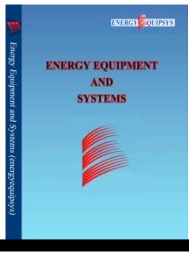
Energy Equip. Sys./ Vol. 6/No. 2/June 2018/ 201-209

Energy Equipment and Systems

http://energyequipsys.ut.ac.ir
www.energyequipsys.com



Enhancers of the energy efficiency in tea processing industry

Authors

Saeed Hadipour Zimsar[a]
Saeed Firouzi[b*]
Mohammad Sadegh Allahyari[a]

[a] Department of Agricultural Management, Rasht Branch, Islamic Azad University, Rasht, Iran

[b] Department of Agronomy, Rasht Branch, Islamic Azad University, Rasht, Iran

Article history:

Received : 5 January 2018
Accepted : 30 January 2018

ABSTRACT

The cost reduction of green tea processing, the control of fossil fuel resources, and the curbing of corresponding greenhouse gases emission depend on the energy efficiency of tea processing units. Therefore, it is imperative to identify and analyze factors determining energy efficiency of these agro-industrial units. To this end, the present descriptive survey was carried out on 40 managers of tea factories in Guilan Province, Iran. At the first phase of the study, the experts and managers of the tea manufacturing units were given an open-response question to identify the factors affecting energy productivity of tea industry. Then, the factors were divided into three broad categories of technical, managerial-policy, and knowledge-skill. The statistical analysis of final questionnaire data showed that "the correct and sound design of the new hot air furnaces", "the enhancement of technical knowledge of technicians in withering, fermentation, drying and storage units", and "optimum scheduling of withering operation with respect to the final status of green tea leaf" were found to be the most important technical, managerial-policy, and knowledge-skill factors determining the improvement of energy productivity in tea factories of Guilan Province, respectively. Accordingly, it is recommended to hold training courses to enhance energy productivity knowledge of tea factory managers, to improve the technical knowledge of technicians in withering, rolling, fermentation, drying, and storage units, to renew machinery and equipment of tea factories, to enforce manufacturing units to comply with relevant quality standards, and to allocate financial supports through low-interest loans for mounting tea processing machinery and equipment with high energy efficiency.

Keywords: Electricity, Fuel, Energy Use Efficiency, Tea Industry.

1. Introduction

Tea is the second most commonly used natural drink after water [1]. Iran consumes about 5% of the world's tea product while it is home to 1% of the world's population. Guilan and Mazandaran provinces in northern Iran enjoy a temperate climate and fertile lands, giving them unique conditions for agricultural production and related processing industries. In this sense, they possess the most suitable conditions in Iran for growing tea [2]. In these two provinces of Iran, there are over 70,000 tea-growing families who make a living by tea production. They deliver the plucked leaves to 160 tea processing factories, among which 148 units are located in Guilan Province and 13

* Corresponding author: Saeed Firouzi
Department of Agronomy, Rasht Branch, Islamic Azad University, Rasht, Iran
E-mail address: firoozi@iaurasht.ac.ir

units in Mazandaran Province. The tea industry is of a particular importance in production and employment among the economic activities in northern Iran. This industry in Iran is less dependent on the foreign countries than other agricultural industries and can play a role in generating productive employment and activating the commercial sector at the national level [3].

