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Application of Linear Programming Technique to Formulate Least Cost Balanced Ration for Calves-Fattening in Jordan

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Abstract: This study aimed at using the linear programming technique to formulate balanced least cost ration for calves-fattening at the different stages of age. The feed ingredients used were: barley, yellow corn, soybean, wheat bran, vitamin/mineral complex, salt, limestone and dicalcium phosphate. Constructed Linear Programming (LP) Models were designed to reflect various feedstuff combinations used in the diet formulation, current market prices, nutrient composition and range of inclusion to obtain a least-cost ration for fattening-calves according to the available feedstuffs in Jordan. The objective of the models was to minimize cost of producing a particular diet after satisfying a set of constraints. The results showed that the ration for each age group of fattening calves varies according to their nutrient requirements, weight and age. The results also revealed that the ration for age group >12 months of age was the least cost compared to the other two age groups ration combinations. It was 278.10 JDs. The 3-6 months age group was the highest in cost with 283.16 JDs. The age group of 6-12 months was almost the same as the group 3-6 months of age.

Key words: Calves fattening ration, least cost, linear programming, feedstuffs, nutrient requirements

INTRODUCTION

One of the most important agribusiness sectors in Jordan is cattle production. Beef cattle production is a supplementary sector to cattle production sector. It is an alternative solution for the milk production activity. Beef cattle production is an important avenue for income generation for mainly subsistence farmers. This enterprise represents an important component of the agribusiness sector of the economy with great economic, income, poverty reduction and social implications; it is profitable enterprise due to agribusiness context (Sarma and Ahmed, 2011). Beef cattle production could be run as an independent activity within livestock farms. It can be expanded or narrowed without substantially affecting routine farm administration. It is an effective tool in poverty alleviation for the rural poor. One of the advantages of the cattle fattening by the rural farmers is that they use locally available cattle feed resources during the Eid festival (Ahmed *et al*., 2010).

The main source for cattle fattening in Jordan is the male calves which accounts for 65-70% of the beef production, the remainder being produced by the young female calves and cows. Basically, any cattle breed (dairy, dual-purpose or beef breed) can be utilized for the production of fattening calves (Roman, 2007).

Cattle fattening plays a significant role in alleviating shortage between the demand for and supply of red meat. This role is essential taking into account the rapid growth rate of population and high income-demand elasticity of red meat (Yidirim, 2006). A study by Sahin *et al.* (2009) puts forth that the use of meat cattle in the fattening activity is more advantageous. Beef production with appropriate economy of scale through integrated farming approach utilizing crop by-products and wastes with secured link to good quality beef market or cooperatives can become a very viable enterprise (Sarker *et al*., 2010). In this context, there is evidence of profitable beef production with male calves obtained from dairy farm which was reported by Buaphun *et al*. (2000).

Fattening beef cattle depends on the composition of the used feed, age, breed, average daily gain, rate of intake and target weight of slaughtering. Feed costs represent between 70-80% of the total cost of producing various livestock products. Feed formulation is the process of quantifying the amounts of feed ingredients

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that need to be put together to form a single uniform mixture (diet) for animals that supplies all of their nutrient requirements. It is important that returns are maximized through use of adequate diets. Feed formulation is a central operation in different livestock production activities ensuring that feed ingredients are economically used for optimum growth (Fetuga, 1989).

It is therefore essential that formulations are accurate to ensure a large number of flocks are not adversely affected (Chung *et al*., 1983). The problem of least-cost ration formulation can be effectively managed through using linear programming technique (Olorunfemi *et al*., 2006). Patrick and Schaible (1980) defined least-cost feeds as the lowest-cost formula that contains all the nutritional elements needed for maximum performance.

This study aimed at using the linear programming technique to formulate balanced least cost ration for calves-fattening at the different stages of age using local feed ingredients.

Cattle sector in Jordan: Jordan has recorded almost a steady number of cattle in the past 10 years (Fig. 1). The total number of cattle in Jordan according to the results of the livestock survey conducted by the Department of Statistics (DOS) was estimated to be 67,790 heads (DOS, 2010). According to the same survey, the total number of the new born cattle was 33,730. The value of those new born cattle was estimated to be 10,374 and 120 Jordan Dinars (JDs), (1 JD = 1.4 USD). About >80% of those new born animals were fattened for beef production. The local beef cattle production amounts to about 15.5% (6,200 tons) of the total beef available for consumption in the country. The remainding 33.8% was imported (DOS, 2010).

