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Assessment of biomass potential as bio-energy source from fruit trees and grapes in Albania

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Abstract

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Biomass is a natural renewable material originated from agricultural, forestry and household residues, which can generate a low or no cost renewable energy and it has various advantages in terms of sustainable development and environmental protection. Nowadays, agriculture is one of the most important sectors in Albania generating high amount of residues which can be used for energy production. This study aims to assess the potential of biomass generated from fruit trees and grapes for bio-energy production in Albania. Agricultural data on fruit trees, vine and citrus production in Albania were collected. The data shows a considerable increase of fruit trees, vine and citrus production from year 2000 to 2010 and after 2010 it was observed a slight increase of production for all kind of trees. The production in Albania is increasing from year to year with an approximate amount of 15 000 tonnes (t)/year for fruit trees, 4000 t/year for vine and 3000 t/year for citrus. Furthermore, by using a polynomial model is calculated a predictive agricultural biomass production in short and long term in Albania up to 2025. From the estimations the results for biomass production are satisfactory. The increase of agricultural production in Albania lead to the formation of large residues which can be used for energy production with an actual potential of about 637.2 Gigawatt hours (GWh) by using processed and pruned biomass of fruit trees, citrus trees and grapes in Albania.

Keywords: Renewable energy; biomass; bio-energy; fruit trees; pomace
Abbreviations: DM (Dry matter); EC (European Commission); EU (European Union); GEF-UNIDO (Global Environmental Fund – United Nations Industrial Development Organization); GJ (*Gigajoule);* GWh (Gigawatt hours); INSTAT (National Institute of Statistics of Albania); MJ (Megajoule); Small and Medium Enterprises (SME); t (tonne/s)

Introduction

Albania is a candidate country for European Union (EU) membership. It is working closely with the EU to complete reforms that will strengthen its political and economic ties with the EU. Thus, the country is in the process of aligning the national legislation with the EU acquis with the goal of the transposition and implementation of the entire acquis communautaire as a condition for membership. The European Commission (EC) Directive 2009/28/EC (EC, 2009a), is specific on the promotion of use of renewable energy and defines the goals and the ob-

ligations in the area of using renewable energy sources (Bilandzija et al., 2012).

The bio-energy production and its use will contribute to the sustainable development of the Albanian economy which is of high importance for actual and future generations. Nowadays, the use of renewable energy sources is becoming increasingly important with regards to its potential to mitigate the effects of climate change due to reducing fossil fuel consumption. Global warming and climate change is a crucial issue for the international community and strong commitments are required from all the countries to find alternatives to fossil fuels for energy production. The EC Directive 2009/28/EC (EC, 2009a) obliges the EU Member states to reduce their greenhouse gas emissions below specific levels for each country and to reduce their greenhouse gas emissions based on their commitments up to 2020. The recent Directive 2009/29/EC (EC, 2009) aims to further improve and extend the greenhouse gas emission allowance trading scheme of the community by further strengthening the use of alternative energy sources (Iakovou et al., 2010; Burg et al., 2016).

Recently the global interest on using renewable energy sources, especially the energy coming from the use of biomass, has been increased considerably. This is because biomass is a renewable natural resource (Leszek et al., 2014) which is largely available and has a good potential as source for energy production, electricity and heat as well as liquid fuels. Furthermore, the use of biomass as natural material has advantages since it is practical for use. Biomass is evaluated as the third largest primary energy source in the world after coal and petroleum (Bilandzija et al., 2012). Biomass energy differs from other renewable energies, because includes natural vegetation, energy crops, animal residues, forestry, agricultural residues, municipal wastes and different industrial wastes which are directly tied to the farms, forest and other ecosystems (Van Dam et al., 2007; Bilandzija et al., 2012; Gonzalez-Rosas et al., 2013; Burg et al., 2016). The use of biomass in various processes such as thermo chemical, physico-chemical and bio-chemical, nowadays is considered as one of the most important alternatives in energy production (Burg et al., 2016).

Agricultural biomass as energy source is used mainly in rural areas but also in urban energy systems. The interest of using biomass is the fact that it represents a low cost and renewable energy source (Leszek et al., 2014), but also because it provides various advantages in terms of sustainable development and environmental protection. Replacement of fossil fuels by biomass has several benefits such as reduced CO_2, SO_2 and NOx emissions (Vinterback, 2004; Verma et al, 2010). Natural reserves on fossil fuels, such as oil, gas and coal are limited sources of energy, thus the use of alternatives on energy production as bio-energy from biomass is of high importance for actual and future developments.

