Role of Buffalo Production in Sustainable Development of Rural Regions

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January 2018

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Abstract Rice is the main summer crop in Egypt. It is a cash exportable crop that provides a main source of income to the Egyptian farmers and the national economy. However, the farmers used to burn the rice straw at the farm borders and violate the law that forbids such action, which causes socio-economic negative externalities due to the generated smoke from burning. The smoke generated from burning is straw produced as byproduct of cultivated around 0.75 million ha of rice crop in Egypt, causes social costs due to the probability of premature-mortality and morbidity of rural and urban individuals and livestock. To conduct an economic assessment of such negative externalities a field research was conducted. A targeted ration of chopped rice-straw mixed with dissolved urea and molasses at 2% and 3% of weight, respectively, was fed to buffalo-feeder calves for meat production at 40% of the S.E. of the daily ration with a concentrate feed mix of 60% S.E. Such ration was compared with a control ration of dray chopped rice straw with the same proportion of concentrate feed mix. Two feed-response models were estimated for comparison of the two rations on the growth of the buffalo feeder calves for meat production. The Cobb-Douglas response function was the best fitted form according to the economic logic, significance of estimated parameters and the magnitude of R-2. The study derived the production elasticity, marginal daily gain, the value of marginal product from both estimated feed response functions. The economic marketing weight that maximizes the gross margin above the feed costs was estimated under the response model of treat rice straw feeding plan (targeted ration). It reached around 518 Kg live weight, while under the control ration it was only around 384 Kg. The larger market weight of treated rice straw ration was due to higher production elasticity, faster marginal daily gain, better marginal feed conversion and higher palatability of the ration than the control one. Egypt imports of red meat reached about 600 million dollars, due to lack of sufficient feed supply that constrained expansion in red meat production. Therefore, providing treated rice straw feed would provide additional source of livestock feeds which would provide additional 80,000 tons' carcass weight from fed buffalo calves, which currently are slaughtered as rearing veal calves (60-80 days old). The estimated income generated from one buffalo fed calves reached 50% of the average annual per capita income in Egypt. Such program would also stop the social costs stems from probable premature death and/or morbidity of human and livestock when burning rice straw. The study presented a proposed institutional program to introduce such technology into Egyptian agricultural sector.

Keywords Externalities of burning rice Straw · Recycling of treated rice straw as feed · Buffalo-Feed response function · Least cost ration of alternative feeding systems · Most Profitable marketing weight

This chapter focused on the socio-economic evaluation of using treated-rice straw as fodder for fattening buffalo male calves for three feasible reasons: (1) The Egyptian budget has faced an increasing burden due to the speedy increase of net imports of red meat, while the value of the Egyptian pound is decreasing fast in front of the dollar, at least over the last four years, (2) more than 70% of buffalo calves are slaughtered at the rearing period to save fodders for dairy buffaloes. (3) to use treated rice straw as feed would protect the society from probable harmful impacts of burning abundant rice straw on the environment and human health. The socio-economic impacts were derived from two estimated econometric models for buffalo-feed response function. The data were collected from designed field experiments.

Therefore, this chapter dealt with the following issues: Impacts of the economic policies in Egypt on farmers' usage of rice straw; Negative effects of open-field rice straw burning; Alternative recycled products of rice straw; Importance of buffalo in protein production systems in Egypt; Role of treated rice straw in bovine feeding systems; Identification of the research problem; Major objective of the presented research work; Sources of data base; The implemented econometric model's structure and derived function forms; The results were presented under response model of the control feeding system and the response model of the alternative system. The discussion of the results included: (1) The maximum gross margin and optimum marketing weight, (2) the techno-economic efficiency of the feed response under the two feeding systems, (3) socio-economic impacts of the treated rice straw feeding system for buffalo fattening, (4) the biological and economical interpretations of the higher efficiency of rice straw silage than chopped dry straw. The chapter was ended by major conclusions and recommendations for the concerned institutions in the agricultural sector.

