Research Article

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MEDITERRANEAN AGRICULTURAL SCIENCES
(2023) 36(2): 71-76
DOI: 10.29136/mediterranean.1263967

Profit efficiency of mushroom cultivation in Antalya, Türkiye

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ARTICLE INFO

Received: March 12, 2023
Received in revised form: May 11, 2023
Accepted: May 11, 2023

***Keywords*:**

Mushroom
Profit efficiency
Registry
Stochastic frontier
Türkiye

ABSTRACT

Mushroom is an important fresh vegetable for the Turkish consumer market. However, mushroom production can only be carried out in a few places due to its specific climatic and geological requirements. The amount of mushroom produced in Türkiye was 55455 tonnes in 2020, 33518 tonnes of which (60%) was cultivated in Korkuteli town of Antalya/Türkiye. The main purpose of this research was to estimate the level of profit efficiency and determine factors affecting inefficiency of mushroom cultivation in Korkuteli/Antalya. Accordingly, 60 producers were interviewed in Korkuteli in 2020. Respecting effective exchange rate of 28th October 2020 ($ 1= 8.21 TL) the average per unit profit of producers was calculated as $ 24.98 and average profit inefficiency as 44%. The inefficiency score was estimated against socio-economic items relevant to individual farms or farmers with stochastic profit frontier approach. Gender, education and satisfaction levels of the producer and duration of harvest and registry to the Farmer Registration System (CKS) appeared as factors reducing profit inefficiency. However, age of the farmer, garden use of waste compost and mushroom sales through intermediaries were detected as inefficiency rising factors. Due to the findings, supporting female producers, providing applied training and courses, developing approaches to raise the satisfaction level of producers and supporting CKS registry were proposed. In addition, it was concluded that establishment of a waste compost centre and reopening the producer union, that was shut down earlier, might reduce profit inefficiency.

1. Introduction

Mushroom has been consumed by humans since the hunting & gathering era due to its free availability. Mushroom is used as an ingredient for many industries starting with medicine as well as being considered as a nutrient. In addition to free supplies in the nature, mushroom is also cultivated under controlled conditions. Cultured mushroom can be cultivated across the year under valid climatic conditions.

Cultured mushroom is rich in nutrient value due to herbal protein content and has a specific stance in the Turkish nutrition system. Due to FAO data, 12.27 million tonnes of annual mushroom production in 2009 rose by 69.8% to 20.847 million tonnes in 2019 (FAO 2020). The average amount of mushroom cultivated has been around 17 million tonnes annually. Due to average production ranking, China is the foremost market leader with 83% share and more than 14 million tonnes of production. China is followed by Japan and the USA with around 2.5% shares. Türkiye ranks as the sixteenth with 0.2% share and 35570.73 tonnes of production (FAO 2020). Official statistics of Türkiye (TUIK) revealed that 15000 tonnes of mushroom production in Türkiye in 2004 almost tripled by 2020 and reached to 55455 tonnes. Korkuteli town of Antalya has a specific stance in nationwide mushroom cultivation that town's contribution in national supplies is 67% (TUIK 2020). Therefore, the research was restricted to Korkuteli town of Mediterranean province of Antalya. Accordingly, it was intended within this study to measure the profitability of cultured mushroom of *Agaricus Bisporus* variety and determinants of profitability levels at the producer level. The final objective of the case study was to propose policy moves to assure sustainability of mushroom cultivation in Türkiye.

While the history of mushroom research dates back in time, it is new for Türkiye. While recognition and reproduction of mushroom dates to B.C. in the world, the first recorded production in Türkiye took place in 1960 via trials of an MD named Enver and with seeds brought from Germany (Gunay 2004). Accordingly, there are very few studies in Türkiye regarding both cultivation and economics of mushroom. Some relevant global and Turkish studies were summarised below.

Frempong (2000) searched profits of mushroom producers in the Greater Accra district of Ghana with data from 1995-1999. The benefit/cost ratio of cultivation activity was calculated as 1.35. Mushroom cultivation was acknowledged as profitable with $ 6200000 net present value of sales and 48.24% internal efficiency ratio.

Ozcatalbas et al. (2004) conducted a field survey with 150 producers in Korkuteli to develop solutions to specific production problems. By then, almost 60% of producers had less than 5 years of production experience and main income generation activity of 33% of these producers was mushroom production. While low sales price was considered as a problem by producers, intermediaries complained about the VAT rates. Demir and Sonmez (2011) searched existing economic situation and problems of 156 producers in Korkuteli and more than 90% of producers declared that they had a fair income. The most important problem was compost supplies with 61.53% and more than 78% of producers seemed to use waste compost as fertilizer.