The main objective of the current study is to assess the potential of biomass generated from fruit trees and grapes for bio-energy production in Albania.

Methodology

To achieve the above objective, the current study is based on different papers and documents, reports, national and international studies. The study is performed based on the following materials: Agricultural Annual Statistics published by the Ministry of Agriculture and Rural Development; data from the National Institute of Statistics of Albania (INSTAT); data on the surfaces and production of fruits, citrus and vine trees from the Regional Directories of Agriculture; previous studies for the biomass potential; discussions with agricultural specialists, agro food industry specialist farmer associations, and bio-energy experts. The computer program Excel 2016 was used for polynomial model and statistical analysis.

Results

The main agricultural sectors of biomass production in Albania are cereals, olives, grapes, fruit trees, vegetables and citrus. In Table 1 the trends of fruit trees, grapes and citrus production from year 2000 to 2015 are presented. It can be observed that the production of all crop species is increased every year. Thus the production of fruit trees varied from 64 900 t in 2000 to 245 000 t in 2015. The citrus trees production varied from 2600 t in 2000 to 30 000 t in 2015. Total grapes production varied from 79 300 t in 2000 to 205 000 t in 2015.

In Tables 2 and 3 are presented detailed data of planted permanent crops and production in all regions of Albania for the year 2015, and in Table 4, production of fruit trees for the year 2015.

Based on the figures, the production of fruit trees ranges from 3808 t in Gjirokastra region to 71 328 t in Korça. Citrus production varied from 19 t in Gjirokastrato 15 668 t in Vlora region. Also total grapes varied from 5382 t in Kukes to 43 759 t in Fier region.

Figure 1 presents the trend of fruit trees, citrus and grape productions from year 2000 to 2015. The figure shows a considerable increase of fruit trees and grape production in Albania, about four times higher from year 2000 to 2010 due to the increase of new planted surface areas and yield of these plant species. The citrus production has a slight increase during the same period and after the year 2010 it is observed a slight increase of production for all biomass.

Table 1. The production of fruit trees, grapes and citrus in Albania

No	Crop species	Year							
		2000	2005	2010	2011	2012	2013	2014	2015
I	Fruit trees								
	Total (000 trees)	5573	7120	10 190	11 225	11 607	11 909	12 254	12 405
	In production (000 trees)	4179	5370	7439	8313	8992	9292	9654	10 185
	Yield (kg/tree)	15.5	17.2	22.6	22.6	23.4	23.5	22.8	23.6
	Production (000 t)	64.9	90	167.8	188.1	210	218	220	245
II	Citrus trees								
	Total (000 trees)	391	550	763	916	1010	1125	1200	1282
	In production (000 trees)	305	421	530	589	633	767	859	951
	Yield (kg/tree)	8.8	12.3	25.2	25.5	29.8	26.1	24.4	31.5
	Production (000 t)	2.6	5.2	13.4	15	18.9	20	21	30
III	Pergola								
	Total (000 trees)	4638	5364	5501	5743	5859	5974	6075	6109
	In production (000 trees)	3856	4536	5100	5208	5380	5494	5599	5655
	Yield (kg/tree)	11.9	12.3	16.2	16	15.2	15.4	15.0	14.6
IV	Vineyard								
	Total (ha)	5824	7994	9712	10 073	10 136	10 178	10 383	10 438
	In production (ha)	4613	6637	8630	9077	9348	9579	9625	9891
	Yield (kv/ha)	70.5	90.1	118.6	123.4	123.1	124.5	124.5	123.8
	Total Grapes (000 t)	79.3	115.1	184.9	195.2	196.8	204.0	203.7	205.0

Source: Ministry of Agriculture and Rural Development

Table 2. Total area of planted permanent crops (fruit tree, citrus and vineyards) of the year 2015

Planted area (ha)									
No	Region	Fruit trees	In production	Citrus	In production	Vineyards	In production	Total	In production
1	Berat	2365	2206	65	48	1117	1085	12 951	11 114
2	Diber	1728	1281	0	0	195	188	1923	1469
3	Durres	612	556	30	27	757	741	3680	3293
4	Elbasan	1746	1490	49	43	1274	1187	9075	7152
5	Fier	2688	2602	209	181	2062	2000	19 963	17 512
6	Gjirokaster	342	241	2	2	750	698	2210	1558
7	Korce	3531	2765	0	0	1081	997	4612	3763
8	Kukes	2999	2556	0	0	85	76	3084	2632
9	Lezhe	301	529	11	9	385	356	1128	1196
10	Shkoder	1429	656	25	16	726	611	3577	1930
11	Tirane	1069	937	24	16	793	751	6640	5630
12	Vlore	329	270	840	553	1215	1203	12 460	11 132
	Total	19 139	16 089	1255	895	10 440	9893	81 303	68 381

