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ResearchArticle

Determination of Energy Balance in Pumpkin Seed (*Cucurbita pepo* L.) Production

Mehmet Fırat Baran[1*], Osman Gökdoğan[2]

[1] Siirt University, Agriculture Faculty, Biosystem Engineering Department, Siirt, Turkey (ORCID: 0000-0002-7657-1227)
[2] Isparta University of Applied Sciences, Agriculture Faculty, Agricultural Machinery and Technologies Engineering Department, Isparta, Türkiye (ORCID: 0000-0002-4933-7144)

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Abstract

In this study was purposed to define an energy balance of pumpkin seed production in Kavaklı town of Kırklareli province in Turkey. In order to define the energy balance of pumpkin seed production in dry conditions, trials and measurement were applied in pumpkin seed farm in the Kavaklı town of Kırklareli province. Human labour energy, machinery energy, diesel fuel energy, chemical fertilizers energy and seed energy were computed as energy inputs. The pumpkin seedswere computed as output energy. The energy input and output were computed as 10022.42 MJ ha^{-1} and as 9611.25 MJ ha^{-1} in pumpkin seed production. Energy inputs consist respectively for chemical fertilizers energy by 5266.50 MJ ha^{-1} (52.55%), diesel fuel energy by 3375.78 MJ ha^{-1} (33.68%), machinery energy by 805.46 MJ ha^{-1} (8.04%), human labour energy by 429.04 MJ ha^{-1} (4.28%) and seed energy by 145.63 MJ ha^{-1} (1.45%). Energy efficiency, specific energy, energy productivity and net energy in pumpkin seed production were computed respectively as 0.96, 12.15 MJ kg^{-1}, 0.08 kg MJ^{-1} and (-) 411.17 MJ ha^{-1}. 94.27% of total energy inputs in the production of pumpkin seed consisted of non-renewable energy input.

Keywords: Energy balance, Energy productivity, Pumpkin seed, Kavaklı, Kırklareli

Çerezlik Kabak Üretiminin Enerji Bilançosunun Belirlenmesi

Öz

Bu çalışmada, Türkiye'nin Kırklareli ilinin Kavaklı beldesinde çerezlik kabak üretiminin enerji bilançosunun belirlenmesi amaçlanmıştır. Kuru şartlarda çerezlik kabak üretiminin enerji bilançosunu belirlemek için Kırklareli ilinin Kavaklı beldesinde bir çerezlik kabak işletmesinde denemeler ve ölçümler gerçekleştirilmiştir. Enerji girdileri olarak insan işgücü enerjisi, makine enerjisi, dizel yakıt enerjisi, kimyasal gübre enerjisi ve tohum enerjisi hesaplanmıştır. Çıktı enerjisi olarak çerezlik kabak ürünü hesaplanmıştır. Çerezlik kabak üretiminde enerji girdisi ve çıktısı 10022.42 MJ ha^{-1} ve 9611.25 MJ ha^{-1} olarak hesaplanmıştır. Enerji girdileri sırasıyla; 5266.50 MJ ha^{-1} (%52.55) ile kimyasal gübre enerjisi, 3375.78 MJ ha^{-1} (%33.68) ile dizel yakıt enerjisi, 805.46 MJ ha^{-1} (%8.04) ile makine enerjisi, 429.04 MJ ha^{-1} (%4.28) ile insan işgücü enerjisi ve 145.63 MJ ha^{-1} (%1.45) ile tohum enerjisinden oluşmuştur. Çerezlik kabak üretiminde enerji etkinliği, spesifik enerji, enerji verimliliği ve net enerji sırasıyla; 0.96, 12.15 MJ kg^{-1}, 0.08 kg MJ^{-1} ve (-) 411.17 MJ ha^{-1} olarak hesaplanmıştır. Çerezlik kabak üretiminde toplam enerji girdilerinin %94.27'si yenilenemez enerji girdisinden oluşmuştur.

Anahtar Kelimeler: Enerji bilançosu, Enerji verimliliği, Çerezlik kabak, Kavaklı, Kırklareli

[*] Corresponding Author: Siirt University, Agriculture Faculty, Biosystem Engineering Department, Siirt, Turkey (ORCID: 0000-0002-7657-1227) mfb197272@gmail.com

1. Introduction

Pumpkin (*Cucurbita maxima*) belongs to the cucurbitacae family, which covers cucumber, melon and squash (Robinson and Decker-Walters, 1997; Teppner, 2000; Azarpour et al., 2013). Pumpkin seed has very intensive oil and protein rate and it is used as a medicinal plant for products such as pumpkinol, prostaclenz and prostalog that wereshowed good results for therapies of minor disorders of the prostate gland and the urinary vesica. Pumpkin plants are hardy creepers or soil surface runners, but able to swarm where there are supports. The fruits are various in shape, colour and sizes. They are monoecious and can be bred from pure lines. The pumpkin orange flesh is used for human consumption such as soup, purees, jams, and pies throughout the world (Alfaz, 2004; Azarpour et al., 2013).