1 Impacts of the Economic Policies in Egypt on Farmers' Usage of Rice Straw

Till the early eighties of the last century, wheat straw was the major roughage feed for Egyptian livestock and farmers had negative views towards using rice straw for livestock feeding. Till that time, Egypt was practically under a planned economy system. Whereas the domestic and imported wheat price and supply distribution were controlled by the government, wheat straw was at free market price. Therefore, up to the seventies of the last century, its price surpassed wheat grain price for many years (Soliman and Nawar 1986). This was mainly due to the limited area cultivated with wheat and the low yield of wheat grains, leading to a low yield of wheat straw. The wheat area in Egypt was 1,395,382 feddans in 1961, (1 feddan = 4200 M^2), due to controlled cropping patterns, and the yield per feddan, at that time, was about 1.029 tons (FAOSTAT 2015). Since 1986/1987, Egypt has started an economic reform program which implied liberalization of the prices and marketing of crops and agricultural inputs (Hezall et al. 1995). The program was associated with introducing new high yield varieties of grains and expansion in agricultural mechanization systems. Therefore, the yield per feddan of wheat increased rapidly to reach about 2.778 tons per feddan in 2013, associated with expansion in the wheat area to reach 3,404,899 feddans due to the free decision to cultivate and provide high farm guaranteed price. Since then, wheat straw production and supply has increased to a great extent. The major summer crop, i.e. rice, was exposed to the same policies and then showed the same performance over the same period. Its area and yield increased from 941,667 feddans and 1.213 tons per feddan, respectively, in 1961 to 2,916,667 feddans and 2.314 tons per feddan, respectively, in 2013. Accordingly, the farmers have been faced recently with an abundant supply of rice straw, as the farmers still prefer to use wheat straw rather than rice straw as feed. Thus, the majority of them preferred to burn the rice straw at the farm border, which caused the phenomenon of "the black cloud" all over the Nile delta governorates during the rice harvesting season (September–October) of every year. As burning of rice straw has harmful impacts on the environment and human health, farmers have thus been encouraged to refrain from burning rice straw and to adopt more environmentally safe and human-friendly rice straw management practices.

2 The Negative Effects of Open-Field Rice Straw Burning

Burning causes atmospheric pollution and results in nutrient loss, even though it is a cost-effective method of straw disposal and helps reduce pest and disease populations (Dobermann and Fairhurst 2002) The environmental consequences of rice straw burning in terms of greenhouse gas (GHG) emissions are, mainly, carbon dioxide, methane and nitrous oxide gases, that require adoption of selected rice straw management alternatives (Launio et al. 2013). The compositions of biomass are variable, especially with respect to inorganic constituents. Alkali and alkaline earth metals, in combination with silica, sulfur and chlorine, are responsible for many undesirable reactions in the combustion of straw (Jenkins 1999).

Burning of rice straw causes almost complete N loss, P losses of about 25%, K losses of 20%, and S losses of 5–60%. The proportion of nutrients lost depends on the method used to burn the straw. When straw is heaped into piles at threshing sites and burned after harvest, the ash is usually not spread on the field, resulting in large losses of minerals K, Si, calcium (Ca) and magnesium (Mg) leached from the ash piles.

3 Alternative Recycled Products of Rice Straw

There are several approaches to utilizing rice straw nutrient components. The most common approach is to be removed from the field, burned in situ, piled or spread in the field, incorporated in the soil, or used as mulch for the following crop. About 40% of the nitrogen (N), 30–35% of the phosphorus (P), 80–85% of the potassium (K), and 40–50% of the sulfur (S) taken up by rice remains in vegetative plant parts at crop maturity. Each of these measures has a different effect on overall nutrient balance and long-term soil fertility. When straw is the only organic material available in significant quantities to most rice farmers and where S-free mineral fertilizers are used, straw may be an important source of S; thus, straw burning should not be practiced. However, spreading and incorporation of straw are labor-intensive tasks and farmers consider burning to be more expedient (Dobermann and Fairhurst 2002).

In contrast, burning effectively transforms straw into a mineral K nutrient source, and only a relatively small amount of K is lost in the process. Therefore, the effect of straw removal on long-term soil fertility is much greater for K than for P (Launio et al. 2013). Straw is also an important source of micronutrients such as zinc (Zn) and has the most important influence on the cumulative silicon (Si) balance in the soil (Nelson et al. 1980).

In addition to being a fertilizer, rice straw can be used as fuel for cooking, ruminant fodder, and stable bedding or as a raw material in industrial processes, e.g., paper making (Nelson et al. 1980).

4 Importance of Buffalo in Protein Production Systems in Egypt

The Egyptian buffalo is a river buffalo type which is a milk and meat producing animal. The number of buffalo stock increased from 2.897 million heads in 1990 to more than 3.949 million heads in 2014, (FAOSTAT 2016), i.e. at an average annual growth rate of 2.2%[1]. The buffalo meat production in Egypt was about 161 thousand tons of carcass weight in 1990, i.e. about 41.7% of the total red meat production in 1990. Even though buffalo meat production increased to about 390 thousand tons of carcass weight in 2014, its share in total red meat production had not changed much, i.e. it amounted to 41% due to slaughtering most of the male calves at rearing age. This behavior stems mainly from the shortage in feed availability and to save buffalo milk yield that receives a high sale price because of consumer preferences, (Soliman 2006).