Barmon et al. (2012), researched benefit/cost (B/C) ratios of 30 selected producers in Bangladesh in 2011. The calculated average cost of production per producer was $ 574.63 corresponding to $ 888.02 income on average. With 1.55 B/C ratio, the activity appeared to be profitable.

Mayanja (2018), determined mushroom cultivation profitability in Kampala – Uganda with 52 producer responses from 2016. The evaluation was made with benefit/cost ratio, break-even analysis, data envelopment analysis. The profitability determinants were estimated with multiple regression and efficiency determinants were estimated with Tobit analysis. It was understood that per farmer average gross profit was more than $ 4000 and net profit was $ 2385.31. The break-even point per enterprise was 106.41 kg. Efficiency scores were recorded under different conditions. Under variable returns to scale conditions, technical efficiency was 0.942, distributive efficiency was 0.593 and cost efficiency was 0.557. Under constant returns to scale assumptions, the scores were recorded as 0.681, 0.487 and 0.331 respectively. Tobit estimation results revealed that efficiency was mainly affected by sales price and number of carrier bags. The most important problems faced by producers appeared to be the low sales price in a complementary way and lack of proper consultancy services.

Departing from these research experiences, profit efficiency of mushroom cultivators in Korkuteli Antalya was estimated and evaluated in this study.

2. Materials and Methods

2.1. Material

As noted, Korkuteli is a very significant district for mushroom cultivation in Türkiye. Recognition and acceptance of mushroom production as an alternative income generation activity in Kokuteli - Antalya dates to 1990s, when harsh drought conditions were observed. Over time, compost companies were established and more farmers were supported in mushroom production. The population of the study, number of mushroom growers in Korkuteli was 1200 in 2020 due to TUIK data. However, due to 2019 records of the Farmer Registry System of Ministry of Agriculture and Forestry, the number of registered producers was 122 (MoAF 2020). The sample of field survey was determined as 60 respecting 5% of the population with non-probabilistic purposive sampling. This sample also referred to 49% of officially registered farmers. Choice of purposive sampling was also related to the homogeneity of cultivar scale in the town so that the possibility to manipulate the parameters and estimates was low enough. Therefore, 60 of Agaricus bisporus variety mushroom cultivators were visited in October-November of 2020 and primary data was retrieved with a face-to-face survey. Mushroom cultivation takes place four times per year. Researchers were directed to choose between two cultivation periods, October-November and March-April. The temperatures are similar in these two periods and range between 5 and 22 degrees Celsius due to records of the Meteorological Service of Türkiye (MS 2020). Therefore, researchers undertook the survey in the autumn period considering climatic conditions and time availability.

2.2. Methodology

Different ratios and parametric and non-parametric methodologies are being used in the measurement of efficiency. Parametric stochastic frontier analysis was used in this study. This stochastic approach explains probabilistic effects leading to inefficiency within composite variation in the objective function, i.e. production, cost, or profit (Aigner et al. 1977; Battese and Corra 1977; Battese and Coelli 1995). Profit function is preferred where possible, as the decision-making process for input use was included as an external factor in profit maximization approach (Ali and Flinn 1989; Lau and Yotopoulos 1971; Yotopoulos and Lau 1973; Abdulai and Huffman 1998; Ozkan et al. 2009). The Cobb-Douglas profit function utilised was as follows (Battese and Coelli 1995; Ceylan et al. 2018):

$$\pi_i = f(P_{ij}, Z_{ik})\exp(e_i) \qquad [1]$$

π_i: gross profit ([total sales revenue – variable costs of the i^{th} farm] /amount cultivation land –m^2)

P_{ij}: input price (price of input j^{th} of the i^{th} farm/ amount of output produced - kg)

Z_{ik}: level/amount of k^{th} fixed production factor of the i^{th} farm)

e_i: error term

Augmented form of the Cobb-Douglas gross profit function is as following.

$$\begin{aligned}\ln\pi = {} & \ln\beta_0 + \beta_1\ln Z_{ik} + \beta_2\ln P_{2i} + \beta_3\ln P_{3i} \\ & + \beta_4\ln P_{4i} + \beta_5\ln P_{5i} + \beta_6\ln P_{6i} \\ & + \beta_7\ln P_{7i} + (u_i + v_i)\end{aligned} \qquad [2]$$

In the equation ln represents linear logarithm. The dependent variable π was gross profit per unit land in m^2. Z_{ik} is the amount of fixed factor, P_{2i} is the amount of land utilised for mushroom cultivation (m^2). The remaining independent variables were calculated per unit land used for mushroom farming in m^2. P_{3i} was compost cost, P_{4i} was pesticide/herbicide cost, P_{5i} was energy cost (electricity, water, gas), P_{6i} was temporary labour cost (daily worker payment), P_{7i} was transportation cost (compost and compost disposal carriage) respectively.