The relationship between agriculture and energy is very close. Agriculture is an energy user and energy supplier itself in the form of bio-energy (Alam et al., 2005; Azarpour et al., 2013). Energy usage in agriculture was improved in response to rising populations, limited supply of cultivable land and desire for an rising standard of living. In all societies, these factors were heartened an rise in energy inputs to maximum yields, minimum labor-intensive practices or both (Alam et al., 2005; Azarpour et al., 2013). Effectual energy usage in agriculture is one of the states for consistent agricultural production, since it maintains financial savings, fossil resources preservation and air pollution decreasing (Uhlin, 1998; Azarpour et al., 2013).

Energy balance was analyzed in some researches on pumpkin seed (Azarpour et al., 2013; Sağlam and Çetin, 2018), soybean (Mandal et al., 2002), mustard (Mandal et al., 2002), wheat-maize (Mani etal., 2007), potato (Mohammadi et al., 2008), cucumber (Mohammadi and Omid, 2009), canola (Mousavi-Avval et al., 2011), lentil (Mirzae et al., 2011), maize (Karaağaç et al., 2011), sesame (Ibrahim, 2011), barley (Azizi and Heidari et al., 2013), tobacco (Loghmanpour-zarini and Abedi-firouzjaee, 2013), rice (Yadav et al., 2013), grape (Baran et al. 2017), citrus (Yılmaz ve Aydın, 2020), tomato (Saltuk et al., 2019), chickpea (Karaağaç et al. 2019), groundnut (Baran et al., 2019, Saltuk, 2019), etc. The definition of the energy balance of pumpkin seed is the aim of this study.

2. Material and Method

Kırklareli province is located between 41° 44′-42° 00′ north latitude and 26° 53′-41° 44′ east meridians. The land size of Kırklareli province is 6555 km^2 (Anonymous, 2014). The study was performed on test fields that has 600 square meters in 15 decares, located in Kavaklı region of Kırklareli province (Figure 1).

Figure 1. The location of study area (Baran at al, 2015)

It was used randomized complete-block design with three replicates in this study. While computing energy input-output, the researches performed on defining the coefficients of energy equivalents of inputs-outputs were used. Pumpkin seed input-output values were defined and the computations were given in Table 2. Koçtürk and Engindeniz (2009) reported that; "The input energy can also be classified into direct, indirect, renewable and non-renewable forms (Mandal et al., 2002; Singh et al., 2003)". Energy efficiency computations in pumpkin seed production weregiven in Table 3. Types of energy inputs for pumpkin seed production were given in Table 4.

Total fuel consumption of each parcel was computed as l ha^{-1}. Full tank method was used to measure the amount of fuel (Göktürk, 1999; El Saleh, 2000; Sonmete, 2006). Labor yield of each parcel (ha h^{-1}) was computed by proportion the total time computed for in area of the trial to the area amount. Experiments in parcel were measured with using the effective labour time (t_{ef}) (Özcan, 1986; Güzel, 1986; Sonmete, 2006). The time spent during agricultural operations in the parcel was measured with the aid of chronometer (Sonmete, 2006).Energy equivalents of input-output used in agricultural production were given in Table 1. Energy ratio, specific energy and net energy were computed with using the following formulas (Mandal et al., 2002; Mohammadi et al., 2008; Mohammadi et al., 2010).

Energy efficiency = Energy output (MJ ha^{-1}) / Energy input (MJ ha^{-1}) (1)

Energy productivity = Product output (kg ha^{-1}) / Energy input (MJ ha^{-1}) (2)

Specific energy = Energy input (MJ ha^{-1}) / Product output (kg ha^{-1}) (3)

Net energy = Energy output (MJ ha^{-1}) - Energy input (MJ ha^{-1}) (4)

Table 1. Energy equivalents of inputs and outputs in pumpkin seed production

Inputs	Unit	Energy equivalent (MJ unit^{-1})	References
Human labour	h	1.96	Mani et al., 2007; Karaağaç et al., 2011
Machinery	h	64.80	Singh, 2002; Kızılaslan, 2009
Chemical fertilizers			
Nitrogen	kg	60.60	Singh, 2002
Phosphorous	kg	11.10	Singh, 2002
Diesel fuel	l	56.31	Singh, 2002; Demircan et al., 2006
Seed	kg	11.65	Azarpour et al., 2013; Sağlam and Çetin, 2018
Output	**Unit**	**Energy equivalent (MJ unit^{-1})**	**References**
Yield (Seed)	kg	11.65	Azarpour et al., 2013; Sağlam and Çetin, 2018

3. Results and Discussion

In the farm producing pumpkin seed, an average of 825 kg ha^{-1} pumpkin seed was yielded during the 2017-2018 production season. The energy balance in pumpkin seed production was given in Table 2. According to Table 2, energy inputs in pumpkin seed production were computed as 10022.42 MJ ha^{-1}, energy output was computed as 9611.25 MJ ha^{-1}. Energy inputs consist of chemical fertilizers energy by 5266.50 MJ ha^{-1} (52.55%), diesel fuel energy by 3375.78 MJ ha^{-1} (33.68%), machinery energy by 805.46 MJ ha^{-1} (8.04%), human labour energy by 429.04 MJ ha^{-1} (4.28%) and seed energy by 145.63 MJ ha^{-1} (1.45%), respectively.