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[1]Calculated from the exponential function: $y_t = y_0 e^{rt}$ where y_t = value of the concerned variable in the year t, y_0 = the value in the base year, it is the digital number of years and r is the average annual growth rate which is estimated from: $r = [\mathrm{Ln}(y_t) - \mathrm{Ln}\ (y_0)]/t$

With respect to buffalo milk supply in Egypt, the production of milk was about 1.250 million tons in 1990 and this increased to more than 2.500 million tons in 2014 (FAOSTAT 2016) i.e. an annual growth rate of about 4.5%[1]. It represents about one-half of total milk production in Egypt. However, due to its higher total solids, particularly fat (8%), readjusting the volume of buffalo milk production on the basis of equivalent milk with 4% fat, its share in total milk production would reach more than two-thirds. Due to the high total solids of buffalo milk, it is a main source of domestic "feta" cheese.

The cost of milk production from buffaloes is also less than the cost of reconstituted imported powdered milk at the international market price and the cost of milk from domestic cattle. It is the most important and popular livestock for milk production in Egypt. Buffalo productivity in Egypt is about 210–280 days/lactation, an average of seven lactations and milk yielding 1,600 kg/lactation season with 7–8% fat. The age at the first calving is 32–38 months. The average annual red meat production contributes 45% to the overall meat produced. Artificial insemination is used in one percent of the medium to large herds. There are six artificial insemination (AI) stations owned by the Government and one by the University, possessing a total of 70 bulls. AI is still performed at research level; usually only one semen dose is offered at each estrus, conception at the first estrus being 30%. Milking is done by hand, twice a day, mainly by women. Average slaughter weight is 500 kg, at the age of 18–24 months. Carcass yield is 51%. Overall growth rate is 700 g/day, (Ibrahim 2012). Buffalo exceed cattle in their ability to convert poor quality and forage to meat or milk, (Soliman and Nawar 1986).

5 Role of Treated Rice Straw in Bovine Feeding Systems

Feed resources and nutrition constitute the principal technical constraints to ruminant production in Asia. Among recommended non-conventional feed resources is the option of improving the nutritive value of crop residues. More attention has been given to the chemical treatment of cereal straws than to supplementation. However, failure to demonstrate cost-effectiveness has discouraged on-farm adoption, even though there is significant potential for the more effective use of locally-produced non-conventional feed resources (Devendra and Sevilla 2002).

Tengyun (2000) reported that China produces more than 500 million tons of crop straw and Stover every year. By promoting feeding of livestock with crop straw and Stover, the beef and mutton output could be increased markedly and a great amount of feed grain would be saved. The researcher reviewed the different techniques for the utilization of crop straw and Stover. The techniques that have been used in China include physical treatment (chopping), chemical treatment and microbial treatment methods.

Ruminant production plays an important part in the predominantly agricultural economy of Vietnam, especially in mixed animal-crop production systems. These animals themselves largely rely on crop residues as feed. The scarcity of land and the trend of sustainable agricultural development in the highly-populated country necessitate better utilization of crop residues in general and particularly, rice straw for ruminant feeding. Although rice straw produced every year is plentiful, the amount a ruminant can consume is not sufficient to sustain a reasonable level of production due to its low nutritive value. Therefore, rice straw has not been maximally utilized for ruminant production yet. Suitable treatment techniques in combination with nutrient supplementation could result in improved utilization of rice straw with better benefits. Despite recent local research in this field, no methods for improved utilization of straw are practically applied by farmers in the country, probably because none has proved to be relevant and sustainable under the local physical and socio-economic conditions (Trach 1998).

After conducting a preliminary survey, Duc Vu et al. (1999) carried out a feeding trial in Vietnam to determine the effect of urea–molasses–multi-nutrient block (UMMB) and urea-treated rice straw (UTRS) as a feed supplement on the productivity of dairy cows. Sixty Holstein–Friesian crossbred cows on 11 small-holder farms were divided equally into control, UMMB and UTRS supplementation groups. Milk yield and feed intake were recorded daily. Milk fat content and the body weight of each cow were determined at two week intervals. Recorded data showed that milk production increased by 10.3–11.9% and milk fat content increased by 3–5%; therefore, profit for farmers increased by US $0.55–0.73 per cow per day.