In this equation 2, u and v represent the error term. Error term of the profit function is the sum of inefficiency score and random errors. Also, per unit refers to the amount produced (kg) in the i^{th} farm. With estimation of this profit function, effects of variable costs on the profit level can be measured. Yet, the objective of the research was to determine socio-economic factors affecting profit/loss situation of mushroom producers. It is accepted that error term variance of the profit function represents the sum of inefficiency and random variance as demonstrated below (Battese and Cora 1977; Battese and Coelli 1995; Kumbhakar and Lovell CAK 2000).

$$\sigma^2 = \sigma_u^2 + \sigma_v^2 \qquad [3]$$

The inefficiency index (KEI) was retrieved via inverse logarithm implementation to the error term for each observation – farm.

$$KEI_i = (1 - \exp[-u_i]) \qquad [4]$$

Afterwards, the inefficiency index was estimated against the factors expected to affect it.

$$\mathrm{KEI_i} = f(C_i, Y_i, E_i, M_i, H_i, A_i, K_i, S_i)) \quad [5]$$

C_i: Gender of producer
Y_i: Age of producer
E_i: Education level of producer
M_i: Satisfaction level from mushroom cultivation
H_i: Harvest duration
A_i: Use of compost disposal in the garden
K_i: Official farmer registration status (CKS)
S_i: Sales venue – use of intermediary

The analysis was conducted in STATA 16 following the methodology proposed.

3. Results and Discussion

Mushroom cultivation profitability was evaluated for inefficiency. While net profit represents the success of the managerial process of the enterprise or the farm, gross profit represents the success of productive activities. Accordingly, fixed costs were separated from the statistical measurement and inefficiency interpretation process.

Prior to proceeding, the aggregate and average figures should be noted. The average amount of production for 60 producers in October-November 2020 was 17951 kg. The amount produced by 42 growers was below average. Average per kg price was $ 0.73 and 53 producers (88%) seemed to receive above this average. Average sales revenue was $ 1449.48 and 43 producers (72%) were receiving below this level. The average gross profit was $ 4320.58 and 65% of operators' profit level was below this average. Average profit per kg was recorded as $ 0.16 with respect to the effective exchange rate of 28th October 2020 ($ 1= 8.21 TL). Net profit average on the other hand was $ 2157.49 and 21 producers were in loss due to their declarations.

3.1. Stochastic profit estimation

After a descriptive evaluation of the profit structure, effects of cost items on the profit and impacts of socio-economic factors on profit efficiency were estimated consecutively. Prior to analyses, the linear distribution structures were checked. The profit and cost variables appeared as non-linear on level and logarithmic transformation was made as referred in the literature. The normality of transformed profit and cost accounts was checked with the Shapiro-Wilk W test (Shapiro and Wilk 1965) and unit sales cost (duty and commission payments) and unit cover soil cost were removed from the equation.

The correlations between variables were checked afterwards. Negative correlations were detected between production land and cost items regarding pesticide/herbicide, compost and energy use. In addition, there was a positive correlation between compost cost and pesticide/herbicide and energy use costs. These relationships led to a suspicion of multicollinearity and variance inflation factors (VIF) of variables were calculated and evaluated. If VIF is found out to be equal or more than 10, existence of multicollinearity is suspected (Webster 1995). In contrast to existing relationships between variables, multicollinearity was rejected, and gross profit was estimated in a semi-normal form. The findings were demonstrated in Table 1.

Due to Wald chi-square, detected six independent variables explained 39.25% of variation in the dependent variable or per unit profit. The impact of cultivation land was estimated as -0.57 meaning a reduction of profit by -0.57 units corresponding to a declination of the amount of land by 1 unit. Rising amount of land can be read as rising variable costs. Therefore, the negative impact is an expected economic inference. Rising energy cost per unit led to a reduction in profit by 0.87 units. Therefore, climatic conditions should be kept under control for cultured mushroom cultivation, So, cultivators use air conditioning and electrical energy to provide the most desirable temperatures for heating and cooling. Therefore, rising energy cost reduces profitability as expected.