Energy is perceived as one of the main factors of the formation and development of industrial societies, and the extent to which countries have access to various sources of energy indicates their potential for development and their political-economic power. The enhancement of energy productivity in different sectors can pave the way for economic development and social welfare along with maintaining or even reducing energy consumption. This is why researchers across the globe extensively study the energy use productivity at macro-scale and production units level. In this regard, Miketa and Mulder [4] examined the energy productivity of ten industrial activities across 56 developed and developing countries. They found that energy prices have a limited role in energy productivity growth and that technological change is regarded as an important factor in the improvement of energy productivity. Amini and Yazdi Pour [5] analyzed the determinants of energy productivity in major industrial units in Iran during the period of 1994-2002. The results of model estimation by pooled time-series cross-section (TSCS) data showed that the average capital per unit of energy use and the actual cost of capital use had the greatest impact on energy productivity. The ratio of employees with an academic engineering degree to all employees as a successor to technology had a positive, significant effect on energy productivity. The relative prices of energy carriers over the study period did not influence energy productivity in large industrial units significantly. Adenikinju and Olumuyiawa [6] examined the relationship between energy use and energy productivity improvement in manufacturing industries in Nigeria. According to their results, the conservation of energy reserves, changes in the industrial structure, and fuel composition of industries in many countries have enhanced efficiency in the manufacturing industries. Roy [7] studied the trend of energy productivity for six industries in India. The results showed that the doubling of energy prices in India entailed 0.7% loss of overall productivity of the industry sector. He also stated that the rise in the price of energy carriers, in the long run, would have a negative impact on productivity and would result in welfare decline.

The process of turning green tea leaf into dry tea includes the operations of withering, rolling, fermentation, drying, sorting and packing of tea in tea factories (Fig. 1). Over 75% of the world's tea is black, which is more than 90% in Iran. The tea-making process consumes a remarkable amount of energy inputs. Figure 2 demonstrates where thermal and electrical energies are consumed within the tea-making process. The level of consumption productivity for each individual input plays a significant role in the profitability of the tea factories and the final price of the product. On the other hand, in the macro perspective, the improvement of energy productivity can enable the conservation of production inputs, especially fossil fuels, and reducing environmental pollutants as a national strength. Thus, it is very important to consider energy productivity in the tea-making industry. In this regard, some researchers in the leading tea-producing countries such as China, India, and Kenya have focused on different dimensions of energy at tea factory level. For instance, Qin and Zhou [8] found that tea processing energy in rural areas of China was a function of the type of final product, tea cultivar, and its processing equipment. In a study on identifying the determinants of energy use efficiency in tea-making factories of Kenya, Bulali Sayi [9] evaluated the effect of the capacity to utilize tea-making equipment to be weak to mild. The level of users' awareness of energy use efficiency of tea-making equipment was estimated at about 95%. Therefore, this factor was considered to be ineffective on the energy use efficiency of the tea-making process. The relationship of energy mix ratio with energy use efficiency in the tea-making industry of Kenya was the highest (91.1%) and negative for wood fuel. Taulo and Sebitosi [10] determined the specific electrical and thermal energy in the Malawi tea industry to be 0.64 and 13.41 $kWh\,kg^{-1}$, respectively. They suggested some technical improvements including the use of variable speed drives, thermal energy recovery, combustion efficiency enhancement, the use of energy efficient electromotors, the use of flat belts, and alternative energy sources as strategies to enhance energy use indices in tea-making industry.

Sustainability of tea production as the second strategic agricultural crop in northern provinces of Iran and the source of income for about 70,000 Iranian families is of particular importance. In this regard, it is imperative to promote the efficiency of energy as the major input in the tea industry. This could enable reducing the price of the final product, thereby increasing farmers' income and profitability of tea factories, and ultimately improving the sustainability of tea production in Iran. The review of the literature showed that so far, no comprehensive research has been done to identify all dimensions of the drivers of energy productivity improvement of tea factories in Iran. Thus, the present study focused on identifying and analyzing the drivers of energy productivity enhancement in the tea industry in Guilan Province as the leading tea production region in Iran.