Many farmers fatten animals in pens or large paddocks using bought in or home grown feeds. The livestock can be home produced or purchased animals. Animals can be placed in the feedlot at any age usually after weaning. In practice animals tend to arrive at feedlots shortly after weaning (7-9 months of age) as yearlings

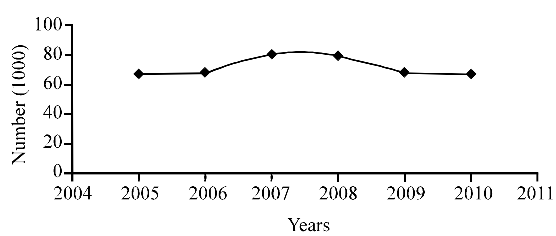

Fig. 1: Number of cattle in Jordan (2005-2010) (DOS, 2010)

(12-18 months of age) or at two and a half years of age. In most feedlots, there is no differentiation in feeding regime between animals of different ages and it has been found that irrespective of the age, animals tend to gain about 150 kg and are then ready for slaughter. Cattle placed on high energy rations at an early age tend to deposit fat more rapidly than if they are kept on low energy diets for a time before being placed on a high energy ration.

In cattle raising, several types of fattening are used to obtain dietetic veal, regular veal, baby beef and beef. Fattening for dietetic veal begins when the calf is born and continues for 45-60 days. The principal feed is milk with skim milk and concentrates added toward the end of the fattening period. To obtain regular veal, the calves are fattened until they are 3-4 months old. Beginning on the 15-20th days, the ration of whole milk is supplemented with whole milk substitutes, skim milk and concentrates. For the production of baby beef, fattening begins at the age of 6-8 months and continues until the cattle are 9-12 months old.

Linear programming: Linear Programming technique (LP) is the most common technique for computer formulation of rations. It is also referred to as Least Cost Ration Formulation. This technique is a systematic method of determining the optimum inputs to output ratio so as to maximize the income and minimize the cost within the limits of available feed resources. In case of changed inputs in terms of feed ingredients due to change in seasons or market price, the right combination can be worked out to face the situation. The information needed to formulate least cost rations are: availability of each feed ingredient, nutritional value of each feed ingredient, level of incriminating factor if any in the ingredient and its maximum permissible limit in the ration, maximum level of a particular ingredient such as molasses in the whole ration unit cost for each of the ingredients and nutrient requirement of the particular class of animal in question.

Linear programming was first put into significant use during World War II when it was used to determine the most effective way of deploying troops, ammunitions and machineries which were all scarce resources (Chvatal, 1983). Patrick and Schaible (1980) stated that linear programming is technically a mathematical procedure for obtaining a value-weighting solution to a set of simultaneous equations. There are hundreds of applications of linear programming in agriculture (Taha, 1987). Olorunfemi *et al*. (2001) reviewed extensively the use of linear programming in least cost ration formulation for aquaculture. Kuester and Mize (1973) reported that Linear Programming (LP) is a technique for optimization of a linear objective function, subject to linear equality and linear inequality constraints. Linear programming is a computational method of selecting, allocating and evaluating limited resources with linear, algebraic constraints to obtain an optimal solution for a linear, algebraic objective function. Informally, linear programming determines the way to achieve the best outcome (such as maximum profit or lowest cost) in a given mathematical model and given some list of requirements represented as linear equations. It is one of the most important techniques to allocate the available feedstuffs in a least cost broiler ration formulation (Dantzig, 1951a, b; Aletor, 1986; Ali and Leeson, 1995).

MATERIALS AND METHODS

Data sources: Feedstuffs specifications, constraints imposed on the selected feedstuffs and the dietary nutrient requirements in each stage of life of calves are the main sources of data needed for studies like the present one. The main source for these data was the National Research Council (NRC, 1998). The objective of this publication is to provide a reference point for the nutrient requirements of the various classes of cattle and in addition provide authoritative information on the nutrient content of feed ingredients. Costs of feedstuffs used in the diet formulation were obtained from the prevailing market prices of feedstuffs in Jordan through survey. The secondary data sources to achieve the study objectives include mainly the Department of Statistics and Ministry of Agriculture in Jordan.