Source: Ministry of Agriculture and Rural Development

Table 3. Production of permanent crops (fruit tree, citrus and vineyards) of the year 2015

No	Region	Production (t)				
		Fruit trees	Citrus	Vineyard grape	Grape from pergola	Total grape
1	Berat	24 406	2672	15 963	9671	25 634
2	Diber	21 203	0	2546	6105	8651
3	Durres	16 106	1393	10 422	3670	14 092
4	Elbasan	32 789	2171	14 549	10 878	25 427
5	Fier	25 125	6015	34 422	9337	43 759
6	Gjirokaster	3808	19	6935	6799	13 734
7	Korce	71 328	–	7752	4593	12 345
8	Kukes	8866	–	987	4395	5382
9	Lezhe	6001	529	3307	3595	6902
10	Shkoder	13 967	375	4778	6033	10 811
11	Tirane	15 447	1158	,756	7536	17 292
12	Vlore	5954	15 668	11 067	9904	20 971
Total		245 000	30 000	122 484	82 516	205 000

Source: Ministry of Agriculture and Rural Development

Table 4. Production of fruit trees by plant group species of the year 2015

No.	Region	Production (t)						
		Fruit trees	Fruit seed	Stone fruit	Subtropical	Berries	Nuts	Others
1	Berat	24 406	4627	9573	8544	60	1276	326
2	Diber	21 203	8691	8921	1063	489	1656	382
3	Durres	16 106	6679	4978	3121	165	899	265
4	Elbasan	32 789	8218	15 078	7057	625	1211	600
5	Fier	25 125	6996	10 921	5292	147	492	1278
6	Gjirokaster	3808	834	1020	1289	68	565	32
7	Korce	71 328	58 556	11 392	108	102	1112	57
8	Kukes	8866	2755	3204	60	96	2574	177
9	Lezhe	6001	1313	2528	1415	48	523	173
10	Shkoder	13 967	2308	4091	4730	432	2131	276
11	Tirane	15 447	5731	5269	3359	165	760	163
12	Vlore	5954	1394	1802	2154	25	410	169
Total		245 000	108 102	78 777	38 192	2422	13 609	3898

Source: Ministry of Agriculture and Rural Development

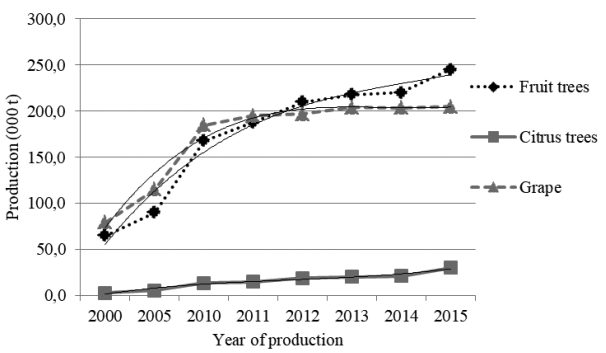

Fig. 1. The trend of fruit tree, grape and citrus production in Albania

A polynomial model of third order was used for the calculations of predictive production trend for the short term of the year 2020 and for long term of the year 2025. These data are presented in the following Figures 2, 3 and 4. Thus, the predictive estimation of fruit trees, grape and citrus production in short term (2-5 year) indicate that production in 2020 will be about 310 000 t/year for fruit trees, 220 000 t/year for grapes and 40 000 t/year for citrus. The estimation of production in long term (6-10 year) indicate that the production in 2025 will be about 370 000 t/year for fruit trees, 240 000 t/year for grape and 56 000 t/year for citrus.

In Table 5 are presented the data for the amounts of processed fruits and grapes and the potential amounts of pomace production for the year 2015.

