods	1,299 ± 12.33	1,261 ± 9.69	1,226 ± 9.74	

Means bearing similar superscripts in a column do not differ significantly.

NS: Not significant

*Significant at p ≤ 0.05

Table 10: Effect of feeding probiotic supplemented diets on relative economics

S. No	Criterion	T_1	T_2	T_3	T_4
1	Cost of feed per kg (Rs)	25.50	25.52	25.54	25.56
2	Feed consumption/12 eggs (kg)	1.69	1.68	1.68	1.68
3	Feed cost/12 eggs (Rs)	43.10	42.87	42.91	42.94
4	Selling price of 12 eggs (Rs)	48	48	48	48
5	Income over feed cost/12 eggs (Rs)	4.91	5.13	5.09	5.06
6	Percent improvement in income over the control	-	4.51	3.83	3.14

Similar findings were also reported by Yoruk *et al.,* (2004) in Hisex brown layers (123.9g in control group vs 122.6 g in probiotic group); Mahdavi *et al.,* (2005) in Hyline 36 layers (97.86g in control group vs 96.82g in probiotic group); Yousefi and Karkoodi (2007) in Hyline 36 layers (106.25 g in control group vs 108.11 g in probiotic group); Panda *et al.,* (2006) in Single Comb White leghorn layers (102.42g in control group vs 104.29g in probiotic group).

Further non-significant difference with regard to feed intake also observed by Ashayerizadeh *et al.,* (2009) in broilers (106.13 g in control group vs 105.46g in probiotic group); Balevi *et al.,* (2009) in Hyline brown layers (113.23 g in control group vs 112.88 g in probiotic group), Yalcin *et al.,* (2010) in Hyline brown layers (103.4 g in control group vs 104.3 g in probiotic group); Kalavathy Ramasamy *et al.,*(2009) in Lohmann Brown pullets (101.23 g in control group vs, 104.17 g in probiotic group); Sattar Bagheri Dizaji and Rasoul Pirmohammadi (2009) in Hyline 36 (103.25 g in control group vs 105.8 g in probiotic group); Berrin (2011) in quails (36.88 g in control group vs 36.99 g in probiotic group); Mikulski *et al.,* (2012) in Hisex brown layers (124.0 g in control group vs 123.7 g in probiotic group); Abdelqader *et al.,* (2013) in Single Comb White leghorn layers (110.8 g in control group vs 110.2g in probiotic group). The addition of probiotic supplementation did not show any impact on feed intake. This might be due to probiotics which do not impart any palatability to the diets and also might be due to the feeding of iso-caloric and iso-nitrogenous diets throughout the experimental period.

On contrary significantly ($p < 0.05$) high feed intake was observed by Nahashon *et al.,* (1996) in DeKalb XL Single Comb White Leg horn pullets (118g in control group vs 121g in probiotic group). On the other hand Swain *et al.,* (2011) reported significantly ($p < 0.05$) decreased feed intake in Vanaraja layers per bird in kg during 14 weeks of experimental period fed on probiotic supplemented group (10.87 kg) over control (11.18 kg).

Feed efficiency (kg feed/dozen eggs) was numerically better in layers fed on probiotic supplemented diets as compared to control diets during the experimental period (Table 5). The feed efficiency of T_1, T_2, T_3 and T_4 diets was 1.69, 1.68, 1.68 and 1.68, respectively. This effect might be due to the establishment of normal gut flora, prevention of pathogenic microbes and better availability of nutrients by the action of probiotics added in the diet. The result in the present investigation for probiotics were in conformity with the findings of Panda *et al.,* (2006) in Single Comb White Leghorn breeders during the late laying period (1.42 in control group vs 1.42 in probiotic supplementation @ 150 mg /kg basal diet group); Yalcin *et al.*, (2008) in Lohmann Brown laying hens (1.42 in control group vs 1.42 in probiotic group). On the contrary, Moorthy *et al.*, (2010) reported that feed efficiency was not improved in layers fed with probiotic supplemented diets.

There was no significant difference observed in feed efficiency (kg feed / kg eggs) in layers fed on probiotic supplemented diets among the treatment groups during the experimental period (Table 6). The results in T_1, T_2, T_3 and T_4 groups were 2.64, 2.61, 2.61 and 2.61, respectively (Fig. 1). This was in conformity with the findings of Mahdavi *et al.,* (2005) in Hy-line 36 strain (1.96 in control group vs 2.02 in probiotic supplemented group); Yousefi and Karkoodi (2007) in Hyline 36 layers during 63 to 75 weeks of age (2.4 in control group vs 2.57 in *Saccharomyces cerevisiae* supplemented group); Yalcin *et al.*, (2008) in Lohmann Brown laying hens (2.03 in control group vs 2.01 in probiotic supplemented birds), Wei Fen Li *et al.,* (2011) in Shaoxing Ducks (3.135 in control group vs 3.020 *Bacillus subtilis* supplemented birds).

On contrary, significantly better feed conversion efficiency (kg feed / kg eggs) observed in probiotic supplemented group by Balevi *et al.,* (2009) in Hysex Brown layers (2.59 in control vs 2.49 in probiotic supplemented birds); Yalcin *et al.,* (2010) in Hyline Brown layers (2.8 in control vs 2.3 in probiotic supplemented birds); Mikulski *et al.,* (2012) in Hisex Brown layers from 22 to 37 weeks of age (2.27 in control group vs 2.21 in probiotic supplemented group). The reason of variable effect of biological additives may be confounded by variations in gut flora and environmental conditions (Mahdavi *et al.*, 2005). The contradictory results reported by various researchers might be related to the dosages of probiotic and concentration of bacteria used in the diet (Shivani Katoch *et al.*, 2011).

Total serum protein in layers fed with different levels of probiotics was not affected during experimental period (Table 7). At the end of the experiment the total serum protein (g/dl) in T_1, T_2, T_3 and T_4 was 6.71, 6.27, 6.91 and 6.69, respectively. The total protein was reduced by 7.33% in control (T_1) but increased in T_2, T_3 and T_4 by 2.60, 1.19 and 2.58% respectively. Similar findings were also observed by Panda *et al.,* (2006) in White Leghorn layers (4.62 in control group vs 4.39g/100 ml in probiotic supplemented group) during 65 to 76 weeks of age. Yalcin *et al.,* (2008) in Lohmann Brown layers (4.46 in control group vs

4.35g/100 ml in probiotic supplemented group); Ashayerizadeh *et al.,* (2009) in Ross 308 broilers (3.89 in control group vs 3.80g/100 ml in probiotic supplemented group).

In the present study, serum cholesterol (mg/dl) was estimated at the start and at the end of experimental period. The twelve weeks of probiotic supplementation to the layers resulted in significantly ($p < 0.05$) low serum cholesterol levels compared to control group (Table 8). High serum cholesterol (mg/dl) was observed in T1 (138.76) and low levels (122.67) in T4 group (Fig 2). The serum cholesterol was increased by 0.56% in control (T1) but reduced in T2, T3 and T4 by 2.39, 6.22 and 8.82% respectively. These findings are in accordance to findings of Panda *et al*., (2006) in White Leghorn layers (133.81 in control group vs 116.17 mg/100 ml in probiotic supplemented group) during 65 to 76 weeks of age; Al-Kassie et al., (2008) in Arbor-Acres broilers (196.83 in control group vs 186.50 mg/100 ml in probiotic supplemented birds); Wei Fen Li *et al*., (2011) in Shaoxing Ducks (126.96 in control group vs 97.09 mmol/L in probiotic supplemented birds).

This reduction in serum cholesterol could be attributable to reduced absorption and/or synthesis of cholesterol in the gastro-intestinal tract by probiotic supplementation (Mohan *et al*., 1995). Utilization of cholesterol by microbes for their own metabolism (Nelson and Gilliland, 1984) and deconjugation of bile salts in the intestine, thereby preventing them from acting as precursors in cholesterol synthesis (Abdulrahim *et al*., 1996) and also observed that the hypocholesteraemic effect on the host due to probiotic feeding was also dependent on duration of feeding.

The results (Table 9) obtained on body weights during the experimental period in layers were significantly ($p \leq 0.05$) higher in T_1 (1296 g), than the probiotic supplemented groups T_2 (1268 g) followed by T_3 (1249 g) and lowest body weight was recorded in T_4 (1234) group (Fig. 3). This might be due to the fact that as egg production increases depletion of nutrients from body increases which leads to lower body weights and also FCR value in T_4 was lowest (2.61) over T_1 (2.64) indicating that the birds consumed less feed per unit gain in live weight. The results of the present study corroborating with the reports of Pedrosso *et al.,* (1999) who concluded that addition of probiotics (*Bacillus subtilis*) increased feed utilization without significantly affecting the live weight gain in pullets. On contrary non-significant results were observed by Sattar Bageri Dizaji and Rasoul Pirmohammadi (2009) in Hy-line W-36 strain laying hens during 46 to 55 weeks of age (1462 in control group vs 1450.6 g in probiotic supplemented group). Panda *et al*., (2006) observed non-significant difference in body weights in White Leghorn layers (1657 in control vs 1644 g in probiotic group) with probiotic supplementation during 65-76 weeks of age.

