Identification and characterization of organic waste in Morocco, an important step towards the valorization of waste

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Abstract

The introduction of new valorization and bioconversion techniques of organic waste in Morocco is a lever for a promising bio-economy able to exploit all available resources of the country including waste. The success of these techniques is first conditioned by the perfect knowledge of the characteristics of the available biomass potential. Thus, this research is particularly interested in the identification and characterization of organic waste at the national level for eventual bioconversion to other products with added value such as bioethanol, lactic acid, amino acids, proteins and fertilizers. The identification of these biological materials has been established by making a state-of-the-art on different researches, studies and statistics to estimate the potential volume at the national level and especially those generated by agriculture and agrifood industry. The determination of the chemical composition of biomass was carried for the nine most important biomaterials in the country in terms of quantitative and qualitative potential. After evaluating the various production sectors, it has been estimated global potential of organic waste at approximately 60 million tons produced annually across Morocco, with 92% of agricultural wastes. A share of this biomass is currently marketed as inputs in the agricultural sector;while other residues have no economic value and are disposed of to landfill or incineration. The results of chemical characterization of the 9 samples studied have identified two types of biomass: sugar based feedstock and nutrient based feedstock including the estimated yield for bioethanol, biogas, lactic acid and fertilizer. These results show that organic wastes available in Morocco are well adapted to transformation process to produce value added bio-based products.

Keywords: Organic waste, valorization, bioconversion, environmental impact, energy, bio-economy, Morocco.

Résumé

L'introduction de nouvelles techniques de valorisation et de bioconversion de déchets organiques au Maroc est un levier pour une bio-économie prometteuse en mesure d'exploiter toutes les ressources disponibles du pays y compris les déchets. Le succès de ces techniques est d'abord conditionnée par la parfaite connaissance des caractéristiques du potentiel de la biomasse disponible. Ainsi, cette recherche s'est particulièrement intéressée à l'identification et à la caractérisation des déchets organiques à l'échelle nationale pour bioconversion éventuelle à d'autres produits à valeur ajoutée tels que le bioéthanol, l'acide lactique, des acides aminés, les protéines et les engrais. L'identification de ces matériaux biologiques a été mise en place en faisant un état de l'art sur les différentes recherches, études et statistiques pour estimer le volume potentiel au niveau national et en particulier ceux générés par l'industrie agro-alimentaire et l'agriculture. La détermination de la composition chimique de la biomasse a été effectuée pour les neuf biomatériaux les plus importants du pays en termes de potentiel quantitatif et qualitatif. Après avoir évalué les différents secteurs de production, il a été estimé qu'un potentiel global des déchets organiques est de l'ordre de 60 millions de tonnes produites chaque année à travers le Maroc, avec 92% des déchets agricoles. Une part de cette biomasse est actuellement commercialisée comme intrants dans le secteur agricole, tandis que d'autres résidus n'ont aucune valeur économique et sont mis en décharge ou incinérés. Les résultats de la caractérisation chimique des 9 échantillons étudiés ont identifié deux types de biomasse: matières premières à base de sucre et celles à base et d'éléments nutritifs y compris le rendement estimé pour le bioéthanol, le biogaz, l'acide lactique et l'engrais. Ces résultats montrent que les déchets organiques disponibles au Maroc sont bien adaptés aux processus de transformation pour produire des produits à haute valeur ajoutée.

Mots-clés: Déchets organiques, valorisation, bioconversion, impact sur l'environnement, énergie, bio-économie, Maroc.

INTRODUCTION

Morocco has a large deposit of waste generated by different sectors of production and service. According to statistics from the Moroccan Department of Environment, domestic waste production reached 6.5 million tons of household waste in 2012 (Memwe, 2012). Concerning waste generated by the industrial sector, the latest estimates indicate a national production of about 1.6 million tons of waste (Ajir, 2009). However, the organic wastes generated by agricultural sector and food industry have never been subjected to specific studies or statistics to assess their quantity.