Akter et al. (2015) conducted an experiment to study the effect of treatment of rice straw with urea and a urease containing midden soil on feed intake of the animals, nutrient digestibility, body weight gain, feed conversion efficiency and the overall economy of feeding for a period of 105 days. Twelve indigenous growing cattle (live weight 130.00 ± 1.67 kg) were selected and divided into four groups having three animals in each group. The animals received 3.0% urea + 2.0% treated rice straw (group A), 3.0% urea + 3.0% midden soil treated rice straw (group B), 3.0% urea + 4.0% midden soil treated rice straw (group C) and 3.0% urea + 5.0% midden soil treated rice straw (group D). In addition, all the animals were supplied with 2 kg green grass, 450 g concentrate mixture and 40 g salt per 100 kg body weight. The total live weight gain by the end of the experimental period (105 days) was 39.00, 42.50, 46.50 and 49.00 kg for groups A, B, C and D respectively. The addition of 5.0% midden soil as a urease source with 3.0% urea (D) treated rice straw significantly ($P < 0.01$) increased the coefficient of digestibility in all nutrient intakes. The total profit of meat production in group D was significantly higher ($P < 0.01$) than in groups A, B and C.

Chemjong (1991) studied the effects of feeding urea-treated rice straw to lactating buffaloes in Nepal. Six pairs of similar buffaloes on farms were selected. All of them were given a conventional diet based on rice straw for four weeks, then one of each pair was given 15–20 kg/day of urea-treated rice straw for a period of 4 weeks while the control group received untreated rice straw. In the final 4 week period, all animals were given a conventional diet. Feeding straw treated with 4% urea increased the voluntary intake of straw by 25% and increased milk yield by 1.6 L/day compared with buffaloes fed the conventional diet containing untreated straw. Milk production remained elevated after the four-week treatment period had finished. The results showed that buffalo cows fed urea-treated straw achieved better weight gain, and milk yield increased significantly ($P < 0.01$) compared with the control animals. During the treatment period the net benefit was US$ 0.16 per day and the incremental rate of return was 46%. Moreover, in the 4 weeks following the treatment period the net benefit was US$ 0.40 per day. Ensiling rice straw with 4% urea, i.e. making silage, can be recommended as a safe, economical and suitable method for improving the nutritional value of rice straw on small farms in Nepal, thus increasing milk production and the live weight of lactating buffaloes. The practice of feeding urea-treated straw is economical for farmers during the dry season from January to April.

Naik et al. (2004) conducted a study on the effect of feeding ammoniated wheat straw treated with HCL and without HCL on meat quality and various sensory attributes of growing male buffalo calves. Due to urea-ammonization, the Crude Protein (CP) content of wheat straw increased from 2.90 to 6.96%. The addition of HCL along with urea further increased the CP content to 10.09%. The proximate composition as a percentage of the fresh first quality meat cuts (muscles) was comparable among the groups. Results indicated the desirable effect of feeding either without or with HCL. The scores of the cooked (2% common salt) for various sensory attributes (appearance, flavor, juiciness, texture, mouth coating and overall palatability) were comparable among the groups. In conclusion the results suggested that feeding of ammoniated wheat straw treated with and without HCL to growing male buffalo calves for 180 days had no adverse effect on the meat quality and various sensory attributes.

Rahman et al. (2009) carried out an experiment to compare a ration combination of urea-molasses-straw with green fodder versus other ration combinations, where they replaced the basic ration ingredients with different levels of concentrate feed. They found a significant tendency of increase in live weight gain, better nutrient digestibility, and improvement in feed conversion rate with increased levels of concentrate supplementation.

Fifteen calves of Baladi cattle and a similar number of buffalo calves in Egypt were used to compare daily gain, feed conversion and costs of producing meat from both types (El Asheeri 2012). Calves were purchased from the local market with a body weight of 229–238 kg. Calves were kept tied in a semi-open yard and fed on concentrate feed mixture and rice straw throughout the fattening period. The initial body weight of Baladi and buffalo calves was similar, averaging 231.4 ± 1.9 and 232.6 ± 1.0 kg, respectively. Calves were kept growing up to the final body weight of 400 kg and the monthly body weight was recorded. Growth curve, average daily gain and total weight gain were also recorded during the fattening period. The cost of producing one kg gain and one kg meat were calculated as economic parameters. The growth curve of the two studied genotypes indicated no significant difference between Baladi and buffalo calves within the first three months of the fattening period. Afterwards, the body weight of Baladi calves increased significantly compared to buffaloes. The fattening period of buffalo calves (252.7 ± 5.7 day) was significantly longer than that of Baladi (185.7 ± 7.4 day) by about 67 day.

This was due to the higher average daily gain of Baladi (0.93 kg) than buffaloes (0.67 kg) by about 38.8%. Total operational costs of fattening buffalo calves were significantly higher than those of Baladi by about 35.9%. The feed conversion rate of buffalo calves (13.1 kg dry matter) was 37.9%, significantly higher than for Baladi calves (9.5 kg dry matter) to reach the target body weight of 400 kg. The cost of producing one kg weight gain in buffalo calves was LE 15.4, i.e. higher than that of the cost of Baladi calves of LE 11.2. The corresponding cost of producing one kg meat was LE 23.8 and 35.9 for Baladi and buffalo calves, respectively.