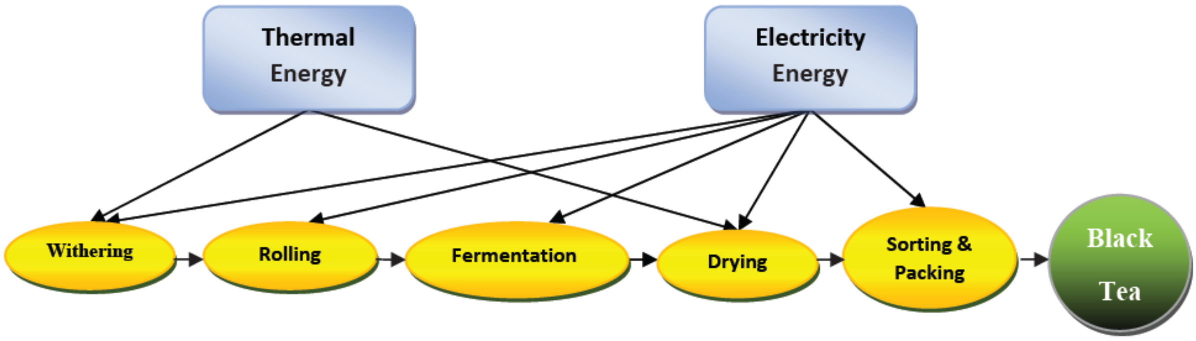


Fig 1. Steps of tea processing in Orthodox method and major energy inputs used in different operations

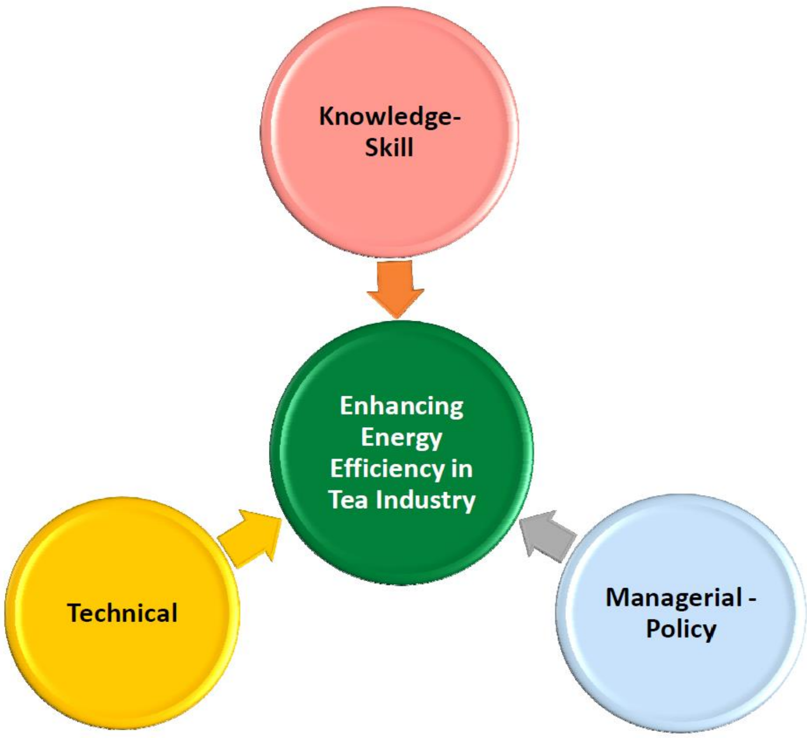


Fig 2. Classification of enhancers of energy use efficiency in tea processing industry

2. Materials and Methods

The present study was conducted in Guilan Province in the north of Iran in spring and summer of 2016. The dominant approach or research model was quantitative research because the research data were collected with a questionnaire. It was a descriptive (non-experimental) survey in terms of research variables control and was a field research in terms of data collection procedure for which a questionnaire was used. The target population consisted of the managers of tea factories in Guilan Province. In order to develop the initial questionnaire, semi-structured interviews were conducted with a number of managers of tea factories and tea experts in Guilan province. The final questionnaire was designed based on the results of the interviews and the review of the literature. Accordingly, a questionnaire was developed containing the following open-response question with corrective feedback capability and was administered to three experienced managers of tea factories and three tea processing experts in the study site:

- What are the energy efficiency enhancers in tea industry of Guilan Province?