Similar findings were also observed by Yalcin *et al.,* (2010) in Hyline Brown layers (1745 in control vs 1811g in probiotic supplemented birds); Wei Fen Li *et al.,* (2011) in Shaoxing Ducks (1710 in control group vs 1699 g/d/bird in probiotic supplemented birds); Abdelqader *et al.,* (2013) in Lohmann white laying hens (1714 in control group vs 1715g in probiotic supplemented group) during 64 to 75 weeks of age.

The results of the present study revealed that probiotic supplementation to the laying hens during post peak period (Table 10), improved percent income from the egg production by 4.51 in T_2, 3.83 in T_3 and 3.14 in T_4 over the control (T_1). These findings are in accordance with the earlier observations of Moorthy et *al.,* (2010). Non-significant improvement in returns in the present study can be attributed to non-significant results obtained with egg production and feed efficiency. On contrary Davis and Anderson (2002) reported net income ($/hen) of 9.74 in control group and 10.33 in probiotic supplemented group in Single Comb White Leghorn layers. Chaurasia *et al*., (2008) found significant gain in net profits (Rs. 19.67 vs 28.03) in Vanaraja birds; this might be due to significant improvement in FCR. Swain *et al.,* (2011) reported that net profit increased (9.2%) due to supplementation of probiotics and yeast @ 2.0g/kg diet compared to control diet (8.1%).

Conclusion

It can be concluded that supplementation of probiotics at 0, 5, 10 and 15% level in layer diets during post peak production has no significant impact on feed intake, feed efficiency, and serum protein. Serum cholesterol levels were significantly ($p < 0.05$) reduced in treatment groups over control group during the experimental period. The percent improvement in income over the control was higher in treatment group with 5% level of probiotic supplementation in layer diets.

Based on the performance, relative economics and serum cholesterol levels it may be concluded that probiotics can be supplemented @ 50g / ton of layer diets during post peak production without any adverse effects. The use of probiotics in the present

study is an alternative source for the use of antibiotic feed supplements in the poultry diets without causing any deleterious effects on the health of the birds. Further studies are required to ascertain the level of incorporation of probiotics with different strains at different periods of egg production in laying hens.

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Fish Farming: A Boon for Enhancing Farmer's Income and Livelihood

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Abstract

In Jammu and Kashmir State, there is a huge network of water resources which are usually in the shape of cold water streams, perennial rivers, lakes, reservoirs, sars, irrigation canals and several high altitude lakes. Besides, there are a great number of community and private ponds which may plays an important role in the fish production enhancement for state. As per the website of Department of Fisheries J&K Government, total fish production of the state was about 20.70 thousand tons (2017-18). Out of which 482 tons was contributed by trout fish. Due to its vast network of aquatic resources, fish and fisheries of Jammu and Kashmir State has great scope and potential to grow and develop exponentially. The State has great potential to promote diversified fisheries in terms of its unique agro-climatic conditions. The Jammu and Kashmir state comprises of three regions viz. Jammu, Kashmir and Ladakh. Due to varied climatic conditions in these three regions, all have the great potential to develop and promote the various commercially important fish species. Jammu division itself has unique agro climatic conditions and offers potential for the development of both warm as well as cold water fisheries. Most of the districts of Jammu Province such as Doda, Ramban, Kishtwar, Jammu, Udhampur, Reasi, Kathua, Rajouri and Poonch offer great potential for the warm water and/or cold water fisheries and aquaculture. While in Kashmir valley, the temperate climate is favourable only for the development of cold water fisheries and aquaculture. The areas of Ladakh regions which comprise of Leh and Kargil are suitable for the development of cold water fisheries and Aquaculture. In all these regions some varieties of carp and/or trout are already introduced and cultured successfully and some farmers are earnings handsome income. There is great untapped potential in fisheries sector. On national level only one third of freshwater aquaculture and small portion of brackish water resources have been utilized for aquaculture. Reservoirs fisheries is also highly under-utilized (Av. annual yield – only 20 Kg/ha). A great amount of waste land in the farmer's field as well as water logged land is also available in the state which may find a potential use in aquaculture sector. Many farmers are now gets attentive about the benefits/profits of aquaculture and thus coming forward for the adoption of Aquaculture along with traditional agriculture. In the coming years, it is hopeful that the fish production of the state will grow exponentially and the wide gap between the demand and supply will be minimized.

Keywords: Fish farming; Aquaculture; Culture system.

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Introduction

Fish farming plays an important role in addressing nutritional and livelihood security, especially of the rural poor in developing countries. Fish are rich sources of protein, essential fatty acids, vitamins and minerals. The fats and fatty acids in fish, particularly Omega 3 fatty acids, are highly beneficial and difficult to obtain from other food sources. The growing gap between supply and demand globally will impact on the health and nutrition of low income families, unless efforts are made to increase the production to meet the growing demand. Fish farming means culture of commercially important fish species or some other aquatic organism under controlled conditions. Fish farming is usually called as Aquaculture. Aquaculture is a new and wide name for what once we called 'fish culture. Present concept of fish farming/aquaculture incorporates culture of all aquatic organisms by following certain management techniques which includes water quality, choice food etc. and to protect them from unwanted predators, diseases, pollutants or any other things which are harmful to them. The aquatic organisms which are normally used for aquaculture for food purpose include fishes, prawns, shrimps, crabs, mussels and some live food organisms like algae and zooplankton.

Aquaculture is essentially an Asian farming practice. India is endowed with vast and varied aquatic resources, of which small portion are being utilized for aquaculture. Aquaculture continues to increase in volume and value of output in many countries of the world, filling the gap between the supply and demand for fish and fishery products, improving nutrition and contributing to the household economy, particularly in rural areas. Besides, there is immense scope for the betterment of mankind through aquaculture. Currently, China leads in Aquaculture production in the world followed by India, but the difference in production is almost 8-9 times. In India, the average growth rate of Aquaculture is about 8%.

Importance of aquaculture

- Integration of fish farming with agriculture and/or animal husbandry is known to be more profitable than agriculture alone.
- Fish culture gives efficient means for recycling agricultural and domestic wastes, in order to help/protect our environment.
- Many high valued and commercially important aquatic items such as trout, ornamental fish and many other may helps in earning good returns.
- Artificial recruitment in the water bodies by fish seed produced in fish hatcheries through aquaculture (ranching), could certainly add new fishery resources or increase existing fish stocks.
- Through Aquaculture, we can utilize the unutilized large size water bodies for fish production by adopting pen/cage culture types of culture systems.
- Aquaculture has the potential to help in generating employment for many unemployed and under-employed people. Aquaculture based farming system is economically viable and can help greatly to stop the migration from villages to urban areas.
- Besides, from human nutrition point of view, the fish food is not only easily digestive but is also rich in essential amino acids like lysine and methionine. The unique poly unsaturated fatty acids (PUFA) namely, eicosa pentaenoic acid of fish is known to reduce the cholesterol level of blood and save human beings from coronary diseases. Further, vitamins and minerals are also present in good quantities in fish.

Types of culture systems

Aquaculture is conducted in all the three types of aquatic environments:

1. *Freshwater aquaculture:* It involves the culture in the water bodies having salinity level of less than 0.5 parts per thousand (ppt).
2. *Brackish water aquaculture:* It involves the culture in the water bodies having salinity level ranges from 0.5 to 30 ppt, and;
3. *Mari culture or sea farming:* It involves the culture in the water bodies having salinity level of more than 30 ppt.

The species of flora and fauna inhabiting the three types of water bodies are accordingly called freshwater species, brackish water species and marine species. Freshwater which is most extensively used sector of aquaculture, is further divided into two segments.

a. *Cold waters* of higher altitudes having temperature range of < 18°C and
b. *Warm waters* of plains having temperature range of > 18°C

Aquaculture practices in these waters are, therefore, called coldwater aquaculture and warm water aquaculture, respectively. Aquaculture is practiced through various methods. Freshwater aquaculture is carried out in fish ponds, fish pens, fish cages, raceways and on a limited scale in paddy fields. Culture of fishes in ponds is the oldest form of aquaculture and throughout the country, this (pond) culture system is mainly adopted by the farmers.