To investigate the effect of concentrate levels of the daily ration combination on the performance of buffalo calves in Egypt, Helal et al. (2011) carried out an experiment on twenty-one male buffalo calves. The average initial body weight was about 286 kg. They were divided into three equal groups and randomly assigned to the following concentrate levels: 70, 85 and 100% of the concentrate feed mixture. They were referred to as groups A, B and C, respectively. Allowance of the concentrates was offered daily in equal portions while roughage (rice straw) was available at all times. Body weight, feed intake and feed conversion were determined. At the end of the experiment all calves were slaughtered and carcass traits were recorded. No differences between groups regarding the change in body weight were detected. Calves fed 100% concentrate gained more than the other two groups in all experimental periods. The overall average feed intake for groups A, B and C was 8.65, 9.81 and 11.11 kg/d, respectively. Feed conversion was better for the 70% group than the control. Heavier weights of carcass, bone and boneless meat were obtained from calves of group C compared to groups A and B. However, such differences were insignificant. Dressing percentage was significantly higher in groups B and C than group A. the meat-to-fat ratio followed the same pattern of dressing percentage. It seems that the close concentrate proportion between the three groups was behind such results of no specific trend in differences.

6 Identification of the Research Problem

This chapter focused on the socio-economic evaluation of using treated-rice straw as fodder for fattening buffalo male calves for three feasible reasons. First, the Egyptian budget has faced an increasing burden due to the speedy increase of net imports of red meat, from around 303 million dollars in 2000 to more than 963 million dollars in 2011 (FAOSTAT 2015), while the value of the Egyptian pound is decreasing fast in front of the dollar, at least over the last 4 years.

The exchange rate was less than 5.6 EGP/ $1 in 2009 and reached 7.47 EGP/$1 in January 2015 (Central Bank of Egypt 2015). Secondly, the buffalo population in Egypt yields around 700,000 heads of male calves. At least 500,000 are slaughtered at the rearing period (around 2–3 months old) to save both buffalo milk for sale and green fodder (clover) in winter for dairy buffalo feeding. Such numbers of buffalo veal yield around 20,000 tons of carcass weight (40 kg per head). If such a large number of buffalo calves were kept for feeding, they yield around 100,000 tons of carcass weight (about 200 kg carcass weight/head at around 24–30 months old). The net added meat production would be 80,000 tons of carcass weight. Such an amount might share significantly in filling in the market gap between domestic production and demand for red meat in Egypt.

7 Major Objective of the Presented Research

Therefore, the empirical objective was to estimate an econometric model for the feed response using a ration composed of treated rice straw silage with the common concentrate feed mix for feed-lot system of male buffalo feeder calves to reach the optimum marketing weight which maximizes the gross margin above the least cost ration.

7.1 Data Base

The author used the data of a field sample survey from progressive large livestock farms in the north-east Nile delta region of Egypt. The sample was composed of 60 buffalo male calves. A subsample of 30 heads were fed chopped rice straw with concentrate feed mix as a control (Feeding System 1) and the other 30 heads were fed chopped rice straw silage treated with dissolved urea (2% of the straw weight) and molasses (3% of the straw weight) with concentrate feed mix (Feeding System 2). The data covered the agricultural year 2013–2014. The ration combination in both systems as Starch Equivalent quantity (kg S.E.) was 60% concentrate feed mix and 40% rice straw. The cumulative live weight till marketing with the associated feed intakes data was recorded bi-weekly. The feeder calf weight (initial weight) was around 185 kg live weight. The annual average input and output prices were collected for the year (2013/2014), as shown in. Table 1, the concentrate feed mix was composed of corn, oilseed meal, bran and molasses. Its S.E. equivalent weight is 0.52%, and 12% crude protein of the natural form weight.

Table 1 Average price of inputs and outputs for buffalo meat fattening (2013/2014)

Item	Fed buffalo male calves (400 kg/Head)	Concentrate feed mix	Rice straw	Rent of chopping machine	Urea	Molasses
Unit	1-Kg Live weight	1-Ton	1-Load = 250 kg	1 h for 1 ton straw	11-Sac = 50 kg	Tin (30 kg)
Egyptian pound (EGP)	28.75	2800	100	60	100	10

1-$ = EGP 7.47

7.2 Methods and Analytical Procedures

A feed response model was estimated for the two feeding systems. However, the two feed items were fed at a constant combination, i.e. 40% rice straw and 60% concentrate feed mix as S.E. equivalent value. Therefore, the estimated linear correlation between the intake quantities of both feed items was about 0.924. It was evidence of a multicollinearity problem (Intriligator 1978), which might cause biased estimates of the production response model and violation of the statistical inferences if both feed variables were introduced to such a model as explanatory variables. Accordingly, the study aggregated the feed items as one explanatory variable that expressed feeding level as S.E. in kg.