The first section of the final questionnaire included items on demographic information and technical skills of the managers of the tea factories and the technical specifications of their managing units. The second section consisted of a list of factors promoting the energy productivity of the tea industry categorized into technical, knowledge-skill and managerial-policy factors according to the results derived from the questionnaires in the first phase of the study (Fig. 2). These factors were included in 27 items scaled on five-level Likert scale (very low = 1, low = 2, somewhat = 3, high = 4, and very high = 5). The validity of the final questionnaire was confirmed by tea processing experts in Guilan Province. In these sorts of studies, the sample size is considered as 10-20 times greater as the number of the categories of main factors [11]. Accordingly, 40 tea factory managers in Guilan Province were selected as members of the research group. Data were analyzed using the SPSS21 software package. The data on the technical specifications of tea factories and the demographic and skill features of managers were analyzed by the statistics of frequency, percentage, and cumulative percentage. In order to analyze the factors promoting energy productivity of tea factories, the scores equivalent to the factors for all members of the research group were fed into the SPSS21 software package. Then, the statistics of mean, standard deviation, and variation ratio were calculated. The variation ratio is used to determine the dispersion of the data measured on nominal and ordinal scales. In other words, it can be used to examine if the provided responses are consistent. It can be calculated by the following equation [12]:

$$VR = 1 - \frac{f_{max}}{f_{total}} \tag{1}$$

in which:
VR = variation ratio,
f_{max} = maximum frequency of responses, and
f_{total} = total frequency (total number of participants).

The present research used Kendall's W test to determine the agreement among the members of the research group (managers of tea factories). Kendall's W is a scale expressing the degree of agreement among several rankings pertaining to N objects or persons. In fact, this scale allows finding the rank correlation between K rank sets. Let's suppose that factor i is ranked r_{ij} after being scored by j^{th} individual in the research group. Then, assuming m factors and n members in research groups, the total ranks of this certain factor is calculated by the following equation:

$$R_i = \sum_{j=1}^{m} R_{i,j} \tag{2}$$

Then, these total ranks are averaged by Equation (3) as shown below:

$$\overline{R} = \frac{1}{n}\sum_{i=1}^{n} R_i \tag{3}$$

in which case, the sum of squared deviations from the means is defined as follows:

$$S = \sum_{i=1}^{n}\left(R_i - \overline{R}\right)^2 \tag{4}$$

Thus, Kendall's W test scale is calculated as follows:

$$W = \frac{12S}{m^2\left(n^3 - n\right)} \tag{5}$$

This scale ranges from 0 to 1 in which 0 implies no agreement, but 1 implies a complete agreement among the opinions of group members [13]. If Kendall's W turns out to be significant at the 1 or 5% probability level, it points to an agreement among the opinions of group members.

The Friedman test was used to compare the factor groups (technical, knowledge-skill and managerial-policy). The Friedman test is a statistical test used to compare several groups and identify their average ranks. This is a non-parametric test that is equivalent to the repeated-measures or intra-group analysis of variance. It is used to compare the means of ranks among *K* variables or groups. To run this test, the data are entered into a table with *K* rows and *N* columns in the SPSS software environment. The rows represent the subjects (here, samples) and the columns represent different locations (here, factors) [14]. SPSS software first calculates the Chi-Squared statistic (χ^2) using the following formula:

$$\chi_r^2 = \frac{12}{NK(K+1)}\sum R_j^2 - 3N(K+1) \qquad (6)$$

where,
K = the number of samples,
N = the number of factors, and
R_j^2 = the squared ranks of each group.

This test makes it possible to compare the mean rank of a certain variable against the mean rank of other variables or groups, facilitating the ranking of the groups.

3. Results and Discussion

This section first presents the characteristics of tea factory managers who participated in the study and the units managed by them. Then, the results are discussed separately for the three groups of energy productivity enhancers, including technical, knowledge-skill, and managerial-policy factors (Fig. 2).

3.1. Demographic information of research group members and their supervising units

According to Table 1, 70% of sample managers were older than 50 years, and only 30% were 40-50 years old. None of them has ever attended technical skill training courses, and they announced that they were unaware of such courses. Among the factories, 57.5% had an annual processing capacity of less than 500 t. Less than 18% of the managers had an academic degree. In addition, 70% of technical experts were graduates of fields irrelevant to tea making.