Fish Ponds and their types

Detailed Knowledge regarding different types of fish ponds is a prerequisite for a profitable business in fish culture. A fish farm comprises of different types of ponds namely nursery ponds, rearing ponds, production ponds and breeding ponds etc. The number and dimensions of these ponds mainly depends upon the water resource, variety and size of fish to be cultured and type of management. A typical fish pond is a drainable water body with an inlet for the entry of water from water source and an outlet for draining the pond during harvest.

Types of Fish ponds

Nursery Pond

Nursery ponds are smaller (0.02-0.06 ha) and is mainly prepared to nurse the hatchlings for a period of about two to three weeks i.e. until they become fry (2.5-4.0 cm). The depth of the water column may be between 1.0 1nd 1.5 m. The maximum stocking density of hatchlings is about 10 millions/ha. However these ponds are used as nursery only for a short time, they could be used three or four times in a single breeding season. During the other seasons, the nurseries can also be used as production ponds.

Rearing Ponds

Rearing ponds are fairly larger than nursery ponds and sizes usually range between 0.06 and 0.1 ha. In these, the fry are grown for about two to three months or until they attain fingerlings stage (4-10 cm). The depth of water column may be between 1.5 and 2.0 m. Like nursery ponds, when rearing ponds are not in use for rearing purpose, they can serves as production ponds.

Production Ponds

In production/stocking ponds, the fingerlings are raised to marketable size fish. The size of this pond varies from 0.1 to 2.0 ha, as ponds larger than 2 ha are not suitable for efficient management. In production ponds for carp culture, the depth of water column should be between 2 and 2.5 m.

Breeding Ponds

These ponds are only needed for breeding purposes. These are used to stock brooders of the fish species to breed.

In case the source of water is turbid, a small sedimentation pond or a filtration system may also be constructed to filter the water before its direct entry into the fish ponds. If areas of water scarcity and high seepage are to be utilized for fish farming, cemented ponds may be constructed there. However, such ponds should be treated/ overlaid with a soil bed/cover of 30-50 cm soil, in order to give the natural substratum with rich organic matter for higher production and growth.

Different levels of Aquaculture

Depending on the intensity of operation and degree of management, aquaculture practices are classified into following four operations/levels:-

1. Extensive aquaculture
2. Semi- intensive aquaculture
3. Intensive aquaculture
4. Super intensive aquaculture

Extensive aquaculture: In extensive level of aquaculture, low stocking densities of 2000-5000 carp fingerlings are used and no supplemental feed is given. Fertilization may be due to stimulate the growth and production of natural food in the water. In such types of culture system, carp culture does not require water exchange during culture period. The ponds used for extensive aquaculture are usually large. The production is generally low, less than 0.5 ton/ha/yr in the case of carps.

Semi-intensive level: Semi-intensive aquaculture uses medium size ponds 0.5 ha each with comparatively higher stocking densities than extensive aquaculture (5000-10000 carp fingerlings/ ha). Supplementary feeding is done in moderate amounts. In carp culture, water replenishment is done once or twice a month @10%. The production averages around 3-7 tons/ha/yr of carps.

Intensive level: In intensive level of aquaculture,

the pond size is generally small (about 0.2 ha approximately) with very high density of culture organisms i.e. 20000 to 25000 carp fingerlings/ha are stocked. The system is totally dependent on the use of formulated feeds. Feeding of the stock is done at regular intervals. Water replacement under intensive culture is effected on a daily basis. Production under intensive level of aquaculture is much higher, for example, about 12 to 15 tons/ha/ year in carp culture.

Super-intensive level: Super intensive aquaculture needs running water supply and complete daily water exchange is performed. This system is mostly practiced in cement tanks, fiberglass tanks and raceways etc. which are fitted with high efficiency biological filters for continues recirculation of water. The size of the tank ranges between 50-100m^3. The cultured organisms are fed with high quality formulated feed. The feed is given through demand feeders. The water quality is regularly monitored with electronic gadgets. Stocking density ranges between 40,000 to 50,000 carp fingerlings/ha. The production ranges between 15-20 tons/ha/yr in case of carps.

Management practices for carp culture

- *Selection of species*

The species to be selected for aquaculture should have following characteristics:

1. It should have high growth rate
2. It should have capabilities of efficiently utilize and convert the organic production of the water into fish flesh
3. It should be compatible with other species under culture
4. It should be hardy to live in changing physico-chemical conditions such as temperature, pH, turbidity, carbon dioxide and dissolved oxygen
5. Able to reproduce under confined conditions
6. It should be easy to handle and harvest
7. It should have good market demand

In carp culture, usually three Indian major carps viz. *Catla catla, Labeo rohita and Cirrhinus mrigala* and three exotic carps such as *Hypophthalmichthyes molitrix, Ctynopharyngodon idella and cyprinus carpio* are selected for culture. This is mainly because of their fast growth and compatibility among each other.

Some Important Cultural System of Aquaculture

- Composite fish culture
- Integrated farming system
- Raceway culture
- Cage culture
- Pen culture

Composite fish culture

A fish pond is a complex ecosystem as the surface is occupied by the floating organisms such as phyto and zoo plankton; the column region has live and dead organic matter sunk from the surface and the bottom is enriched with detritus or dead organic matter. The marginal areas harbor a variety of aquatic vegetation. The different trophic levels of a pond could be utilized for increasing the profitability of fish culture. Keeping this in mind, the concept of Composite fish culture has been developed. The main objective of this culture system is to select and grow compatible species of fish of different feeding habits to exploit all the types of food available in the different nook and corners of the fish pond for maximizing fish production. The common species of carps having compatibility and different feeding habits and which comes under composite fish culture are Indian major carps such as catla, rohu and mrigal and exotic carps such as common carp, silver carp and grass carp.

Integrated farming system

Here, otherwise waste output of one enterprise can be utilized as inputs for other enterprise.

- Wastes/by products produced through agriculture are consumed by cattle and fishes and converted to proteins that build up animal flesh.
- Water from fish ponds can be used as inputs for agriculture/horticulture crops as well as for veterinary enterprises. Mud from fish ponds can be utilized as organic fertilizer for agriculture/horticulture crops.
- All the wastes from veterinary enterprises are utilized as inputs for aquaculture and agriculture.

Cage culture

Cage aquaculture is a method used for raising aquatic organisms (fish, prawns, mollusks,

crabs etc.) within an enclosure, which is installed in suspended state in ponds, reservoirs, lakes, rivers or any other large size water body. In India, it is initiated with the raising of fry (20-25 mm) to advance fingerlings (100-150 mm) in water bodies/ reservoirs to increase their production. Cages can be of various shapes and sizes. Rectangular cages are however, preferred for easy operation and management.

Pen culture

Aquaculture in pens implies rising of required aquatic organisms (fish, prawn, mollusks etc.) in an enclosure which is formed by cordoning off areas of an open water body such as inter-tidal areas of the sea or fore shore waters of lakes, reservoirs, river, wet lands etc by net barriers.

Pens are generally constructed on the shore side, in semi-circular, rectangular or square shapes as per the suitability of the site. They are constructed by barricading the other three sides by a wall of nylon netting hung from poles driven to the bottom. The framework is generally made out of bamboo and other locally available wood.

Raceway culture

Raceways are designed to provide a flow through system to enable the culture/rearing of much denser population of aquatic animals. An abundant flow of good quality, well oxygenated water is essential to provide respiratory needs and to flush out metabolic wastes, particularly ammonia. Raceways are obviously smaller in size than ponds and occupy much less space. Site selection for a raceway farm has to be done with special care. Naturally the most important consideration is the water supply. The main source of water is springs, streams, deep wells and/or lakes. In Jammu and Kashmir, raceways are widely used for trout culture.

Conclusion

The present article indicates that if the available water as well as farm resources are utilized judiciously and farmers/unemployed youths are advised about the benefits and techniques of latest aquaculture technologies along with agricultural enterprises, there will be an increase in per unit area production and productivity and it will be helpful for the enhancement of income and improvement of livelihood security of farmers.

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Review Article

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Climate Change and its Impact on Fisheries: A Review

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Abstract

Climate change will have significant impacts on fisheries and aquaculture. The consequences of climate change will be negative for fishers at low latitudes. In contrast, fish farmers may benefit from expansion of the areas where aquaculture is viable due to increased temperatures and rising sea levels. However, these benefits may be tempered by reduced water quality and availability, increased disease incidence and damage to freshwater aquaculture by salinization of ground water.

Keywords: Fisheries; Climate Change; Aquaculture; Temperature.