The literature showed that the livestock feed response is often not a linear relationship. It follows the principal of dimensioning return of inputs (Soliman 2006). Therefore, the best fitted feed response function was the quadratic function, as shown by Eq. (1):

$$\acute{y}_i = \alpha + b_1 x - b_2 x^2 \tag{1}$$

Several functions were derived from the response function (1) to estimate the technical and economic efficiency of each feeding system. Equation 2 is the estimated physical marginal product "MPP" The average physical production (APP) is presented by Eq. 3. The production elasticity function (Eq. 4) is derived from Eqs. 2 and 3. The estimated optimum marketing weight that recognizes the maximum gross margin above the least cost feed intake (Eq. 5) is derived from Eq. 2 to express the condition of the equilibrium economic point when the value of marginal product (VMP) equals the marginal cost (MC) i.e., the price of 1 kg S.E of the ration. The market prices are presented in Table 1 and the economic efficiency coefficient "EE" (Eq. 6) is derived from Eq. 5.

In addition, the model of the fattening time function as presented by Eq. 7 was used to estimate the required period to reach the optimum marketing weight. The first derivative of Eq. 7 is the marginal time required to consume an additional unit of feed (Eq. 8). From the two parametric Eqs. (2 and 8) a Cartesian equation (Eq. 9) is derived which estimates the marginal daily gain of live weight. The gross margin (Eq. 10) presents a measure of profitability per head of one fed buffalo calf. It is not the normal profit, but the margin left above the feed cost:

$$MPP_x = dy/dx = b_1 - 2b_2 x \tag{2}$$

$$APP_x = Y/X \tag{3}$$

$$\xi_x = MPP_x / APP_x \tag{4}$$

$$\text{Maximum gross margin when: } VMP_x = P_y(MPP) = P_x \quad (5)$$

$$EE = VMP_x/P_x \quad (6)$$

$$T = c_0 + C_1X + C_2X^2 \quad (7)$$

$$MPP_{x\cdot t} = dT/dx \quad (8)$$

$$MPP_t = MPP_x/MPP_{x\cdot t} = dy/dx \quad dT/dx \quad \frac{dy}{dx}dx/dy \quad dy/dx. \quad (9)$$

$$GM = P_y(MW) - \sum P_{xi}X_i \quad (10)$$

where:

ý	Estimated cumulative weight gain in kgs live weight of calf I
α	Estimated intercept
x	Feed intake in kg of S.E. (40% rice straw and 60% Conc. mix)
b_i	estimated feed response coefficient (regression coefficient)
MPP_x	marginal physical product estimates the additional weight gain due to additional 1 kg of ration
APP_x	estimates the average live weight gain per 1 kg of ration
ξ_x	Production elasticity = the relative change in weight gain due to 1% change in feed intake
VMP_x	estimates the marginal revenue per additional 1 kg of feed combination
P_y	Price of 1 kg live weight in EGP
P_x	Price of 1 kg S.E. of ration in EGP
EE	Economic Efficiency coefficient = marginal revenue generated by spending an additional 1 EGP on feeds. If it is >1, this means it is feasible to expand in feed use for more weight gain; if it is less than one, then less feed should be used and less marketing weight is more feasible.
T	time period of feeding a calf till the marketing weight in days
C_i	estimated regression coefficients of the time function of the feed consumption
$MPP_{x\cdot t}$	marginal time for each additional feed unit intake
MPP_t	Marginal Daily Gain
GM	Gross Margin in EGP = Total revenue − Feed costs

7.3 Results and Discussion

The estimated response functions and the derived functions are presented under each feeding system, with associated statistical inferences estimates.

The values under estimated parameters are the SE. of these estimates.

8 Feeding System 1: Chopped Rice Straw with Conc. Feed Mix

$$\acute{y} = 120.155 \quad + 0.283x \quad - 0.000089x^2$$
$$(6.16) \qquad (-2.29) \qquad R^{-2} = 0.93 \quad F = 185.05 \tag{11}$$

$$MPP_t = (0.283 - 0.00018X)/(0.405 - 0.000024X) \tag{12}$$

$$MPP_x = 0.283 - 0.00018X \tag{13}$$

$$T_I' = 4.972 \quad + 0.405X \quad - 0.000012X^2$$
$$(80.23) \qquad (-17.29) \qquad R^{-2} = 0.988 \quad F = 2372.1 \tag{14}$$