Table 1. Gross Profit Estimation with Stochastic Frontier (normal/semi-normal model) - (n: 60).

Wald $X^2(6)$ (p> chi2)	39.25 (0.00)	Log likelihood	-79.54	
lnπ (per unit profit) - Dependent	Coefficient	Std. Error	z	ρ>|z|
$\ln P_{2i}$ (land - m^2)	-0.57	0.15	-3.78	0.00
$\ln P_{3i}$ (compost cost)	0.29	0.42	0.70	0.48
$\ln P_{4i}$ (pesticide/ herbicide cost)	0.50	0.32	1.56	0.11
$\ln P_{5i}$ (energy use cost)	-0.87	0.45	-1.94	0.05
$\ln P_{6i}$ (temporary labour cost)	-0.01	0.21	-0.09	0.93
$\ln P_{7i}$ (transportation cost)	0.32	0.20	1.57	0.11
Constant	8.35	2.21	3.77	0.00
$\ln\sigma_v^2$	-1.47	0.81	-1.81	0.07
$\ln\sigma_u^2$	0.61	0.43	1.41	0.15
σ_v	0.47	0.19		
σ_u	1.35	0.29		
σ^2	2.07	0.66		
λ	2.84	0.46		
LR test (Likelihood ratio) of σ_u=0: X^2(p)= 2.68 (0.051)				

It was seen that the statistical likelihood values of compost, pesticide/herbicide, labour and transportation costs were high. Deterministic tests ran prior to analyses only enabled a general assessment of the parameter estimates. Checking out the estimate signs in Table 1, compost, pesticide/herbicide and transportation costs raise profit levels and profitability attached. Yet, the impact of labour cost was reverse.

It is also important to understand these effects more in detail. Compost cost is rather significant in mushroom cultivation, being the most important input of the process. Scale efficiency can be considered for inference of its positive effect. With a larger closed production warehouse in m^2 and rising production, more compost is required, and rising compost expenditure can be interrelated with rising production and sales revenue the sales revenue is expected to rise. It is almost similar for pesticides/herbicides. Even though climatic conditions are taken under control for the health of compost as a production material, compost is open for diseases due to its nature. Use of herbal medicines is allowed in mushroom cultivation under certain limitations. So, with more pesticide/herbicide costs, more sales revenue and profit are expected. The amount of compost and size of the warehouse also contribute to an explanation of the transportation costs. Subsequently, as these cost items rise, the production and attached gross profit rises as well and this can be read as a positive impact. On the contrary, the effect is minimum for labour cost in a negative direction. As daily labour requirement and use may include implicit costs as well, temporary labour use seemed to have a negative effect. In other terms, temporary labour requirements may also be related to the process planning disruptions and may be read as rising direct costs and thus reducing efficiency.

Following stochastic profit frontier estimation, normality of error terms and existence of heteroscedasticity were checked to confirm the valid specification of the model. The normality of residuals was tested with Skewness/Kurtosis tests (Pearson 1905). With 0.31 Skewness and 0.68 Kurtosis values, a normal distribution characteristic was confirmed (Hair et al. 2018).

The existence of odd values in the data set is considered as heteroscedasticity. When error term variance changes due to variations in independent variables, there is a variance problem (Gujarati 1995). This possibility was checked with the Breusch-Pagan / Cook-Weisberg test. With p value above 0.05, heteroscedasticity was rejected (Breusch and Pagan 1976; Cook and Weisberg 1983). With homoscedastic error variance, it was understood that the model was formed correctly even if some parameters appeared to have low significance. Therefore, it was understood that the factors affecting profit inefficiency could be estimated and inferred for these 60 cultivators.

3.2. *Inefficiency frontier estimation*

The stochastic analysis was followed by retrieving inefficiency scores with inverse logarithm application to error terms' variance $KEI_i = (1 - \exp[-u_i]))$. The scores indicated that the inefficiency ranged between 0.04 and 80 % and the average inefficiency for 60 producers was 44%. After determination of the inefficiency set, profit inefficiency was estimated against previously determined economic, social and farmer related characteristics.