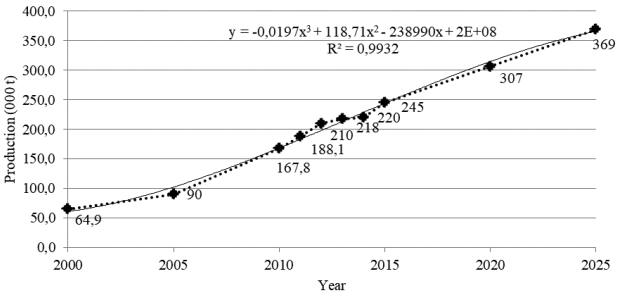

Fig. 2. The predicted trend of fruits production in Albania

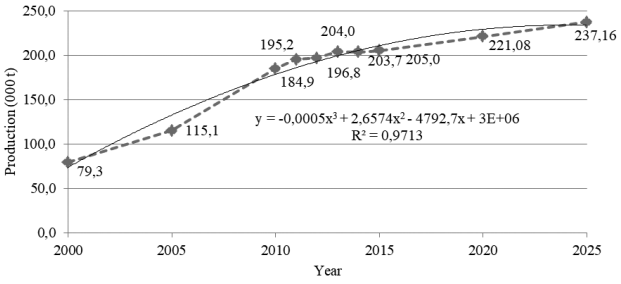

Fig. 3. The predicted trend of grape production in Albania

The data shows that the increase of fruit and grape productions will also increase the amount of processed fruits and grapes. In total the processed fruits are calculated 28 919 t, with the respective residues (pomace) fruits 8676 t and the processed grapes are 115 694 t with their residues about 23 139 t.

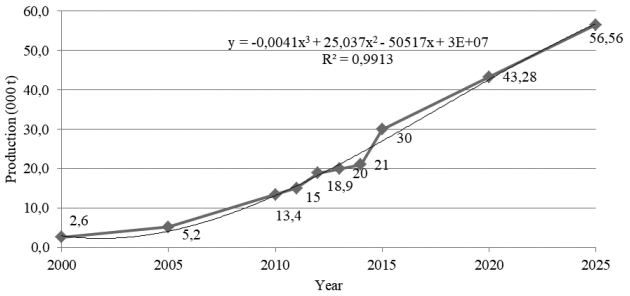

Fig. 4. The predicted trend of citrus production in Albania

The residues of fruits and grapes can be used as renewable energy source. Based on these data, are calculated the potential of produced residues and are estimated the potential of bio-energy production by fruit and grape pomaces. These results are presented in Table 6. Based on the scenario of the productions from year 2015 to 2025, it is analysed that fruit pomace will increase from 8676 t to 52 000 t in 2025 and grape pomace will increase from 23 140 t in 2015 to 31 000 t in 2025. The potential energy generated from pomace fruit ranges from156 164 *Gigajoule* (GJ) (or 43.4 GWh) to 832 000 GJ (or 231.1 GWh). The energy generated from grapes pomace ranges from 393 361 GJ (or 109.3 GWh) to 527 000 GJ (or 146.4GWh).

In Table 7 are presented the calculated data on the potential of bio-energy production, based on the quantities and categories of trees and the total biomass. The total potential energy produced by pruned trees biomass in Albania is about 484.5 GWh

Table 5. Production of residues (waste) from fruit and grape processing of the year 2015

No.	Region	Quantity (t)			
		Processed fruits	The residues (pomace) fruits	Processed grapes	The residues (pomace) grapes
1	Berat	4881	1464	15 893	3179
2	Diber	4665	1399	5623	1125
3	Durres	3221	966	9019	1804
4	Elbasan	3279	984	16 528	3306
5	Fier	2513	754	18 816	3763
6	Gjirokaster	228	69	8240	1648
7	Korce	5706	1712	6419	1284
8	Kukes	532	160	3229	646
9	Lezhe	420	126	4141	828
10	Shkoder	2095	629	6487	1297
11	Tirane	1081	324	5361	1072
12	Vlore	298	89	15 938	3188
Total		28 919	8676	115 694	23 140

Source: Ministry of Agriculture and Rural Development

Table 6. Potential of bio-energy production from fruit and grape pomaces

	Fruit pomace (t)	Potential Energy (GJ)	Grape pomace (t)	Potential Energy (GJ)
Total, year 2015	8676	156 164 (3730 toe* or43.4 GWh)	23,140	393 361 (9395 toe or 109.3 GWh)
Predicted, year 2020	30 000	480 000 (11465 toe or 133.3GWh)	27,000	459 000 (10963 toe or 127.5GWh)
Predicted, year 2025	52 000	832 000 (19872 toe or 231.1GWh)	31,000	527 000 (12587 toe or 146.4GWh)

*t of oil equivalent (https://www.iea.org/statistics/resources/unitconverter)

Table 7. Total number of trees and potential of bio-energy production

			Total tree	Total biomass (t)	Potential Energy (GJ)	Total Potential Energy (GJ)
Tree number (000) or Ha vineyards	Fruit trees		12 405.29	54 723.01	875 568	1 744 146 (41 658 toe or 484.5 GWh)
	Plant group species	Fruit seed	4933.63	22 201.34	355 221	
		Stone fruit tree	4216.34	21 081.70	337 307	
		Subtropical tree	1518.35	5314.24	85 028	
		Berries tree	107.94	269.86	4318	
		Nuts tree	1320.40	4621.40	73 942	
		Other fruits	308.62	1234.48	19 752	
	Citrus		1281.62	3204.05	51 265	
	Grapevine	Vineyards	10 438.19	44 362.31	709 797	
		Pergola	6 108 891	6719.78	107 516	