3.2. Technical factors

Table 2 shows that "the correct and sound design of the new hot air furnaces" was ranked first among technical determinants of energy productivity (CV=0.17) with an average agreement of 2.92 in tea factory managers' opinion. The tea processing industry is heavily dependent on energy consumption that is mainly used during the operations of withering, drying, machinery running, and material transportation [9]. Although both thermal energy and electrical energy are used in green tea processing, the thermal energy is much costlier than the electrical energy [15]. The cost of energy needed for tea processing, especially during the energy-intensive process of drying green tea leaves,

Table 1. Demographic features, labor characteristics and processing capacity of the factories managed by the participants

Feature	Level/stratum	Frequency	Percent (%)
Manager's age (year)	40-50	12	30
	50-60	22	55
	>60	6	15
Managers' educational level	Diploma or under-diploma	27	67.5
	Associate degree	3	7.5
	Bachelor's degree or higher	10	25
Manager's educational field	Relevant	14	35
	Irrelevant	26	65
Technical expert's educational field	Relevant	25	62.5
	Irrelevant	15	37.5
Attended training courses	Yes	0	0
	No	40	100
Annual processing capacity (Ton/year)	100-400	21	52.5
	400-700	13	32.5
	>700	6	15

is one of the major sources of cost in this agricultural industry [16]. The furnaces supply hot and dry air for the withering and drying phases. Drying is one of the most important stages of tea making, in which the enzyme activity is stopped first, and then the rolled green leaves are dried to 3-4% moisture content. This stage is responsible for a large part of the energy consumed in tea manufacturing. In other words, tea drying is an energy-intensive process. Due to the increase in the cost of energy carriers, the saving of fuel consumption in hot air furnaces would reduce the final price of the processed dry tea, which would, in turn, make dry tea processing more profitable. Therefore, the correct and sound design of these furnaces can play a key role in the reduction of fuel consumption and the improvement of energy productivity [17].

The second rank of technical factors was assigned to “the use of standard burners in hot air furnaces” with average response agreement of 3.97 (CV=0.27). Standard burners can convert 100% of the fuel into thermal energy, enhancing its energy productivity. Similarly, Taulo and Sebitosi [10] indicated consumption efficiency improvement as a practical way to enhance energy use efficiency in tea industry of Malawi.

“The shared use of hot air furnace for withering and drying” that makes it impossible to mount an automatic temperature control system in the withering unit was ranked third among technical factors with average response agreement of 4.67 (CV=0.32). Mabvuu et al. [18], who designed an automatic control system for tea-dryer, listed automatic temperature adjustment, output tea moisture content, and fuel consumption rate of dryer among the parameters that can be controlled by automatic control systems.

“The correct and sound design of hot air delivery channels to withering and drying units” was ranked the fourth important technical factor determining energy productivity with an average agreement of 4.02 (CV=0.37). The sound design of the hot air channels can be largely effective on avoiding the waste of thermal energy during its transfer from the hot air furnaces to the withering and drying units, resulting in higher energy productivity of tea processing [17]. Also, Rudramoorthy et al. [19] relate 35-55% of thermal energy losses to exhaust chimneys and the hot air leakage in hot air channels and driers.

3.3. Managerial-policy factors

According to Table 3, the results of managerial-policy factors showed that “the enhancement of technical knowledge of technicians in withering, fermentation, drying and storage units” was ranked the first priority among managerial-policy factors influencing the enhancement of energy productivity of tea manufacturing in Guilan Province with average response agreement of 3.95 (CV=0.05). It was figured out that those who work in tea factories have not been trained in specific courses and have mostly acquired their skills by experience (Table 1). Therefore, by improving the knowledge of energy productivity among the experts of withering, fermentation, drying and storage units, we can reduce energy use of these units remarkably. According to Bulali Sayi [9], the tea making technicians in Kenya had over 95% awareness of energy efficiency