Data analysis: Linear Programming Models were constructed to achieve the objectives of the study. The models were designed to reflect various feedstuff combinations used in the diet formulation, current market prices, nutrient composition and range of inclusion to obtain a least-cost ration for calves-fattening according to the available feedstuffs in Jordan. The constructed linear programming models guarantees that a minimum cost ration can be selected if a unique minimum exists among the many possible ration formulations. To do this, a linear expression (called the objective function) is minimized subject to linear constraints. For feed formulation, the objective function is a cost function representing the total cost of the various feed ingredients needed to supply the specified nutrients. The variables in the models were the ingredients while the cost of each ingredient and the nutrient value of each ingredient was the parameter.

Construction of Linear Programming Models: Linear Programming Models were constructed according to the calves body weight development. Three distinct age groups were considered. The included groups chosen based on the data collected about calves fattening operations in Jordan. The groups were: 3-6, 6-12 and >12 months. Three mathematical models were constructed to compare rations costs and to determine the least cost ration for each body weight category. The local feedstuffs used in ration formulation include: barley (x_1), yellow corn (x_2), soybean (x_3), wheat bran (x_4), limestone (x_5), dicalcium phosphate (x_6), salt (x_7) and vitamin/mineral complex (x_8). The general LP Model of the study was:

$$\text{Minimize } Z = \Sigma Cij\ Xi$$

Where:

Z = Total cost of the ration

Cij = Ingredient cost

Xi = Ingredient quantity

Subject to the following constraints:

$$x_1 + x_2 + x_3 + \ldots + x_8 = b_1$$
$$a_{11}\, x_1 + a_{12}\, x_2 + \ldots + a_{18}\, x_8 \le b_2$$
$$a_{21}\, x_1 + a_{22}\, x_2 + \ldots + a_{28}\, x_8 \ge b_3$$
$$a_{31}\, x_1 + a_{32}\, x_2 + \ldots + a_{38}\, x_8 \le b_4$$
$$a_{41}\, x_1 + a_{42}\, x_2 + \ldots + a_{48}\, x_8 \le b_5$$
$$a_{51}\, x_1 + a_{52}\, x_2 + \ldots + a_{58}\, x_8 \ge b_6$$
$$a_{61}\, x_1 + a_{62}\, x_2 + \ldots + a_{68}\, x_8 \ge b_7$$
$$a_{71}\, x_1 + a_{72}\, x_2 + \ldots + a_{78}\, x_8 = b_8$$
$$a_{81}\, x_1 + a_{82}\, x_2 + \ldots + a_{88}\, x_8 = b_9$$

Where:

a_i = Technical coefficients of nutrient components in feed stuffs

b_i = Constraints of the ration

Feedstuffs and nutrient requirements: Table 1 shows data on typical nutrient levels for fattening calves and Table 2 shows cost implications of raw materials and nutrient levels of feed ingredients. Table 3 shows

Table 1: Nutrient requirements for fattening calves

	Age groups (months)		
Nutrients	3-6	6-12	>12
Energy (Mcal day^{-1})	8.30	14.70	20.70
Crude protein (%)	16.00	14.00	12.00
Fat (%)	3.00	3.00	3.00
Crude fiber (%)	13.00	15.00	15.00
Calcium (%)	0.52	0.41	0.29
Phosphorus (%)	0.31	0.30	0.23
Vitamin A (IU day^{-1})	4.25	10.60	16.90

NRC (1998)