Introduction

It is now widely accepted that climate change is no longer simply a potential threat, it is unavoidable; a consequence of 200 years of excessive greenhouse gas (GHG) emissions from fossil fuel combustion in energy generation, transport and industry, deforestation and intensive agriculture (IPCC, 2007a). IFAD and other development agencies have recognized climate change as one the greatest threats facing mankind today (IFAD, 2007; World Bank, 2010) and have highlighted the fact that the poorest and most vulnerable will be disproportionately affected by its impacts (IFAD, 2008). Small-scale fisheries and aquaculture have contributed little to the causes of climate change but will be amongst the first sectors to feel its impacts. Some anticipated consequences include falling productivity, species migration and localized extinctions, as well as conflict over use of scarce resources and increased risks associated with more extreme climatic events such as hurricanes. These result from direct impacts on fish themselves as well as from impacts on the ecosystems on which they depend, such as coral reefs.

In general the consequences of climate change will be negative for fishers at low latitudes. In contrast, fish farmers may benefit from expansion of the areas where aquaculture is viable due to increased

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temperatures and rising sea levels. However, these benefits may be tempered by reduced water quality and availability, increased disease incidence and damage to freshwater aquaculture by salinization of groundwater. The precise and localized impacts of climate change on fisheries are, however, still poorly understood (FAO, 2008a; Stern, 2007).

The Importance of Fisheries and Aquaculture

In 2006, fisheries and aquaculture produced a total of 143.6 million tonnes of fish (FAO, 2009a), 81.9 million tonnes from marine capture fisheries, 10.1 million tonnes from inland capture fisheries, 31.6 million tonnes from inland aquaculture and 20.1 million tonnes from marine aquaculture. China is by far the largest producer of fish, producing 51.5 million tonnes of fish in 2006, 17.1 million tonnes from capture fisheries and 34.4 million tonnes from aquaculture (FAO, 2009a). The Asia–Pacific region dominates both fisheries and aquaculture, particularly in terms of the number of people working in these sectors: 86% of fishers and fish farmers worldwide live in Asia, with the greatest numbers in China (8.1 million fishers and 4.5 million fish farmers) (FAO, 2009a). Asia is also a major producer of fish, accounting for 52% of the world's wild caught fish, while aquaculture in the Asia–Pacific region accounts for 89% of world production by quantity and 77% by value (FAO, 2009a).

Livelihoods: The livelihoods of 520 million people depend on fisheries and aquaculture (FAO, 2009a), 98% of whom live in developing countries (World Bank, 2005). FAO data reported by the World Bank (2005) indicates that the number of fishers in the world has grown by 400% since 1950, compared with a 35% increase in the number of agricultural workers over the same period. Most of the growth has been in small-scale fisheries in the developing world. It is likely that more poor people will turn to fishing and other common-pool resources in future as a result of the negative impacts of climate change on agriculture and other sectors.

Trade: Fish is the most widely traded foodstuff in the world: 37% of fish produced (live weight equivalent) is traded internationally (FAO, 2009a). In 2006 exports of fish were worth a total of $85.9 billion (FAO, 2009a), more than half of which originated in developing countries (Paquotte and Lem, 2008). In 2002, net exports of fish generated more foreign exchange earnings for developing countries than rice, coffee, sugar, and tea combined (World Bank, 2005). Aquaculture has grown by 6.9% per annum since 1970 (FAO, 2009a) and now provides half of global fish supply (Naylor et al., 2009). As global demand continues to grow, there are opportunities for poverty reduction within the sector if supplies of wild fish can be maintained and aquaculture expanded sustainably.

Health and nutrition: One third of the world's population rely on fish and other aquatic products for at least 20% of their protein intake (Dulvy and Allison, 2009) and fish provides more than 50% of all the protein and minerals consumed by 400 million of the world's poorest people (MAB, 2009) and is also an important source of other nutrients such as vitamins A, B and D, calcium, iron and iodine (FAO, 2005). Even in small quantities, fish can have a positive effect on nutritional status by providing essential amino acids that are deficient in staple foods such as rice or cassava. Fish accounts for 30% of animal protein consumed in Asia, 20% in Africa and 10% in Latin America and the Caribbean (Prein and Ahmed, 2000). It is thus central to the food security of many of the world's poor, especially in coastal areas and small Island developing states.

Climate Change, Fisheries and Aquaculture

A number of changes already evident can be attributed to the impacts of rising GHG emissions. Global average air temperatures rose by 0.74°C in the period 1906–2005 (IPCC, 2007a). Global average sea surface temperatures have also risen since 1950 as the ocean has absorbed 80% of heat added to the climate system; temperature increases are also being detected as deep as 3000 m. Increasing water temperature and associated thermal expansion accounts for 57% of the global average sea level rise of 1.8 mm per year between 1961 and 2003; a further 28% of the rise is attributed to the melting of glaciers and polar ice sheets (IPCC, 2007a). Oceans also absorb approximately 25% of anthropogenic CO_2 causing ocean acidification (Eakin et al., 2008). To date average alkalinity has declined from 8.2 to 8.1 (IPCC, 2007b), equivalent to a 30% increase in acidity.

Changing patterns and seasonality of snow melt are affecting freshwater hydrology in glacier and snow-fed rivers and lakes and rivers are warming in many regions (IPCC, 2007a). Deep water in large East African lakes including Lake Tanganyika and Lake Malawi has warmed by 0.2–0.7°C over the past 100 years (Rosenzweig et al., 2007). This warming has resulted in increasing thermal stratification, reducing mixing of cold deep and warm surface waters. This prevents upwelling of nutrients and lowers primary productivity.

In both freshwater and oceanic water bodies

changes are being observed in salinity, oxygen levels, currents and circulation (IPCC, 2007a). Though their consequences are often difficult to distinguish from damage caused by overfishing and pollution, these climatic changes are having impacts on aquatic ecosystems (IPCC, 2007a).

In the North East Atlantic there is evidence of changes in abundance of algae, plankton and fish species as well as rapid poleward shifts in their ranges (Brander, 2007). In just 40 years the range of some plankton species has moved north by over 1100 km (IPCC, 2007a). Changes in the abundance, productivity, community composition, distribution and migration of freshwater aquatic species are all being detected.

Rising water temperatures and ocean acidification are damaging coral reefs. When sea temperatures exceed long-term summer averages by 1°C for more than 4 consecutive weeks coral reefs suffer 'bleaching' (Nicholls *et al*., 2007), rejecting the colourful algae with which they normally have a symbiotic relationship, resulting in loss of colour, greater exposure to disease and often to death. Bleaching severely affects those species which are most dependent on coral reefs and thus the fishers who depend on them (Roessig *et al*., 2004). The most optimistic climate projections would lead to the bleaching of 80–100% of the world's corals by 2080 (Nellemann et al., 2008). In addition ocean acidification slows the rebuilding of coral reefs and weakens their structure and anticipated increases in extreme weather events as a result of climate change will further damage reefs (Vergara *et al*., 2009; Roessig *et al*., 2004; Eakin *et al*., 2008).

The most pessimistic scenario would likely result in temperatures rising by 4°C by 2100, causing widespread extinctions, ecosystem collapses and sea level increase of 0.26–0.59 m, again from thermal expansion alone (IPCC, 2007a). Glacier meltwater, the main contributor to sea level rise in most popular accounts, is not included in these models hence there is potentially significant underestimation. Currently emissions are rising by more than 3% per annum, a rate close to the fastest considered in the IPCC reports, suggesting the future may hold something "worse than the worst-case scenario" (Hamilton, 2009).

Based on current rates of GHG emissions increases, the results of future climate change and GHG emissions for fisheries and aquaculture are therefore likely to include:

- Average sea level rise of at least 0.6m by 2100 (IPCC, 2007a).
- Increased average sea surface temperatures (Nicholls *et al*., 2007)
- An overall increase in marine primary productivity of 0.7–8.1% by 2050 but with large regional variations (IPCC, 2007a). Productivity is likely to decline at lower latitudes (FAO, 2008a).
- Continued increases in ocean acidification (IPCC, 2007a).
- Intensification of extreme weather events, potentially including a stronger and more prolonged El Nino (Nicholls *et al*., 2007).
- Changing hydrological conditions including reduced water levels and flow rates as a result of reduced snow cover, increased frequency of heat waves and heavy precipitation events (even where average rainfall decreases), decreases in subtropical rainfall (IPCC, 2007a).
- Increases in run-off of 10–40% in some wet tropical areas (East and Southeast Asia) but decreases of 10–30% in some dry regions (North Africa and the Mediterranean, Southern Africa) due to declining rainfall, increased evaporation and increased demand for irrigation water (IPCC, 2007a).