9 Feeding System 2: Rice Straw Silage with Urea and Molasses and Conc. Feed Mix

$$\acute{y} = 0.902 + 0.349x \quad - 0.000079x^2$$
$$(17.14) \quad (-2.98) \qquad R^{-2} = 0.985 \quad F = 1634.1 \tag{15}$$

$$MPP_x = 0.349 - 0.00016X \tag{16}$$

$$T_I' = 4.075 \quad + 0.386X \quad -0.00012X^2$$
$$(99.95) \qquad (-23.99) \qquad R^{-2} = 0.988 \quad F = 2372.7 \tag{17}$$

$$MPP_t = (0.349 - 0.00016X)/\,(0.386 - 0.00024X) \tag{18}$$

Table 2 presents the estimated techno-economic criteria of fed calves under the two tested feeding systems at the price levels of inputs and outputs shown in Table 1. The results are presented in two sections: the first compares the optimum live weight, least cost ration and gross margin of the two systems, and the second section provides a comparative analysis of the estimated average techno-economic criteria of the two feeding systems.

10 Maximum Gross Margin and Optimum Marketing Weight

At the market price level of feeds and live weight of buffalo fed calves in 2013/2014, the estimated marketing weight that maximizes the gross margin above the feed costs was 383 kg live weight under Feeding System 1, while it reached about 517 kg live weight under Feeding System 2 (Table 2 and Fig. 1). Both estimated

Table 2 Economic analysis profile of the fed buffalo calves on two different feeding systems

Estimated techno-economic criteria	Unit	Feeding system 1	Feeding system 2
Average marginal live weight gain/ Kg S.E	Kg live weight	0.150	0.231
Production elasticity of feed intake	%Gain/1% feed	0.72	0.84
Least cost ration quantity	Kg S.E.	872	1381
Optimum marketing weight	Kg live weight	383	517
Feeding period to reach marketing weight	Days	436	382
Total revenue	EGP	10632	14354
Feed costs	EGP	3092	5012
Gross margin	EGP	7540	9342
Average marginal daily gain/day	Kg live weight	0.351	0.881
Average daily gain	Kg live weight	0.21	0.27
Average economic efficiency	EGP	1.17	1.76

Source Estimated from: Eqs. (10–17), Table (1) and application of the Cartesian Eqs. (5, 6 and 9)

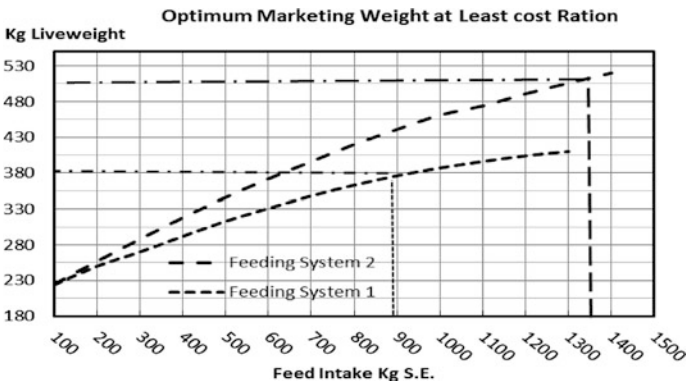

Fig. 1 Optimum marketing weight at least cost ration

weights were achieved at the least cost ration which maximizes the gross margin. Obviously, Feeding System 2 reaches a higher marketing weight at a larger quantity of kg S.E. than Feeding System 1 of less marketing weight, i.e. 1381 kg S.E. versus 872 kg S.E, respectively. Therefore, the least cost ration value of Feeding System 2 was higher than that of Feeding System 1, i.e. 5012 EGP and 3092 EGP, respectively. The higher price per kg S.E. of Feeding System 2 compared to Feeding System 1, i.e. 3.64 EGP versus 3.54 EGP, respectively was also behind the higher feeding cost under Feeding System 2. However, the higher total revenue at the larger marketing weight of Feeding System 2 much surpassed that of Feeding

System 1, i.e. 14353 EGP and 10632 EGP, respectively. Therefore, the acquired gross margin under Feeding System 2 reached 9342 EGP while that generated under Feeding System 1 was 7540 EGP. In other words the farmer would acquire a gross margin under Feeding System 2 of about 124% of what he/she could reach under Feeding System 1. As both subsamples had started with feeder calves of the same initial weight (185 kg/head) at an average age of calves around 14 months old, therefore, such higher marketing weight and gross margin generated by Feeding System 2 were due to better techno-economic performance resulting from the nutrient content of the second system, as discussed in the following section.