Despite the fact that organic wastes are full of enormous potential, their use is currently very limited. Indeed, the development projects in the field of waste management have so far concerned only the treatment of household

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waste in urban areas and are lacking specific environmental policies for organic wastes management.

Some experiences in recovery of organic waste have emerged in Morocco to assess the feasibility of setting up channels for bioconversion. Some pilot composting units were setup on a small and large scale. In most cases, these units encountered blockages of various kinds which hindered the development of this sector in Morocco (MEMEE, 2003). Also, some biogas units were tested using Chinese systems in rural areas, but without success because of insufficient technical monitoring facilities and incentive measures.

Currently, Morocco has launched several strategies and programs that fall within the framework of sustainable development which are aimed to preserve the country's natural resources. In this context, the establishment of waste valorization projects could be the first step towards a bio-based economy capable of exploiting all available bioresources. These bioresources correspond to all exploitable biological resources across the country including the organic waste.

In this sense, it is important to differentiate between two types of organic waste which are «Bio-residues» (corresponding to bio-resource with significant value) and «Biowaste» (without or with only a nominal economic value). Thus, the term of «Biowaste» cannot be applied to all organic waste. The concept of biowaste is rather well defined in some specific contexts. For example in the European Union waste directive, the definition states*:" bio-waste means biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises and comparable waste from food processing plants"* (European Parliament 2008). In this work, we will consider organic waste with its two types: bio-residues and biowastes.

In Morocco, the organic waste is generated mainly from two sectors

- Agricultural sector: crop residues, pruning residues from trees, manure, roots.... etc.

- Agro-industrial sector: by-products of agricultural products transformation such as bagasse and molasses (from sugar refining), margines and pomace (from olive crushing), oilcake (from soybean and sunflower processing)... etc.

The chemical composition of this waste varies according to the nature of biomass and the conditions of production. Thus, their valorization process could not be done by the same techniques; hence the characterization for categorization of these waste materials is needed to adapt each bioconversion process with the suitable biomass (Gustavsson *et al*, 2014).

In this research project, we considered two categories of biomass, based on chemical composition: sugar based feedstock and nutrient-based feedstock. The first category of biomass can be used as feedstocks of bioconversion for the production of ethanol, lactic acid, proteins and amino acids. The second is more adapted with biogas processes and fertilizer production (Gustavsson *et al*, 2014).

Other than the chemical composition, different factors should be considered in the choice of the best bioresource to recover. Indeed, the availability of biomass during the year, its current economic value and the annual volume are all important factors to ensure continuation of the upgrading process set up in a given region.

MATERIALS AND METHODS

Estimation of global potential of organic waste in Morocco

The estimated amount of organic waste at the national level was carried out by focusing on the four steps that constitute the life cycle of biomass (Figure 1). Thus, the information collected for the identification of organic waste will cover the following levels:

- Production of biomass (Agriculture)

- Processing

- Use

- End of life

For each of these four steps, a detailed inventory was made based on the information and statistics collected at public organizations. In case of no available data, approximation methods were used to assess the potential quantities of certain wastes. These methods were applied especially for characterization of agricultural wastes, given their nature and their economic value. Thus, the estimation methods applied are as follows:

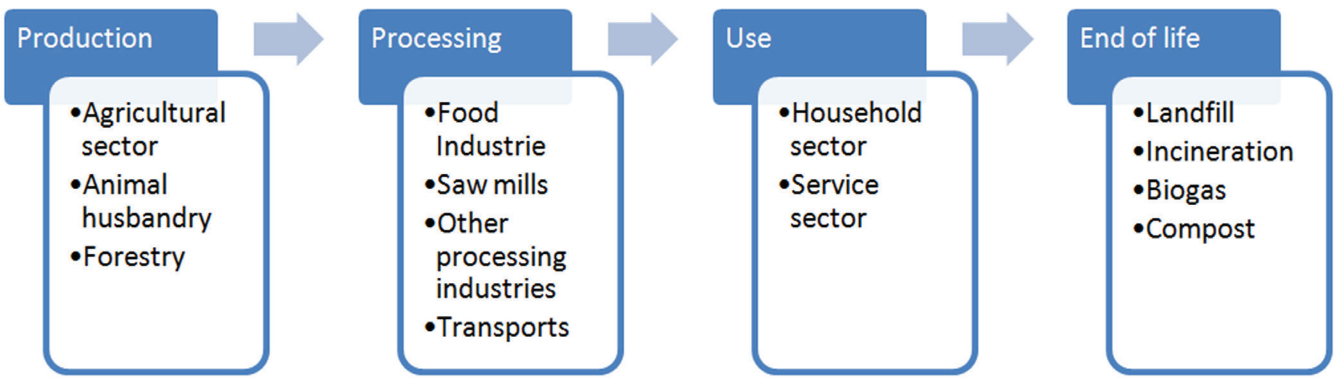

Figure 1: Schema of life cycle stages of organic waste

- Use of ratios to calculate the quantities of fresh organic matter after harvesting according to studies carried out in Morocco;

- Use of ratios from FAO data and statistics for production coefficients of crop residues in the world;

- The means of animal manure production according to the works of Corpon (Corpon, 1988) to estimate manure quantities.

The established inventory includes the key features of current management for each waste as follows:

- Quantity produced annually;

- Composition description of biowaste/bioresidue;

- Current use;

- Economic value;

- Environmental and socio-economic impact.

Short-listing of feedstock

After the establishment of the inventory that contains the characteristics of different organic wastes identified in Morocco, a second stage of short-listing was made in the aim of selection the most important biowastes and bioresidues in terms of valorization potential at the national level. These selected wastes will be object of sampling and chemical analysis according to the protocols described below.

Methods for sampling and preparation of samples

Nine samples selected after short-listing were collected from several regions of Morocco. The sampling of these bioresources was operated according to a protocol established in the framework of *Biowaste 4 Sp* project. All samples were done according to the protocol that included the following steps (Sundqvist *et al.,* 2013):

1. Identification of feedstock that should be tested and analyzed;

2. Take a set of primary samples from the identified biomass (covering randomly different parts of the total volume to be sampled);

3. Mix these primary samples;

4. Use coning and quartering method to reduce the volume of the mixed primary samples. Reduce the mixed samples to about 10 kg (Figure 2);

5. Have the sample dried in 60°C. Particle size may be reduced in order to dry the sample, but no parts should be removed from the sample. The sample is dry when the weight of the sample is not reduced more between periods of time in the oven (<10%);

6. The sample particle size is milled to a size of <1 mm;

7. Sample is labeled and packed in sealed black plastic bags for storage.

Figure 2: Coning and quartering in progress as part of the process of creating a final sample. The biomass here is cattle manure

The sampling procedure and preparation of sample was documented in a template that included information on site and contact details, as well as details from completing the steps in the sample procedure.

Methods for characterization of the biomass sampled

The chemical characterization of the samples was also based on prepared protocols.

Dry Matter content determination

Dry Matter content (DM) of the prepared samples were measured according to the protocol A0001 from Enzyme Lab of DTI (Denmark) by weighing the samples before and after overnight drying in oven at 105 °C.

Ash content determination

Ash content of samples were measured according to the protocol A0002 from Enzyme Lab of DTI (Denmark) by weighing the samples before and after ashing at 550 °C for two hours in Muffle Furnace.

Carbohydrate content characterization

The Carbohydrate composition of samples were determined following the protocol A0003 from Enzyme Lab of DTI (Denmark). It consists of releasing the monomer sugars by two steps acid hydrolysis and quantifying the released sugars by HPLC analysis. Samples were first made soluble in 72% (w/w) H_2SO_4 at 30°C for 60 minutes and then hydrolyzed in 4% (w/w) H_2SO_4 at 121°C for 60 minutes. Klason lignin contents were measured as the ash free residue contents after hydrolysis. The released monosacharaides were quantified by high performance liquid chromatography (HPLC) system using refractive index detector equipped with an Aminex HPX-87H column (Bio-Rad Laboratories Ltd., USA) running at 63°C with 4 mM H_2SO_4 as eluent with a flow rate of 0.6 ml/min.