Impacts of Climate Change on Fisheries

The links between fisheries and their ecosystems are deeper and more significant than those that exist in mainstream agriculture (FAO, 2008b). The productivity of a fishery is tied to the health and functioning of the ecosystems on which it depends for food, habitat and even seed dispersal (MAB, 2009); generally the only control humans can exert over a fishery's productivity is adjustment of fishing effort (Brander, 2007). Estuaries, mangroves, coral reefs and seagrass beds are particularly significant in the provision of ecosystem services, especially as nurseries for young fish, and are also amongst the most sensitive and highly exposed to the negative impacts of coastal development, pollution, sedimentation, destructive fishing practices and climate change. Fish also tend to live near their tolerance limits of a range of factors; as a result, increased temperature and acidity, lower dissolved oxygen and changes to salinity can have deleterious effects (Roessig *et al*., 2004). Particular characteristics of the aquatic environment which will be affected by climate change are temperature and primary production.

Table 1: Twenty national economies most vulnerable to the impacts of climate change on fisheries and aquaculture (with IFAD Regional Division indicated)

Rank Country	Rank Country	Rank Country	Rank Country
1 Angola (WCA)	6 Mali (WCA)	11 Morocco (NEN)	16 Uganda (ESA)
2 DR Congo (WCA)	7 Sierra Leone (WCA)	12 Bangladesh (APR)	17 Zimbabwe (ESA)
3 Russia (WCA)	8 Mozambique (ESA)	13 Zambia (ESA)	18 Côte d'Ivoire (WCA)
4 Mauritania (WCA)	9 Niger (WCA)	14 Ukraine	19 Yemen (NEN)
5 Senegal (WCA)	10 Peru (LAC)	15 Malawi (ESA)	20 Pakistan (APR)

Source: Allison et al. (2009)

Temperature: All marine and aquatic invertebrates (molluscs, crustaceans, worms etc.) and fish are poikilotherms; their internal temperature varies directly with that of their environment. This makes them very sensitive to changes in the temperature of their surrounding environment. When changes do occur they move to areas where the external temperature allows them to regain their preferred internal temperature. This "behavioural thermoregulation" (Roessig et al., 2004) is resulting in rapid migrations poleward or into cooler bodies of water (FAO, 2008a), corresponding to the poleward shift of climatic zones. As a result, benefits are likely to accrue at higher latitudes and losses will be experienced in the tropics. Some species will also shift from shallow coastal waters and semi-enclosed areas, where temperatures will increase fastest, into deeper cooler waters (Cheung *et al*., 2009a). Recent predictions suggest this migration alone could reduce maximum catch potential in some areas of the tropics by up to 40% (Cheung *et al*., 2010), but this may be a conservative estimate as it does not take into account predicted negative effects of climate change on coral reefs or the impact of ocean acidification (Cheung *et al*., 2009b). Recruitment is also strongly affected by climate variability (Walther *et al*., 2002) and some stocks may become vulnerable to overfishing at levels of fishing effort that had previously been sustainable (Easterling et al., 2007).

Where fish continue to inhabit warming bodies of water the increases in temperature will increase their metabolic rate slowing growth and reducing maximum size (Roessig *et al*., 2004). There are likely to be local extinctions of fish species at the edges of their ranges, especially among freshwater and diadromous species (IPCC, 2007a). However, overall extinction rates for marine species are lower than those predicted for terrestrial species (15–37%), in part due to their higher potential for migration (Cheung *et al*., 2009b). As mentioned above, a 1–3°C temperature rise relative to 1990–2000 would result in the bleaching and possible death of most of the world's coral reefs (IPCC, 2007a). This would have serious negative effects on coastal reef fisheries. It would also increase the risk of Ciguatera, a form of poisoning contracted by eating fish that have grazed on the toxic algae that grow on dead coral reefs (IPCC, 2007a).

Primary production: Primary productivity is affected by availability of nutrients in the water, which in turn depends on freshwater run-off and ocean mixing as well as levels of light and temperature. In some areas reduced precipitation could lead to reduced run-off from land, starving wetlands and mangroves of nutrients and damaging local fisheries. In other areas increased precipitation or increased extreme weather events, including flooding, will lead to excessive nutrient levels in rivers, lakes and coastal waters as sewage and fertilizer is washed into water bodies causing harmful algal blooms, also known as red tides (Roessig *et al*., 2004; Epstein, 2000). With climate change primary productivity is predicted to decline at lower latitudes (FAO, 2008a), where the majority of the world's small-scale fisheries are located, reducing the productivity of the fisheries.

Other effects: Increased frequency of extreme weather events will affect the safety of fishers, damage homes, services and infrastructure, particularly in coastal areas (IPCC, 2007a) and will also damage many coastal ecosystems. Mangroves and reefs, which provided vital defence in many areas of the Indian Ocean following the Indonesian tsunami in 2004 and which protect small islands from wave damage during regular hurricanes and tropical storms, will be damaged by climate change, reducing their effectiveness as coastal defences (UNEP-WCMC, 2006). Increases in heavy rainfall events will increase flood risk, reduce water quality and threaten physical infrastructure. Reduced dry season flow rates in South Asian rivers and most African river basins are expected to result in reduced fish yields due to impacts on spawning and larval dispersion (FAO, 2007).

Impacts of Climate Change on Aquaculture

The impacts of climate change on aquaculture are more complex than those on terrestrial agriculture owing to the much wider variety of species produced (Brander, 2007) but different to fisheries because of the greater level of control possible over the production environment. Greater control can be exerted over the production environment (e.g., by providing food, controlling breeding and disease etc.), and over environmental conditions (e.g., by controlling water flows, temperature, water quality etc.), thus reducing dependence on ecosystem services. However many small-scale fish farmers in developing countries practise a low-input, low-output form of aquaculture depending heavily on ecosystem services and naturally available feed to support their fish. Rice–fish systems in south-east Asia often depend upon wild fish entering paddy fields (Haroon and Pittman, 1996; Rothuis, 1998; Das, 2002); reduced wild stocks will affect farmers who rely on catching fish in their paddy fields for part of their food or income. Many forms of aquaculture still depend heavily on wild stocks for food and seed (FAO, 2008c). The future supply of fishmeal and oils from capture fisheries, used as feed stock in aquaculture, is far from certain (Naylor *et al*., 2000; Roessig *et al*., 2004; Brander, 2007).

Changes in rainfall will cause a spectrum of changes in water availability ranging from droughts and shortages to floods and will reduce water quality, while salinization of groundwater supplies and the movement of saline water further upstream in rivers caused by rising sea levels will threaten inland freshwater aquaculture (IPCC, 2007a). Increased run-off bringing in nutrients from sewage or agricultural fertilizers may cause algal blooms which in turn lead to reduced levels of dissolved oxygen and 'fish kills' (Diersing, 2009). Rising temperatures similarly reduce levels of dissolved oxygen and increase metabolic rates of fish, leading to increases in fish deaths, declines in production or increases in feed requirements while also increasing the risk and spread of disease (FAO, 2008a).

Coastal aquaculture will be exposed to major economic losses from extreme weather events and red tides, the frequency and severity of which are likely to increase (Roessig *et al*., 2004).

However, not all of the changes will be negative.

As sea levels rise, flooding of low lying areas and salinization of groundwater and soil will create ideal conditions for aquaculture in many areas (MAB, 2009), while simultaneously rendering them unsuitable for regular agriculture. There has been a suggestion that Bangladesh could turn from a "rice-bowl into a fish-pond" due to this and increases in other flooding (World Fish Center, 2007a). Other benefits of rising water temperatures and sea levels include reduced cold water mortality of valuable fish and expansion of areas suitable for brackish or saltwater aquaculture such as shrimp and mudcrab (World Fish Center, 2007b).

Likewise increasing investment in water storage infrastructure such as dams, on-farm ponds and irrigation systems to retain reduced levels of precipitation and buffer variability in supply will create many potential sites for aquaculture production (MAB, 2009).

In currently cooler areas, such as those at higher altitudes or in more northerly latitudes, rising temperatures may result in increased growth rates and food conversion efficiencies, longer growing seasons, reduced cold water mortality and expansion of areas suitable for aquaculture (Brander, 2007; IPCC, 2007a).

Threats

The principal threats to future fisheries production identified here are expected to act progressively (i.e., a linear response) and to interact with each other. However, marine ecosystems can also respond to changes in physical or biological forcing in a nonlinear way, e.g., when a threshold value is exceeded and a major change in species composition, production, and dynamics takes place. We know that such nonlinear responses occur but do not yet understand how or under what conditions. This is a key limitation in our ability to forecast future states of marine ecosystems.