Table 2: Cost implications and nutrient level of used feedstuffs

Ingredients	*Cost (JDs kg^{-1})	ME (kcal kg^{-1})	CP (%)	Fat (%)	CF (%)	Ca (%)	P (%)
Barley	0.200	2820	8.70	0.00	2.00	0.24	0.00
Yellow corn	0.350	3430	8.80	4.00	2.00	0.01	0.09
Soybean	0.420	2730	44.00	3.50	6.50	0.23	0.20
Wheat bran	0.120	1680	15.90	0.00	10.50	0.04	1.15
Limestone	0.100	0.00	0.00	0.00	0.00	38.00	0.00
Dicalcium phosphate	0.600	0.00	0.00	0.00	0.00	21.00	18.50
Salt	0.150	0.00	0.00	0.00	0.00	0.00	0.00
Vitamin and minerals	2.500	0.00	0.00	0.00	0.00	0.00	0.00

NRC (1998); *Costs according to Jordanian market prices (1 JD = 1.4 US$)

Table 3: Constraints imposed on the selection of feedstuffs (per 1000 kg feed)

	Age group (months)		
Nutrients	3-6	6-12	>12
Energy (Mcal kg^{-1})	≤2.70	2.80	3.00
Crude protein (%)	≥18.00	16.00	16.00
Fat (%)	≤2.70	3.00	4.00
Crude fiber (%)	≤4.50	5.00	5.00
Calcium (%)	≥0.60	0.65	0.75
Phosphorus (%)	≥0.30	0.40	0.40
Salt (%)	= 1.00	1.00	1.00
Vitamins and minerals (%)	= 0.10	0.10	0.10

NRC (1998); (Wt. = 1000 kg); *1 kg of premix contains: 600,000 IU Vitamin A, 100,000 IU Vitamin D3, 1,850 mg Vitamin E, 160 mg Vitamin B1, 480 mg Vitamin B2, 500 mg Vitamin B6, 2,000 mg Vitamin B12, 200 mg Vitamin K3. 2800 mg nicotinic acid, 1000 mg Ca-pantothenat, 60 mg folic acid, 10,000 mg biotin, 80,000 mg cholinchlorid, 2500 mg Fe, 1600 mg Cu, 8000 mg Mn, 8000 mg Zn, 120 mg L, 25 mg Se, 55 mg Co, 10000 mg B.H.T, 350 mg canthaxanthin B2

constraints imposed on the selection of feedstuffs by linear programming for calves fattening diets (the weight is 1000 kg).

Model construction for fattening calves 3-6 months of age:

$$\text{Min (Z)} = 200\ x_1 + 350\ x_2 + 420\ x_3 + 120\ x_4 + 100\ x_5 + 600\ x_6 + 150\ x_7 + 2500\ x_8$$

Subject to:

1. $x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 ... = 1000$
2. $2.82\ x_1 + 3.43\ x_2 + 2.73\ x_3 + 1.86\ x_4 ... \leq 2700$
3. $0.087\ x_1 + 0.088\ x_2 + 0.44\ x_3 + 0.159\ x_4 ... \geq 180$
4. $0.04\ x_2 + 0.035\ x_3 ... \leq 27$
5. $0.02\ x_1 + 0.02\ x_2 + 0.065\ x_3 + 0.105\ x_4 ... \leq 45$
5. $0.001\ x_1 + 0.0024\ x_2 + 0.0023\ x_3 + 0.0004\ x_4 + 0.38\ x_5 + 0.21\ x_{12} ... \geq 6.0$
6. $0.0009\ x_2 + 0.002\ x_3 + 0.0115\ x_4 + 0.185\ x_6 ... \geq 3.0$
7. $x_7 ... = 10$
8. $x_8 ... = 1.0$

$x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}, x_{12} ... \geq 0.0$

Model construction for fattening calves 6-12 months of age:

$$\text{Min (Z)} = 200\ x_1 + 350\ x_2 + 420\ x_3 + 120\ x_4 + 100\ x_5 + 600\ x_6 + 150\ x_7 + 2500\ x_8$$

Subject to:

1. $x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 ... = 1000$
2. $2.82\ x_1 + 3.43\ x_2 + 2.73\ x_3 + 1.86\ x_4 ... \leq 2800$
3. $0.087\ x_1 + 0.088\ x_2 + 0.44\ x_3 + 0.159\ x_4 ... \geq 160$
4. $0.04\ x_2 + 0.035\ x_3 ... \leq 30$
5. $0.02\ x_1 + 0.02\ x_2 + 0.065\ x_3 + 0.105\ x_4 ... \leq 50$
5. $0.001\ x_1 + 0.0024\ x_2 + 0.0023\ x_3 + 0.0004\ x_4 + 0.38\ x_5 + 0.21\ x_{12} ... \geq 6.5$
6. $0.0009\ x_2 + 0.002\ x_3 + 0.0115\ x_4 + 0.185\ x_6 ... \geq 4.0$
7. $x_7 ... = 10$
8. $x_8 ... = 1.0$