Table 2. Statistical comparison of technical factors influencing energy productivity enhancement in tea factories of Guilan Province

Factors	Mean	Standard deviation	Coefficient of Variation
The correct and sound design of the new hot air furnaces	2.92	0.41	0.17
The use of standard burners in hot air furnaces	3.97	0.53	0.27
The shared use of hot air furnace for withering and drying	4.67	0.47	0.32
The correct and sound design of hot air delivery channels to withering and drying units	4.02	0.61	0.37
The shift in tea manufacturing system from orthodox to CTC	1.42	0.59	0.37
Insulation of the existing hot air furnaces and air delivery channels	4.45	0.50	0.45
On-time maintenance or renewal of worn-out hot air furnaces	4.52	0.50	0.47
Optimization of the existing hot air furnaces	4.50	0.50	0.50
Optimization of rolling devices	3.6	0.59	0.50
Reuse of thermal energy lost in withering and drying units	1.77	0.76	0.55
Reuse of thermal energy of exhaust gas of hot air furnaces	1.75	0.70	0.55
W Kendall=0.35**			

Table 3. Statistical comparison of managerial-policy factors influencing energy productivity enhancement in tea factories of Guilan Province

Factors	Mean	Standard deviation	Coefficient of Variation
The enhancement of technical knowledge of technicians in withering, fermentation, drying and storage units	3.95	0.22	0.05
The enhancement of factory owners' technical and administrative knowledge by holding practical courses	3.75	0.49	0.22
Improved linkage of tea factories with the industrial sector	3.12	0.46	0.22
The limited financial resources available for tea factory owners to renew and optimize tea processing equipment and facilities	3.75	0.58	0.25
Seasonality of labor and unavailability of skilled workers	2.87	0.56	0.25
Specific support of applied research in tea processing industry	3.20	0.56	0.27
Correct policy making for tea importation	2.30	0.79	0.27
Actual pricing of energy inputs	3.67	0.47	0.32
Access to skillful tea experts	3.67	0.52	0.37
Attempts of the organizations in charge of tea production to optimize energy use in tea processing industry	3.37	0.70	0.47
W Kendall=0.47**			

and this factor was ineffective on the enhancement of energy efficiency in those agro-industrial units. We found that only 30% of technical users in tea factories had relevant educations and that only less than 20% have attended relevant technical courses.

The second priority among managerial-policy factors was assigned to "the enhancement of factory owners' technical and administrative knowledge by holding practical courses" with response agreement of 3.75 (CV=0.22). This holds that it is of vital importance to hold practical training courses so that the trainers who are experienced in tea industry can help tea factory owners improve their knowledge of energy productivity. In addition, similar practical courses to enhance technical-skill knowledge of the personnel of tea factories form an important priority for the productivity enhancement of these manufacturers.

"Improved linkage of tea factories with the industrial sector" was ranked the third priority among managerial-policy factors with an average agreement of 3.13 (CV= 0.22). The connection of tea factories with the industrial sector can enable them to use modern technological devices and to stop using old machinery that has low energy efficiency.

The fourth priority was found to be "the limited financial resources available for tea factory owners to renew and optimize tea processing equipment and facilities" with average response agreement of 3.75 (CV=0.25). Obviously, worn-out equipment and facilities increase fuel consumption during tea processing and reduce energy productivity. Faced with limited financial resources, tea factory owners are unable to renew the equipment and facilities of their factories. It is worthy of note that the government can provide factory owners, who are financially in need, with long-term low-interest loans so that they can renew their equipment and facilities and improve their energy productivity.