Fishing activity: Fishing is the greatest threat to future global fish production; however, the impacts of fishing and of climate change interact in a number of ways, and they cannot be treated as separate issues. Fishing causes changes in the distribution, demography, and stock structure of individual species and direct or indirect changes in fish communities and marine ecosystems. These changes have consequences for other ecosystem services (such as nutrient cycling and recreational use) and for sustainability, resilience and ability to adapt to climate change, and other pressures. Future sustainable fisheries depend on effective management of fishing activity, which in turn requires an understanding of the effects of climate change on the productivity and distribution of exploited stocks. Management must take into

account the interactive effects of fishing, climate, and other pressures.

Fishing is size-selective and causes changes in the size and age structure of populations, which results in greater variability in annual recruitment in exploited populations. The truncation of age structure and loss of geographic substructure within populations makes them more sensitive to climate fluctuations. To sustain the resilience of fish populations, in particular when they are confronted by additional pressures such as climate change, their age and geographic structure must be preserved rather than relying only on management of their biomass. We are currently fishing most stocks at levels that expose them to a high risk of collapse, given the trends in climate and the uncertainty over impacts.

Fishing is one of a number of human pressures that have resulted in a global decline in biodiversity. This raises concerns over the role biodiversity plays in maintaining ecosystem services and, in particular, resilience to climate change. A recent meta-analysis concluded that the oceans' capacity to provide food, maintain water quality, and recover from perturbation has been impaired through loss of biodiversity, but other studies of the relationship between biodiversity and ecosystem functioning and services produce a more nuanced picture.

Direct and indirect effects of climate change on distribution, productivity, and extinction. Climate change has both direct and indirect impacts on fish stocks that are exploited commercially. Direct effects act on physiology and behaviour and alter growth, development, reproductive capacity, mortality, and distribution. Indirect effects alter the productivity, structure, and composition of the ecosystems on which fish depend for food and shelter. The effects of increasing temperature on marine and freshwater ecosystems are already evident, with rapid poleward shifts in distributions of fish and plankton in regions such as the North East Atlantic, where temperature change has been rapid. Further changes in distribution and productivity are expected due to continuing warming and freshening of the Arctic. Some of the changes are expected to have positive consequences for fish production, but in other cases reproductive capacity is reduced and stocks become vulnerable to levels of fishing that had previously been sustainable. Local extinctions are occurring at the edges of current ranges, particularly in freshwater and diadromous species such as salmon and sturgeon.

Threats to inland fisheries and aquaculture: Many inland fisheries are threatened by alterations to water regimes that, in extreme cases, cause whole lakes (e.g., Lake Chad) and waterways to disappear. Climate change has direct effects, through reduced precipitation and greater evaporation, and indirect effects when more water is used for irrigation to offset reduced precipitation. Threats to aquaculture arise from

- Stress due to increased temperature and oxygen demand and decreased, pH,
- Uncertain future water supply,
- Extreme weather events,
- Increased frequency of diseases and toxic events,
- Sea level rise and conflict of interest with coastal defences, and
- An uncertain future supply of fishmeal and oils from capture fisheries.

Aquaculture poses some additional threats to capture fisheries, and the development of aquaculture could affect the resilience of capture fisheries in the face of climate change. There will also be some positive effects due to increased growth rates and food conversion efficiencies, longer growing season, range expansion, and the use of new areas as a result of decrease in ice cover.

Economic impacts: A key factor concerning future economic impacts is the need to identify which countries and regions are most vulnerable. Modeling studies have assessed country vulnerability on the basis of exposure of its fisheries to climate change, high dependence on fisheries production, and low capacity to respond. The studies show that climate will have the greatest economic impact on the fisheries sectors of central and northern Asian countries, the Western Sahel, and coastal tropical regions of South America, as well as on some small and medium sized island states. Indirect economic impacts will depend on the extent to which local economies are able to adapt to new conditions in terms of labor and capital mobility. Change in natural fisheries production is often compounded by decreased harvest capacity and reduced access to markets. Global fish production is forecast to increase more slowly than demand to 2020, and the proportion of production coming from aquaculture is forecast to increase. Therefore, zero growth in capture fisheries production will not threaten total supply unduly, but a decline could affect global fish consumption.

Evidence of climate impacts: Climate change affects the survival, growth, reproduction, and distribution

of individuals within a species, but impacts can also be shown at the level of populations, communities, or entire ecosystems. The following examples of observed climate impacts are intended to illustrate some of the main processes involved, their complexity, and their interactions. The climate-related drivers include temperature, salinity, wind fields, oxygen, pH, and the density structure of the water column. The examples range in scale from experimental studies on individual fish, through a combination of experimental and field studies, to modelling and observation of whole ecosystems and large sea areas.

Metabolic stress and its effects: Changes in the distribution of common eelpout (Zoarces viviparus) in the southern North Sea have been related to thermally limited oxygen delivery during summer hot spells, using a combination of experimental and field work to identify the physiological effects and consequences for mortality. Salmon in the Fraser River, Canada, suffered enhanced mortality when summer temperatures exceeded the levels previously recorded in a 60-year time series over a period of weeks in the summer of 2004. These examples show that the impacts of climate change can occur during short periods within a year and should, therefore, be ascribed to changes in the frequency and intensity of extreme events (floods, droughts, heat waves, hurricanes), as well as to changes in the mean values.

What Can be Done to Help Fishers and Fish Farmers?

The main focus of development efforts aimed at fishers and fish farmers in the developing world must be on helping them to build their capacity to adapt to climate change in ways that allow them to moderate potential damages, to take advantage of opportunities or to cope with consequences (IPCC, 2007a; Prowse *et al*., 2009).

Despite suggestions that adaptation is limited to altering catch size and effort (Easterling et al., 2007) there are in fact many options available, many of which actually benefit or provide an advantage to small-scale fishers and fish-farmers. These include direct adaptations to specific changes as well as actions that increase the resilience and adaptive capacity of communities and ecosystems, particularly by reducing other stresses such as social (poverty, inequality) and environmental (over-fishing, habitat destruction, pollution) stresses that can significantly increase vulnerability of communities and ecosystems to the impacts of climate change (Cheung *et al*., 2009a; IPCC, 2007a; Walther *et al*., 2002).

Many fishing communities are dependent on stocks that exhibit regular fluctuations and so have already developed considerable coping capacity (Easterling *et al*., 2007). Development agencies should direct efforts to documenting and understanding existing adaptation mechanisms and, where these prove successful, supporting and strengthening them and applying them elsewhere. Examples of such mechanisms include diversification of livelihood systems, such as switching between farming and fishing in response to seasonal and interannual variation in fish availability, as is done in parts of Asia and Africa, and seasonal migration to locations where fish are available; and flexible institutional and management strategies, such as integration of land and sea tenure to control access to fisheries and flexible redistribution of fishing rights between neighboring regions to buffer localized scarcities in Palau, Micronesia (Allison and Ellis, 2001). However, although traditional management systems may support sustainable livelihoods, they may also reinforce the social positions of those who oversee them, at the expense of less privileged members of the community (Neiland *et al*., 2005) and thus may not meet the requirements of equitable development.

Fish products are extensively traded. European Union countries and the USA are major markets, and there is a growing awareness of sustainability issues in these countries. Certification and similar sustainability initiatives could contribute to moves towards more efficient and sustainable systems.

This should go beyond a simple 'carbon labelling' approach. This should be applied to both fisheries and aquaculture, with a focus on market-led mechanisms that are affordable to developing countries; at present affordable options are rather limited.

Future Fish Production

The quantity of future fish production depends on changes in NPP and on what proportion is transferred through the marine ecosystem to human consumption. Because there are considerable uncertainties about both of these factors, very low confidence can be placed in current predictions of future fish production. Regional and local forecasts may be more reliable than the global forecast because of special factors (such as loss

of ice cover in high latitudes, which will allow greater light penetration). Some recent observation-based studies found that NPP has been declining, particularly in low latitudes, because of increased warming of the surface layers, which increases stratification and reduces nutrient mixing from depth. The scientific base is improving rapidly, as is evident from the very recent dating of key publications cited here, but we are some way from achieving a reliable consensus.

The examples of observed climate impacts cited above show changes in distribution and abundance of particular species, but because species are often replaced by functionally similar species, the net effect on trophic structure and fish production may be small. It is generally difficult to predict the changes in trophic structure and composition of ecosystems, therefore one simplifying assumption is that such functional replacement always occurs and that fish production is proportional to NPP. A second possible approach is to study the impacts of climate on fish communities rather than at the individual-species level. The rising proportion of aquaculture in global fisheries production will increasingly determine the trophic structure of fisheries; however, aquaculture is likely to remain dependent on capture fisheries for its food supply.