The frontier estimation results were demonstrated in Table 2. To replicate, the average inefficiency was 44%. With a female farmer, it was understood that inefficiency declined by 9% at 0.10 significance level. With rising age, inefficiency rose by 9%, rising education level reduced inefficiency by 4%. If the farmer was satisfied or had the tendency towards higher satisfaction regarding the mushroom cultivation process, inefficiency reduced by 21%. With longer harvest period allocated, declination in inefficiency was 14%. The declination percentage was 42% when the cultivator was registered in the farmer registry system (CKS). If the farmer had been using compost disposal in the garden, inefficiency seemed to rise by 31% and use of intermediary led to rising inefficiency by 5%. The estimates were significant and their signs or directions of effect were in conformity with economic and social expectations.

4. Conclusions

With this study, the efficiency level of mushroom cultivation and effective factors attached were analysed for Türkiye with respect to a sample from the important cultured mushroom cultivation district of Korkuteli, Antalya. Turning back the profit inefficiency estimates, the average inefficiency was 44% for 60 producers. In other words, 34 of 60 mushroom farms were operating efficiently with respect to the profit they received. The effective factors can be differentiated in terms of the direction of their impact.

Inefficiency reducing factors

- Farmer is female
- Farmer has more education
- Farmer is satisfied with the process
- Farmer is registered officially.
- Harvest duration is longer

Inefficiency rising factors

- Farmer is older
- Farmer uses compost disposal in the garden.
- Farmer maintains sales via intermediaries.

Table 2. Determinants of cultivar inefficiency (σ_u^2) - (n: 60)

Wald $X^2(6)$ (p> chi2)	30.47 (0.00)	Log likelihood	-74.44	
In (inefficiency score) - Dependent	Coefficient	Std. Error	z	ρ>|z|
C_i (gender)	-0.09	0.67	-0.15	0.08
Y_i (age)	0.09	0.04	1.90	0.05
E_i (level of education)	-0.04	0.29	-0.15	0.08
M_i (satisfaction level)	-0.21	0.24	-0.87	0.03
H_i (harvest duration)	-0.14	0.10	-1.32	0.01
A_i (use of compost disposal in the garden)	0.31	0.71	0.44	0.06
K_i (official registration)	-0.42	0.65	-0.66	0.05
S_i (use of intermediary)	0.05	0.96	0.05	0.09
Constant	6.81	6.96	0.98	0.33
σ_v	0.55	0.14		

Due to the statistical findings, it is possible to propose the following measures to reduce inefficiency or increase efficiency with respect to profit earned.

- Female farmers/entrepreneurs should be supported in mushroom cultivation.
- More on-site and off-site training programmes should be developed for technical aspects of mushroom cultivation and these programmes should be delivered to farmers.
- The farmers should be encouraged to form joint organisations to increase the possibility of accessing more technical and economic support.
- The public sector should propose more agricultural support for establishment of mushroom cultivation facilities.
- Increasing producer registration is important and should be a focus point.
- Increasing traceability of the process is essential for product and process quality. Public organisations should promote traceability for further gains.
- Younger farmers should be supported to enter the market or take over management of existing structures.
- Support should be provided to mushroom processing in the form of pickles or canned form to increase value-added activities. Producers should be directed towards industrialisation.
- Establishing a specific monitoring mechanism to prevent the use of compost disposal in the gardens is essential. Public sector should act accordingly and provide extension services to farmers.
- Merging compost and mushroom production actors may provide price competition power. Support should be provided to merge, to extend overseas activities or to promote international trade.

Findings and inferences of the field study have portrayed the sustainability of problems in mushroom cultivation in Türkiye. There were non-governmental initiatives formed to organise the sector and represent actors. Yet, the attempts have been previously unsuccessful. Producer and merchant actors in the sector and policy maker/implementer organisations recognize the need to organise the sector for more efficiency in economic and social manners.

Considering the target district and its economic dependency on mushroom production, problems in the sector cannot be neglected and more focused economic planning is essential. The enterprises should recognise their need for profits and importance of mushroom in the Mediterranean diet so that further investments can be made. Especially, in countries where mushroom is recognised as a traditional producer/consumer product, actions to enrich production schemes, develop international trade lines and contacts should be considered seriously. Such policies and measures might assure sustainability of the sector. Therefore, it can be said that this study suggests the recognition and development of mushroom economics as a research and policy field. Besides, socio-economic proposals can be considered as valid in most of the mushroom-producing countries for commercialisation of production activities.

Acknowledgements

This manuscript was prepared depending on the findings of the MSc dissertation written by Esra Mülazımoğulları in Akdeniz University Institute of Sciences in 2021. The thesis entitled ‘Profit Efficiency on Culture Mushroom Growing in Korkuteli District’ was prepared and submitted under the guidance of Assoc. Prof. Rahmiye Figen CEYLAN.

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