3.4. Knowledge-skill factors

The ranking of knowledge-skill factors that can improve energy productivity in tea factories shows that "optimum scheduling of withering operation with respect to the final status of green tea leaf" was ranked first with an average score of 3.15 (CV=0.22) (Table 4). Meanwhile, none of the studied tea factory managers were found to have attended technical training courses of tea processing (Table 1). Green tea leaves initially have about 70-80% moisture on fresh base, which is reduced to 50-60% during withering. This stage triggers the chemical interactions that continue during rolling and fermentation phases [20]. Withering lasts for 12-24 hours depending on tea type, temperature, and humidity of air flow. Withering is of crucial importance for tea quality because if the leaves are not withered well, they will be broken down during rolling, so their contents will be lost and the tea will lose its quality. Clearly, the optimum scheduling of the withering operation can affect the reduction of energy used during the withering stage. Salavatian et al. [17] showed that withering operation accounted for 31% of thermal energy and 58.16% of the total electrical energy used during black tea processing.

Table 4. Statistical comparison of knowledge-skill factors influencing energy productivity enhancement in tea factories of Guilan Province

Factors	Mean	Standard deviation	Coefficient of Variation
Optimum scheduling of withering operation with respect to the final status of green tea leaf	3.15	0.53	0.22
Updated technical knowledge of those who work in tea industry	3.85	0.48	0.25
Time management of tea production processes toward saving in energy use	3.05	0.50	0.25
Lack of scientific information about the moisture and air temperature in fermentation site for optimum control of electrical energy	3.27	0.45	0.27
Updated technical knowledge of tea experts	3.67	0.57	0.35
Optimal scheduling of rolling operation with respect to device setting	3.35	0.53	0.40
W Kendall=0.64**			

The second rank was assigned to “updated technical knowledge of those who work in tea industry” with an average agreement of 3.85 (CV = 0.25). Obviously, if those who work in tea industry have updated technical knowledge, this can help enhance energy productivity of tea factories to a great extent.

3.5. Final comparison of energy efficiency determinants

The final results showed that the technical and managerial-policy factors were ranked first and second among factors influencing energy productivity in Guilan Province. A look at the factors indicates that all are, in some way, related to poor management and outdated knowledge of tea making technicians and also to the economic status of tea factory owners. In this respect, Miketa and Mulder [4] stated that the promotion of technology in industrial activities is the most important factor in increasing energy productivity in this economic sector. Also, Taulo and Sebitosi [10] considered technical issues in different sections of tea processing as an approach to enhance energy use indicators in the tea industry of Malawi.

Table 5. Final comparison of factors underpinning energy productivity enhancement of tea factories in Guilan Province

Factors	Priority
Technical factors	1
Managerial-policy factors	2
Knowledge-skill factors	3
n= 40 ; χ^2=183.7 ; df=2 ; α=0/00	

4. Conclusion

According to the results, we categorized factors influencing the enhancement of energy efficiency in tea industry of Iran into three main categories: technical, managerial-policy, and knowledge-skill. Accordingly, “the correct and sound design of the new hot air furnaces”, “the enhancement of technical knowledge of technicians in withering, fermentation, drying and storage units”, and “optimum scheduling of withering operation with respect to the final status of green tea leaf” were found to be the most important technical, managerial-policy, and knowledge-skill factors determining the improvement of energy productivity in tea factories of Guilan Province, respectively. The final comparison of these categories revealed that all in all, the technical category was the most influential factor on the energy use efficiency of tea process in Guilan Province. In this respect, the following recommendations can be drawn:

1. Holding training courses in energy productivity by experienced trainers for tea factory owners and the technicians of different parts of tea processing. The review of lessons learned by leading tea manufacturing countries, e.g. China, India, and Kenya, will be useful.
2. Continuous training to deliver technical skills to managers, experts, and operators in tea factories.
3. Sound renewal of worn-out factories by low-interest loans under adequate, regulatory monitoring.
4. Renewal of tea machinery from withering until packing phases by low-interest bank loans.
5. Motivating tea processing units to improve their energy productivity through subsidization and bonus.

Acknowledgments

The authors would like to thank Rasht branch, Islamic Azad University for their support.