11 Techno-Economic Efficiency of the Feed Response Under Two Feeding Systems

The estimated production elasticity showed that while a 10% increase in feed intake under Feeding System 1 raises the live weight gain by 7.2%, it raises the live weight gain under Feeding System 2 by 8.4%. On average, an additional 1 kg S.E. of the ration under Feeding System 1 adds only 0.15 kg live weight gain, but adds 0,231 kg live weight gain under Feeding System 2. The buffalo fed calf would reach an optimum marketing live weight of 383 kg in 436 days under Feeding System 1 and an optimum marketing weight of 517 kg live weight in 517 days under Feeding System 2. Accordingly, the estimated average daily gain was 0.21 kg under Feeding System 1 and 0.27 kg under Feeding System 2. However, the average marginal daily gain from the time function is a better measure for growth speed. It is the average increase in live weight per additional day of growth. While such gain reached 0.351 kg under Feeding System 1, it was 0.881 kg under Feeding System 2, i.e. under Feeding System 2, the buffalo calves grow faster.

As the technical criteria of Feeding System 2 highly surpass those criteria under Feeding System 1, the estimated average economic efficiency coefficient under Feeding System 2 was significantly higher than such a coefficient under Feeding System 1, i.e. 1.76 and 1.17, respectively. It means that while each additional 1 EGP of ration costs under Feeding System 2 generates marginal revenue of 1.76 EGP, it generates only 1.17 EGP under Feeding System 1.

12 Socio Economic Impacts of the Feeding System (2) for Buffalo Fattening

Each buffalo calf fed a ration combination of concentrate feed mix with rice straw silage enriched with dissolved urea and molasses generates direct and external benefits to the rural communities: (1) it generates additional annual income to the farm household of about $1251, equivalent to one-half of the average per capita income in

Egypt, i.e. $2500 (World Bank 2013); (2) it generates extra employment opportunities for the family labor on the farm, which currently suffers from high unemployment (Soliman 2004); (3) it shares in decreasing the annual red meat imports; (4) it utilizes potential livestock resources by stopping the slaughtering of buffalo veal calves during the rearing period; (5) it stops the burning of rice straw which enables communities to avoid the probability of premature mortality and morbidity of not only rural but also urban human resources; and (6) some studies have measured the social costs of the probability of losing one's life by $2,00,000, (Soliman 1995).

13 Causes of the Higher Efficiency of Rice Straw Silage Than Chopped Dry Straw

It seems that the high techno-economic efficiency of the ration composed of 60% starch equivalent from concentrate feed mix and 40% from chopped rice straw silage (with 2% dissolved urea and 3% molasses) is due to some physiological reasons: (1) the enriched rice straw with dissolved urea raises the protein content of the ration; (2) addition of molasses activates the bacterial activities, during silage preparation, which raises the digestibility of the rice straw, and therefore its starch equivalent value; and (3) making silage from rice straw increases its palatability and gives it a preferable smell to the animals. Therefore it increases the intake of the rice straw silage.

13.1 Conclusion and Recommendations

Rice is the main summer crop in Egypt. It is a cash exportable crop that provides a main source of income to the Egyptian farmers and the national economy. However, farmers used to burn the rice straw at the farm borders, violating the law that forbids such action. Burning rice straw on the field causes socio-economic negative externalities due to the generated smoke from burning the straw produced from 1.8 million feddans of rice i.e. about 0.75 million ha. It is a main cause of the probability of premature mortality and morbidity of rural and urban individuals. Chopped rice straw silage mixed with dissolved urea and molasses at 2% and 3% of straw weight, respectively, was provided as feed, at 40% of the S.E. of the daily ration and the rest was from concentrate feed mix (oil meal, yellow corn, bran and salt) to buffalo male calves for meat production. Two feed response models were estimated to compare such ration with untreated rice straw ration. The treated rice straw ration raised the marketing weight derived from the estimated feed-response model that maximizes the gross margin above the feed costs, from 384 to 518 kg live weight. Using treated rice straw as feed for buffalo calves seems more feasible to the rural communities, than using it as a soil fertilizer or in manufacturing wood and paper. While Egypt imported red meat of 963 million dollars in 2013, due to lack of sufficient feed supply, enriched rice straw silage as feed would provide an additional 80,000 tons of carcass weight from fed buffalo calves, rather than slaughtering them as rearing veal calves. The estimated extra income generated from a buffalo-fed calf reached 50% of the average annual per capita income in Egypt, with more employment opportunities for the rural communities, and preventing probable premature mortality due to burning rice straw. 92% of the Egyptian farmers holding 88% of livestock are with small farms (less than 2 ha/farm). They should be the target of a training program on how to make enriched rice straw silage

Therefore, the study recommends: (1) providing extension services to train the small farm managers on how to make such silage as feed for buffalo feeder calves, as they represent the majority farm holdings in Egypt and hold most of livestock numbers; (2) providing options for reducing the cost of collection and transportation of rice straw; and (3) intensifying information campaigns and drives regarding environmental regulations and policies as well as increasing the demand for rice straw for other recommended uses.

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