Summary and Conclusion

Climate change will have significant impacts on fisheries and aquaculture. At low latitudes these are likely to be largely negative for fisheries, damaging important ecosystems such as coral reefs and mangroves and causing reductions in fish stocks due to rising water temperatures and reduced primary production. This could have significant effects on food security and employment in areas dependent on fisheries that are particularly vulnerable to the impacts of climate change; these include reef fisheries, fisheries in shallow lakes or wetlands and fisheries in other enclosed or semi-enclosed bodies of water. However, some areas may experience localized increases in fish stocks due to in-migration of species from other areas and rising primary production. Brackish and saltwater aquaculture could benefit from rising sea levels and freshwater aquaculture in cooler regions could benefit from increased feed efficiency and reduced cold water mortality, though reductions in availability of wild fish for feed and seed, increased spread of disease and reduced water quality pose threats.

Responses to these changes must centre on boosting adaptive capacity and resilience both of communities and the ecosystems on which they depend. The heavy dependency of smallscale fishers and fish-farmers in developing countries on ecosystem services must be recognized and measures taken to increase the health of these ecosystems by reducing other stresses such as over-exploitation and pollution. Communities themselves must be strengthened through provision of services such as insurance and weather warnings to reduce risk, support for participatory natural resource management and sustainable fishing operations, and assistance in post-harvest processing and preservation to maximize valueadded and employment and minimize waste from both fisheries and aquaculture.

Adaptation in the fisheries sector need not be restricted to altering catch size and effort (Easterling *et al.* 2007). Numerous options are available, many focusing on building adaptive capacity and resilience, and many also contributing to additional goals of improved fisheries management and poverty reduction, improving the livelihoods of those poor rural people most at risk from the effects of climate change.

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Review Article

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Effect of Low Temperature Preservation on Quality Characteristics of Meat

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Abstract

Meat is highly perishable commodity due to higher moisture and nutrient content. The main causes of spoilage in meat are microbial, chemical and enzymatic. Various preservation techniques have been developed to preserve meat and meat products with ten advancement of technology, consumer awareness for healthy and safe product as well as increased socio-economic status of people. Still low temperature preservation techniques viz. chilling and freezing are the best methods for short and long term preservation of meat respectively. These methods are used to slow down the enzymatic reactions and microbial growth, but also effects the physico-chemical and sensorial properties of meat with progression of storage.

Keywords: Chilling, Freezing, Sensory properties, Physical and microbiological changes.

Introduction

The food processing industry is one of the largest sectors in India in terms of production, growth, consumption, and export. Food processing industry is widely recognized as the 'sunrise industry' in India and is of enormous significance for India's development because of the vital linkages and synergies that it promotes between the two pillars of the economy, namely Industry and Agriculture. As the country moves on the path of development, agricultural sector evolves from traditional level farming to commercial agriculture producing high value and processed products. Now a days, meat has become one of the staple food because of it's nutrients dense quality, high in protein, low in fat, high content of minerals and vitamins. The meat safety regarding its physical damage, chemical changes and microbiological quality has become crucial because of consumer awareness and competition in international food market. Adequate meat preservation complements a marketing system which by necessity has been adapted to a fast throughput of fresh meat and which does not facilitate the use of surplus meat in periods of meat shortage. Spoilage is the deterioration of food which makes it taste and smell bad (e.g. when it is sour, rotten or mouldy) and/or makes it a carrier of

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disease germs. The onset of spoilage in meat is seen by changes in colour, among other things.

Main causes of food deterioration

Preservation techniques are designed to counteract or slow the changes which cause deterioration by:

- Microorganisms
- Enzymatic Reactions
- Chemical Reactions

1) Bacteria are single-celled micro-organisms that are invisible to the naked eye. They break down the wastes and bodies of dead organisms. Some cause severe illness. Under favorable conditions microbiological spoilage starts quickly in fresh and non-acidic products such as fish and meat. Bacteria from the animal's skin or intestines can rapidly reproduce.

2) Enzymes are proteins which assist biological reactions, e.g. the conversion of certain organic substances into different ones. When fish or animals are killed, the enzymes inside them are still intact. Those enzymes start breaking down components into smaller parts. This affects smell, taste and texture. Several hours after death rigor mortis occurs (a stiffening of the flesh). After that the flesh gets softer again due to enzymatic reactions (autolysis). Heat treatment (e.g. pasteurization) can inactivate enzymes.

3) With fatty fish or meat, chemical reactions can take place between the fat and oxygen in the air (oxidation reactions). By exposing these products for a long time to air, e.g. during drying and smoking, the product acquires a rancid smell and taste. It is therefore better to use less fatty kinds or pieces of fish or meat for smoking and drying.

Food preservation

It involves preventing the growth of bacteria, fungi (such as yeasts), or other micro-organisms (although some methods work by introducing benign bacteria or fungi to the food), as well as retarding the oxidation of fats that cause rancidity. Food preservation may also include processes that inhibit visual deterioration, such as the enzymatic browning reaction in apples after they are cut during food preparation. Preservation is the processing of foods so that they can be stored longer. Man is dependent on products of plant and animal origin for food. Because most of these products are readily available only during certain seasons of the year and because fresh food spoils quickly, methods have been developed to preserve foods. Preserved meat can be eaten long after the fresh products would normally have spoiled. With the growth of towns, the need to preserve foods longer increased as some people could no longer grow their own vegetables nor keep animals. Preservation must be seen as a way of storing excess meat and meat products that are abundantly available at certain times of the year, so that they can be consumed in times when food is scarce. Meat preservation includes any method by which meat is protected against spoilage by oxidation, bacteria, molds, and microorganisms. Traditional methods include dehydration, smoking, salting, controlled fermentation (including pickling), and candying; certain spices have also long been used as antiseptics and preservatives. Among the modern processes for meat preservation are refrigeration (including freezing), canning, pasteurization, irradiation, and the addition of chemical preservatives.

Preservation of meat- classified on the basis of these principles

1) Temperature controlled
    # Low temperature- chilling, freezing
    # High temperature- pasteurization, canning
2) Moisture control
    # Drying
    # Freeze drying
    # Curing
    # IMF
    # Smoking
3) Direct microbial inhibition
    # Irradiation
    # Use of chemicals and preservatives
    # Antibiotics
    # Bio preservation
    # Organic acids
4) Atmosphere control
    # Vacuum packaging
    # Modified atmospheric packaging
5) Newer methods
    # High pressure processing
    # Pulse electric field

Refrigeration and freezing

Meat is a highly perishable product and soon becomes unfit to eat and possibly dangerous to health through microbial growth, chemical change and breakdown by endogenous enzymes. These processes can be curtailed by reducing the temperature sufficiently to slow down or inhibit the growth of micro-organisms, to inactivate the enzymes and to slow down the rate of chemical reactions.

While mechanical refrigeration is a modern process it is known that the ancient Romans kept food cool with ice. "Chilled" meat is usually stored at temperatures around 1°C to +4°C when it keeps well for several days. Provided that the meat is kept very cool (1°C to 0°C) and that slaughter and meat cutting are carried out under strict hygienic conditions, modern packaging techniques including storage under carbon dioxide or nitrogen or in vacuum can extend this period to about 10 weeks. Chilling at temperatures very close to the freezing point of meat, -15°C diminishes the dangers of most pathogens and slows the growth of spoilage organisms; growth of some organisms, moulds, virtually ceases at -10°C. Most pathogens *(Salmonella, Staphylococcus species and Clostridium perfringens)* are inhibited by cooling but *Listeria monocytogenes* can grow at + 2°C, some *Salmonella* species at +5°C and *Campylobactor* at +7°C. Non-pathogens include *Pseudomonas* species which predominate on the exposed surface of chilled meat. Freezing - commercially at -29°C and domestically at -18°C - is now a standard method of preserving for periods of 1-2 years but there is some deterioration of eating quality compared with fresh or chilled meat.

However, there are problems in chilling and freezing meat. If it is cooled too rapidly below 10°C before the pH of the muscle has fallen below a value of about 6, the muscle fibres contract (cold shortening) and the meat is tough when cooked. This problem applies more to small animals, such as lamb, which cool down rapidly. The modern procedure is to cool the carcass to 10-15°C ("conditioning") and to hold that temperature for a few hours until the pH has fallen to 6. Beef carcasses can be suspended in such a way as to exert a pull on certain muscles to prevent contraction. Another method is to apply electrical stimulation to the carcass after slaughter (low volt) or after evisceration (high volt) for 2-4 minutes to bring down the pH rapidly.

Another problem can arise during thawing of pre-rigor frozen meat when the muscle contracts and exudes a substantial part of its weight as tissue fluids (thaw rigor) (Lawrie, 1991). Clearly, freezing of meat is not a straightforward procedure and calls for certain expertise. Only post-rigor meat should be frozen.