References

[1] Saptashish D., Jolvis Pou K.R., A Review of Withering in the Processing of Black Tea, Journal of Biosystems Engineering (2016) 41(4):365-372. doi: 10.5307/JBE.2016.41.4.365
[2] Hasanpour M., Tea Cultivation and Technology. University of Guilan's Press (in Persian) (1998).
[3] Mahdavi R., Abbasi R, Measurement and Analysis of Factors Affecting Tea Industries of Guilan Province, Guilan's Management and Programming Organization Publication (in Persian)(2007).
[4] Miketa A, Mulder P., Energy Productivity Across Developed and Developing Countries in 10 Manufacturing Sectors: Patterns of Growth and Convergence, Energy Economics (2005) 27(3):429-453.
[5] Amini A., Yazdi Pour F., Analysis of Factors Affecting Energy Productivity in Iran's Large Industrial Workshops, Journal of Business Research (2008) 8(3): 71-104.
[6] Adenikinju A., Olumuyiawa A., Energy Use and Productivity Performance in the Nigerian Manufacturing Sector, OPEC Review (1999) 23(3): 251–264.
[7] Roy J., Productivity Trends in India's Energy Intensive Industries, Energy Journal (1999) 20(3): 33-61
[8] Qin Ni J., Zhou H., Energy Consumption and Conservation in Tea Processing in China, Renewable Energy (1992) 2(1): 1-5.
[9] Bulali Sayi J., Determinants of Energy Efficiency in Black Tea Processing Factories a Case of Kenya Tea Development Agency. A Research Project Report Submitted In Partial Fulfillment of The Requirements for the Award of the Degree of Master of Arts in Project Planning and Management of the University of Nairobi (2014) 94.
[10] Taulo L., Sebitosi A.B., Energy Consumption Analysis for the Malawian Tea Industry, IEEE, 2015 International Conference on the Industrial and Commercial Use of Energy (ICUE), Cape Town, South Africa (2015) 8, doi: 10.1109/ICUE.2015.7280268.
[11] Bartlett J.E., Kotrlik J.W., Higgins C.C., Organizational Research: Determining Appropriate Sample Size in Survey Research, Information Technology, Learning, and Performance Journal (2001) 19(1):43-50.
[12] Pansalan T.G., Uriarte G.G. Statistics: A Simplified Approach, First Edition, REX Book Store, Manila, Philippine (1987) 215.
[13] Heiko A., Consensus Measurement in Delphi Studies: Review and Implications for Future Quality Assurance, Technological Forecasting and Social Change (2012) 79 (8):1525-1536.
[14] Azar A., Momeni M., Statistics and Application in Management. Samt Publication, Tehran (2007) 350 (In Persian).
[15] Okoth M.W. Thermal Energy Conservation in Kenyan Tea Processing Plants Presented to a Workshop Held at Nyeri, As part of the Kenya Industrial Energy, Management Programme (1990) 271-273.
[16] Langat N., Thoruwa T., Wanyoko J., Kiplagat J., Plourde B., Abraham J., Models and Experiments for Energy Consumption and Quality of Green Tea Drying, Energy Science and Engineering (2015) 3(1): 43–50.
[17] Salavatian S.B., Madjd Salimi K, Javadi A., Energy Consumption in Black Tea Production in Tea Factories, Article Ready to be Published in Agricultural Mechanization and Systems Research, 10.22092/erams.2017.106506.1100.
[18] Mabvuu N., Nyanga L., van der Merwe A.F., Matope S., Mhlanga S., Towards the Implementation of e-Manufacturing: Design of an Automatic Tea Drying Control System, South African Journal of Industrial Engineering (2014) 25(3): 199-211.
[19] Rudramoorthy R., Sunil Kumar C.P., Velavan R., Sivasubramaniam S. Innovative Measures for Energy Management in Tea Industry, Energy Engineering Division, Department of Mechanical Engineering, PSG College of Technology, Coimbatore, India(2008).
[20] De Silva W.C.A., Status Review of Energy Utilization by the Tea Industry in Sri Lanka, Sri Lanka Journal of Tea Science (1994) 63(2):46-58.