Similarly, in previous researches; Azarpour et al. (2013) computed that the fertilizer application energy had the biggest share by 80.49% (pumpkin seed),Mohammadi and Omid (2010) computed that the fertilizer application energy had the biggest share by 40.17% (cucumber), Abbas (2011) computed that the fertilizer application energy had the biggest share by 36.30% (canola), Karaağaç et al. (2011) computed that the fertilizer application energy had the biggest share by 58.21% (wheat), Baran (2017) computed that the fertilizer application energy had the biggest share by 52.79% (vetch) etc.

Table2.Energy balance in pumpkin seed production

Inputs	Unit (br)	Energy equivalent (MJ br^{-1})	Input used per hectare (br ha^{-1})	Energy value (MJ ha^{-1})	Ratio (%)
Human labour	h	1.96	218.90	429.04	4.28
Machinery	h	64.80	12.43	805.46	8.04
Chemical fertilizers				5266.50	52.55
Nitrogen	kg	60.60	75	4545	45.35
Phosphorous	kg	11.10	65	721.50	7.20
Diesel fuel	l	56.31	59.95	3375.78	33.68
Seed	kg	11.65	12.50	145.63	1.45
Total				10022.42	100.00
Outputs	**Unit (br)**	**Energy equivalent (MJ br^{-1})**	**Yield per hectare (br ha^{-1})**	**Energy value (MJ ha^{-1})**	**Ratio (%)**
Yield (Seed)	kg	11.65	825	9611.25	100.00
Total				9611.25	100.00

Energy efficiency, specific energy, energy productivity and net energy in pumpkin seed production were computed as 0.96, 12.15 MJ kg^{-1}, 0.08 kg MJ^{-1} and (-) 411.17 MJ ha^{-1}, respectively (Table 3). In previous researches; Sağlam and Çetin (2018) computed energy efficiency as 1.005 (pumpkin seed), Azarpour et al. (2013) computed energy efficiency as 0.16 (pumpkin seed), Mandal et al. (2002) computed energy efficiency as 1.10 (soybean), Mandal et al. (2002) computed energy efficiency as 1.98 (mustard), Mohammadi et al. (2008) computed energy efficiency as 1.25 (potato) etc.

Table3.Energy computations in pumpkin seed production

Computations	Unit	Values
Energy efficiency		0.96
Specific energy	MJ kg^{-1}	12.15
Energy productivity	kg MJ^{-1}	0.08
Net energy (-)	MJ ha^{-1}	411.17

The consumed total energy input in pumpkin production was classified as 37.96% direct, 62.04% indirect, 5.73% renewable and 94.27% non-renewable (Table 4). Similarly, in previous researches; Azarpour et al. (2013) computed renewable energy ratio of 5.68% (pumpkin seed), Mohammadi et al. (2008) computed renewable energy ratio of 25.73% (potato), Mohammadi and Omid (2010) computed renewable energy ratio of 6.85% (cucumber), Abbas (2011) computed renewable energy ratio of 1.20% (canola), Loghmanpour-zarini and Abedi-firouzjaee (2013) computed renewable energy ratio of 16.55% (tobacco), etc.

Table 4. Types of energy inputsforpumpkin seed production

Type of energy	**Energy input (MJ ha^{-1})**	**Ratio (%)**
Direct energy [a]	3804.83	37.96
Indirect energy [b]	6217.59	62.04
Total	10022.42	100.00
Renewable energy [c]	574.67	5.73
Non-renewable energy [d]	9447.75	94.27
Total	10022.42	100.00

[a] Includes human labour and diesel fuel
[b] Includes seed, chemical fertilizers and machinery
[c] Includes human labour and seed
[d] Includes diesel fuel, chemical fertilizers and machinery

4. Conclusions and Recommendations

The study was explained with these summarized conclusions:

Pumpkin seed production consumed a total energy of 10022.42 MJ ha^{-1}, which was the highest due to chemical fertilezers (52.55%). The energy input of diesel fuel (33.68%) and machinery (8.04%) were the second and third share within the total energy inputs.

Energy efficiency, energy productivity, specific energy and net energy were determined as 0.96, 0.08 kg MJ^{-1}, 12.15 MJ kg^{-1} and (-) 411.17 MJ ha^{-1}.

The renewable and non-renewable energy inputs were 5.73% and 94.27% of the total energy input.

Decreasing chemical fertilizers consumption is important for energy efficiency management. Thus, farm fertilizers using may be decreased.

In this study, the energy efficiency of pumpkin seed production in the Kırklareli province was determined. According to the evaluated results, pumpkin seed production is not an economic production in terms of energy usage (0.96).

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