Physical changes

There is not much change in physical state of meat during chilling condition, but dung freezing ice formation involves a series of physico-chemical modifications that decrease meat quality. The principal physical changes in frozen meat and other food products are freeze cracking, moisture migration, recrystallization of ice and drip loss during thawing. During chilling, there may be problem of chiller loss due to temperature fluctuation and high RH.

Freeze cracking- in general, high freezing rate leads to small ice crystals and better quality meat. However, some products may crack when they are submitted to very high freezing rates or at very low temperature. The crust formed during freezing on the surface of a product serves as a shell that prevents further volume expansion, when the internal portion of the unfrozen stress is higher than the frozen material undergoes phase transition. If the internal stress is higher than the frozen material strength, the product will crack during freezing. Precooling prevents it because it reduces the differences in temperature between products and freezing medium.

Moisture migration- during freezing, supercooling of cell contents can lead to moisture movement through an osmotic mechanism. The driving forces for this are the temperature difference and resultant vapour pressure difference. Moisture migration in meat products produce surface desiccation and freezer burn, along with formation of ice inside the package. During thawing, it produces drip, which leads to nutrients loss, affects texture and juiciness and modifies the appearance of the products. Various components in meat products, which differ in their water activity, produce moisture redistribution and textural characteristics are lost. This condition is minimized by maintained small temperature fluctuation and small temperature gradients, and by the inclusion of internal barriers within the product and within the packaging.

Recrystallization of ice crystallization- it is defined as the increase in the average size of the ice crystals. The driving force for this phenomenon is the difference in the surface energy of two adjacent crystals, this energy being proportional to the crystal curvature.

The increase in ice crystal diameter during recrystallization leads to the redistribution of this solution around the tissue; its interaction with the protein structure contributes to denaturation, which also produces an increase of the exudate released by the tissue after thawing. Commonly hydrocolloids are recommended as ice crystal inhibitors.

Drip loss- During freezing, pure water is separated from the system in the from of ice crystals. Solute concentration increases and melting temperature decreases following the thermodynamic equilibrium line. With regard to exudates production, in frozen meats a slow thawing process at low temperatures is sometimes recommended to permit water diffusion in the thawed tissue and its relocation in the fibres.

Chemical changes

As the freezing process converts a large proportion of liquid water into ice, it also concentrates the remaining solution. Enzymes increase the possibility of water being in contact with different substrates. The most common chemical changes that can proceed during freezing and frozen are following:

Lipid oxidation- It is a complex phenomenon. A free radical process is the basic mechanism upon which lipid oxidation proceeds and the process includes a number of stages. One electron transfer from metal ions like haem and non-haem iron would dominate hydroperoxide breakdown during frozen storage. The occurrence of lipid oxidation in frozen meat leads to loss of quality:- flavor, appearance, nutritional value and protein functionality (Estevez, 2011). Decomposiiton of hydro peroxides of hydroperoxides of fatty acids to aldehydes and ketones is responsible for the characteristic flavors and aroma known as rancidity.

Protein denaturation- The main causes of freeze-induced damage to proteins are ice formation and recrystallization, dehydration, salt concentration, oxidation, changes in lipid groups and the release of certain cellular metabolites. This is very much common in frozen fish, meat, poultry, egg products and dough. Freezing has an important effect in decreasing water holding capacity of muscle systems on thawing.

Enzyme activity- Storage at low temperatures can slow (but not inactivate) the enzymes in the tissue; enzymatic reaction (hydrolyses like lipases, phoslipases, proteases etc., which catalyse the transfer of groups to water) may remain active during frozen storage. Hydrolytic enzymes can produce quality deterioration. Lipolytic enzymes, like lipases and phoslipases, hydrolyse ester linkages of triglycerols and phospholipids respectively. Hydrolytic rancidity, textural softening and color loss are direct consequences of hydrolytic enzymes activities.

Microbiological changes

Chilling is important for prevention of many spoilage and pathogenic batcteria, but there are some microorganisms which can grow at chilling temperature, like pseudomonas, *Listeria monocytogenes, Clostridium botulinum type E, Aeromonas hydrophila, Achromobactor* etc. which can cause spoilage in meat and meat product at chilling temperature. Sometimes mould can also grow when RH is much higher.

Freezing doesn't cause destruction of bacterial cells, but inactivate them at this temperature, which can be activated during thawing. Meat freezes at -1.5^0C, at this temperature microorganisms are inactivated. At -10^0C almost all the microorganisms are not grown but the commercial temperature is set at -18^0C, because at this temperature almost all the chemical reactions are inhibited. At -38^0C all chemical reactions are complelety inhibited but, economy is not upto the mark.

Nutritional Changes

Meat is frozen without any prior treatment, unlike vegetables which have to undergo a preliminary blanching process to destroy enzymes involving considerable loss of water-soluble nutrients. So there is little or no loss of nutrients neither during the freezing procedure, nor, so far as there is reliable evidence, during frozen storage - apart from vitamin E.

Proteins are unchanged during frozen storage but fats are susceptible to rancidity. Pork and poultry meat are more susceptible since they are richer in unsaturated fatty acids than other meats, and comminuted meat is also very susceptible to rancidity because of the large surface area which is accessible to oxygen. The vitamin E is damaged because the first products of fat rancidity, hydroperoxides, are stable at the low temperature and oxidize the vitamin. At room temperature they break down to harmless peroxides, aldehydes and ketones, so that vitamin E is more stable at room temperature than during frozen storage. The losses incurred in frozen

meat mostly take place when the meat is thawed, and juices are exuded containing soluble proteins, vitamins and minerals. This is termed "drip thaw" and the amount depends on the length of time of ageing (time between slaughter and freezing), whether frozen as carcass or meat cuts, conditions of freezing and speed of thawing; it varies between 1% and 10% of the weight of the meat and is usually about 5%. There is some loss of nutrients when the meat is cooked after thawing; results published in the scientific literature tend to measure the combined losses from the original fresh meat to the final cooked product. Unfortunately the results vary so much that it is not possible to draw conclusions.

It must be emphasized that the variations are largely due to difficulties in analysis of the B vitamins, and to differences in conditions and methodology - even results from the same laboratories are inconsistent. This is illustrated very clearly by results published from one group of investigators who examined pork loin after freezing and storage at -12°C and 24°C and subsequent cooking at regular intervals over one year for changes in thiamin, riboflavin and pyridoxine. Despite constant experimental conditions analyses at two monthly intervals showed wide fluctuations, especially for thiamin, which were attributed by the authors to difficulties in analytical methods.

It was tentatively concluded after storage at -12°C and cooking that about 90% of the thiamin was retained but no firm conclusions could be drawn about other vitamins. No conclusions could be drawn about storage at the lower temperature. For riboflavin about 90% was retained at -12°C and 100% after storage at -24°C and cooking, although these results were also variable. For pyridoxine 80% was retained when stored at -12°C and cooked but the results were erratic. In the same report ground beef was examined only after 1 year storage and showed 80% retention of thiamine, 85% of riboflavin and 100% of pyridoxine at both temperatures. Akhtar *et al.* (2013) suggested that losses during freezing and storage of meat and poultry for 6 - 12 months at -18°C but excluding subsequent cooking, ranged between zero and 30% for thiamin, riboflavin, niacin and pyridoxine. A survey of frozen meals analyzed after freezing, storage and cooking reported losses of up to 85% of thiamin, 55% of vitamin A, 33% vitamin E, 25% niacin and pyridoxine (De Ritter *et al*., 1974).

Sensory Changes

Some muscles are susceptible to cold shortening and thaw rigor, and in general allowing the muscle to undergo rigor mortis prior to freezing is recommendable. Due to lipid oxidation and protein denaturation there is liberation of free fatty acids and amino acids, which cause sensory and flavor changes. Metmyoglobin formation in red meats and caretenoids bleaching in fish and poultry tend towards parallel fat oxidation. In case of fish, the major problems found during freezing are oxidative deterioration, dehydration, toughening, loss of juiciness and excessive drip. Low temperature preservation is also one of the most commonly used processes commercially and domestically for preserving a very wide range of food including prepared meat and various meat products. Cold stores provide large volume, long-term storage for strategic food stocks in international global food market.

Conclusion

Meat is highly perishable commodity as it contains more moisture and nutrient content. These properties make it more prone to lipid oxidation and microbial spoilage. Therefore it becomes necessary to preserve meat and meat products to maintain quality and retard various physico-chemical changes and enzymatic reactions. Low temperature preservation viz. chilling and freezing is the best method of short and long term preservation of meat upto a prescribed time period. Low temperature preservation enhances the acceptability of meat and meat products in terms of sensorial and microbiological quality characteristics.

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