$x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}, x_{12} ... \geq 0.0$

Model construction for fattening calves >12 months of age:

$$\text{Min (Z)} = 200\ x_1 + 350\ x_2 + 420\ x_3 + 120\ x_4 + 100\ x_5 + 600\ x_6 + 150\ x_7 + 2500\ x_8$$

Subject to:

1. $x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 ... = 1000$
2. $2.82\ x_1 + 3.43\ x_2 + 2.73\ x_3 + 1.86\ x_4 ... \leq 3000$
3. $0.087\ x_1 + 0.088\ x_2 + 0.44\ x_3 + 0.159\ x_4 \geq 160$
4. $0.04\ x_2 + 0.035\ x_3 ... \leq 40$
5. $0.02\ x_1 + 0.02\ x_2 + 0.065\ x_3 + 0.105_4 ... \leq 50$
5. $0.001\ x_1 + 0.0024\ x_2 + 0.0023\ x_3 + 0.0004 x4 + 0.38\ x_5 + 0.21\ x_{12} ... \geq 7.5$
6. $0.0009\ x_2 + 0.002\ x_3 + 0.0115\ x_4 + 0.185\ x_4 ... \geq 4.0$
7. $x_7 ... = 10$
8. $x_8 ... = 1.0$

$x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}, x_{12} ... \geq 0.0$

RESULTS AND DISCUSSION

The optimum solutions Using Linear Programming technique for all age groups of calve fattening with their chemical composition are shown in Table 4. The results shown in Table 4 were the least cost rations from a group of six alternative rations formulated using linear programming technique.

The results of the linear programming technique revealed various costs of the formulated rations. The variation in the cost is a result of the variation in the nutrient requirements of the calves according to their weight. Each weight requires certain level of combined

Table 4: Ingredient composition of least-cost ration formulation produced by computerized linear programming for fattening calves

	Age (months)		
Ingredients	3-6	6-12	≤12
Barley (kg ton^{-1})	365.000	217.000	241.000
Yellow corn (kg ton^{-1})	196.000	332.000	388.000
Soybean (kg ton^{-1})	280.000	207.000	149.000
Wheat bran (kg ton^{-1})	133.000	218.000	196.000
Limestone (kg ton^{-1})	10.000	10.000	10.000
Dical. phosphate (kg ton^{-1})	5.000	5.000	5.000
Salt (kg ton^{-1})	10.000	10.000	10.000
Vitamin and minerals (kg ton^{-1})	1.000	1.000	1.000
Total	1000.000	1000.000	1000.000
Cost (JDs)	283.160	280.700	278.100
Calculated composition (nutrients)			
Crude protein (%)	19.200	16.010	13.510
ME (kcal kg^{-1})	2.670	2.580	2.591
Fat (%)	3.000	3.020	3.120
Ca (%)	0.660	0.540	0.335
P (%)	0.320	0.340	0.284
Crude fiber (%)	13.090	16.100	15.830

nutrients in the used feedstuffs. This will cause different quantities of feedstuffs to be used in each ration. The results showed that the ration for each age group of fattening calves varies according to their nutrient requirements, weight and age. As shown in Table 4, the (≤12 months) of age ration cost was the least compared to the other two age groups ration combinations. It was 278.10 JDs. The 3-6 months age group was the highest in cost with 283.16 JDs. The age group of 6-12 months was almost the same as the group 3-6 months of age.

CONCLUSION

The least cost ration combinations of the three studied age groups of fattening calves produced by the linear programming technique was 278.10 JDs for the age group of >12 months followed by the 6-12 months age group then the 3-6 months age group. These all three costs are lower by nearly 50 JDs ton^{-1} than those imposed on the producers by the market. These results confirm the fact that linear programming is a very important technique to allocate the available feedstuffs in a least cost ration formulation for fattening calves.