Discussion

The calculated potential of energy production from biomass is considerable and this fact should serve to stimulate the scientific research studies in this area. The increases of agricultural production in Albania lead to the formation of large residues which in turn can be used for energy production. Currently the use of agricultural residue for energy production is limited but it has a great potential for the future. At the other hand, the trend of fruit trees, grape and citrus production in Albania is increasing from year to year with an approximate amount of 15 000t/year for fruit tree, 4000t/year for grape and 3000 t/year for citrus. Furthermore, based on the potential of available agricultural areas that can be planted with fruit trees, grapes and citrus trees in Albania the predictive estimations are even more promising. The calculation of predictive production trend in short and long term in Albania, are based on actual production trends, potential of available surface areas for new plantation, the intensification of applied technology of plant production and the potential of agricultural farms to increase production and plant yield.

Produced fruits can be fresh consumed, exported and processed in agro-industries. The part that is processed varies according to presence of agro processing lines in different regions of Albania and type of fruit species. Only a small amount of fruit production, about 10-20% is processed in Albania. This amount is low compared to the processing potential and farmer interest for increasing the economic value of fruits. The main activities of agro processing lines are on wine and raki production and on fruits, vegetables and olives processing. A part of fruits and grapes production are processed in home conditions by producers or farmers. The increase of fruit production will lead to the increase of processing amounts; therefore, will increase the amount of formed residues during processing steps.

The stone fruits such as plum, cherry and peach are processed more than the other fruits in different regions of Albania. The processing of stone fruits is related with the formation of residues that can be used as biomass for energy production. The citrus fruits are not actually processed in Albania, but the processing of citrus fruit can be developed in the future as the production of citrus will increase up to 85% in the year 2025 compare to the year 2015. The processing of grapes in Albania varies from 50 to 70% of the production. Grapes processing is related mainly to the production of wine and raki. During the process of wine and raki production a considerable amount of residues is produced. These residues can be further processed (in pomace form) and used as biomass source for energy production. Fresh fruit pomace contains usually 15-30% of dry matter (DM) and pressed pomace 30-40% DM.

Based on the predictive amounts the processed fruit in the year 2020 will reach up to 75000 for 25% of production and in the year 2025 will be about 130000 t or 35% of production. The use of fruit trees, citrus and grape biomass for bio-energy production include the use of fruit processing waste or fruit pomace and also the use of pruned trees biomass for heating or energy production. The residues of fruits and grapes can be used as renewable energy source and the fraction of residues that remains after juice processing ranges from approximately 15% for grapes to 50% for citrus (Oreopoulou & Tzia, 2007; Harald et al., 2015).

Pellets production from fruit and grape processing residues represents a great opportunity for bio-energy production. Thus, in Albania there is a potential on using the waste of processed fruits, vegetables, citrus, grapes, etc., due to the increasing productions from year to year. The produced energy from fruit pomace varies from type of fruit, thus the reported data in literature indicate that apple pomace has an energy value from 17 to 19 Megajoule (MJ)·kg^{-1}, whereas stone fruit as plum or cherry pomaces have higher energy value from 20 to 22 MJ·kg^{-1} (Wojdalski et al., 2016). Furthermore, according to Burg et al. (2016), grape pomace produces energy with a calorific value about 16-19 MJ kg^{-1}, thus, grapevine processing can be considered as a significant source of biomass**.** In addition, the energy production from pruned biomass reported by Bilandzija et al. (2012) varies in average values from 15 to 18 MJ/kg. Based on reported data in literature on calorific value are calculated the potential of bio-energy production from fruit and grape pomace (Table 6) and potential of bio-energy production from pruned tree biomass (Table 7) showing the great potential of bio-energy production in Albania.

Conclusions

The use of agricultural biomass mainly from fruit trees and grapes represents an important source for bio-energy production in Albania.

The data showed that an amount of 156 164 GJ or 43.4 GWh can be produced by fruit pomace; 393 361 GJ or 109.3 GWh from grape pomace and 1 744 146 GJ or 484.5 GWh from pruned biomass of fruit trees, citrus trees and grapes. Thus, a total of about 637.2 GWh bio-energy can be produced annually from using of processing waste and pruned biomass of fruit trees, citrus trees and grapes in Albania.

Acknowledgments

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