REFERENCES

Ahmed, T., M.A. Hashem, M. Khan, M.F. Rahman and M.M. Hossain, 2010. Factors related to small scale cattle fattening in rural areas of Bangladish. Bang. J. Anim. Sci., 39: 116-124.

Aletor, V.A., 1986. Some agro-industrial by-products and wastesin livestock feeding: A review of prospects and problems. World. Rev. Anim. Prod., 22: 35-41.

Ali, M.A. and S. Leeson, 1995. The nutritive value of some indigenous Asian poultry feed ingredients. Anim. Feed Sci. Technol., 55: 227-237.

Buaphun, S., P. Skunmun, S. Prasanpanich, N. Buathong and C. Chantalakhana, 2000. Cost and return in raising male calves from smallholder dairy farms for beef production. Asian-Austr. J. Anim. Sci., 13: 1461-1466.

Chung, S.B., I.C. Cheong and B.K. Ohh, 1983. The relative economic importance of the major traits in laying hens. Res. Rep. Office Rural Dev., 25: 13-20.

Chvatal, V., 1983. Linear Programming. W.H. Freeman Co., New York, Pages: 187.

DOS, 2010. Agricultural statistics report. Department of Statistics, Amman, Jordan.

Dantzig, G., 1951a. A Proof of the Equivalence of the Programming Problem and the Game Problem. In: Activity Analysis of Production and Allocation, Koopmans, T. (Ed.). John Wiley and Sons, New York, pp: 330-335.

Dantzig, G., 1951b. Application of the Simplex Method to a Transportation Problem. In: Activity Analysis of Production and Allocation, Koopmans, T. (Ed.). John Wiley and Sons, New York, pp: 359-373.

Fetuga, B.L., 1989. Techniques in feed formulation part II: Feedmill management in Nigeria. Proceedings of the Feedmill Management Training Workshop, Aprail 10, 1989, Ibadan, Nigeria, pp: 145-159.

Kuester, J.L. and J.H. Mize, 1973. Optimization Techniques with Fortran. McGraw-Hill Book Co., New York, pp: 1-12.

NRC, 1998. Nutrient Requirements of Dairy Cattle. 6th Edn., National Academy Press, Washington, DC., USA.

Olorunfemi, T.O.S., F.M. Aderibigbe, B.K. Alese and E.A. Fasakin, 2006. Utilization of duckweed (*Lemna paucicostata*) in least-cost feed formulation for broiler starter: A linear programming analysis. Inform. Technol. J., 5: 166-171.

Olorunfemi, T.O.S., F.M. Aderibigbe, S.O. Falaki, O.T. Adebayoand and E.A. Fasakin, 2001. An over view of linear application to least-cost. Ration Formulation in Aquaculture.

Patrick, H. and P.J. Schaible, 1980. Poultry: Feed and Nutrition. 2nd Edn., AVI Publishing, USA., pp: 417-458.

Roman, M., 2007. The production of calves for fattening an alternative for milk quota. Univ. Agric. Sci. Vet. Med. Sci. Pap., 52: 385-388.

Sahin, A., B. Miran, I. Yildirim, A. Onenc and A. Alcicek, 2009. Fattening costs of beef breeds reared under controlled conditions and the determination of optimum fattening period. Turk. J. Vet. Anim. Sci., 33: 485-492.

Sarker, M.K., M.R. Amin, M. Harun-Ur-Rashid and A.K.M.A. Kabir, 2010. Growth performance of red chittagong and holstein crossbred bull calves using growth promoter. J. Bangladesh Agril. Univ., 8: 83-86.

Sarma, P.K. and J.U. Ahmed, 2011. An economic study of small scale cattle fattening enterprise of Rajbari district. J. Bangladesh Agric. Univ., 9: 141-146.

Taha, H.A., 1987. Operations Research. 4th Edn., Macmillan Publishing Co., USA., Pages: 876.

Yidirim, I., 2006. A comparison of profitability and economic efficiencies between native and culture-breed cattle fattening farms in Eastern part of Turkey. Pak. J. Biol. Sci., 9: 1061-1067.