RESULTS AND DISCUSSION

Estimated production of organic waste

According to this study, the agricultural sector in Morocco generates a large amount of organic waste which is about 55 million tons. This estimate is based on ratios of residues production per hectare from previous studies and research findings of FAO. It is noted that these ratios depend on many factors and may change depending on edaphic-climatic conditions and cultural practices. Indeed, a study conducted in 2003, led to an estimate of crop residues in Morocco of 67 million tons (Rafrafi and Kabil, 2003).

The biomass produced by the vegetal sector totaled an annual amount of 19 million tons (Table 1). This biomass consists mainly of residues of cultivated plants (leaves, stems, and roots) left in the fields after harvesting.

Cereals are the most crops exporting residues with a ratio of about 2.5 ton/ha. They constitute 69% of crop residues production in Morocco (Figure 3). A large part of crop residues are collected after harvest as bale.

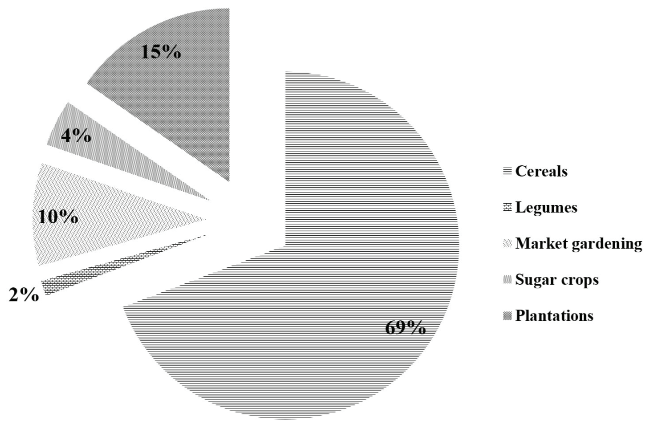

Figure 3. Distribution of the estimated production of crop residues in Morocco in 2013.

Plantations and vegetable crops also export considerable quantities of residues with production ratio respectively of 3.4 ton/ha and 6.8 ton/ha.

Livestock sector is the agricultural sector that generates the most organic waste with an annual production of 35.7 million tons of manure (Table 2). It should be noted that the estimate of manure quantities produced was established on the basis of the assumption that only the manure produced during the stay in the barn are recoverable with an average in the barn of 12 hours on 24 hours.

Table 2: Distribution of manure production by type of farming (Bartali and Belmakki, 2013)

Animal	Manure production (1000 ton/year)
Cattle	15 539
Sheep	6 590
Goat	3 349
Chicken	1 506
Equines	6 322
Camels	2 435
Total	35 741

Different transformation process of agri-food sector generates bioresidues with a total volume of 1 million tons (Table 3). In many cases, these bioresidues are considered as by-product and not as waste; it is the case of dry beet pulp, bagasse and molasses for the sugar industries.

Table 3: Production of organic waste from food industries in Morocco (Bartali and Belmakki, 2013)

Type of industry	Organic waste production (1000 ton/year)
Sugar industry	657
Cereal processing	47
Edible oil industry	368
Fish cannery	13
Total	1 085

In terms of service sector, national statistics on household waste collection in urban areas consider an annual volume of 4 million tons corresponding to the biodegradable fraction of municipal waste. In addition to these biomaterials, the sludge generated by sewage treatment plants is also a source of biomass with an annual output of 333,340 tons.

Table 1: Production of crop residues by crop type in Morocco (Bartali and Belmakki, 2013)

Type of culture	Area (1000 ha)	Main product (1000 ton)	Crop residues (1000 ton)
Cereals	5 329	10 440	13 184
Legumes	377	275	275
Market gardening	267	7 300	1 825
Sugar crops	62	3 479	830
Plantations	860	2 435	2 927
Total	6 895	23 929	19 041

Therefore, and according to the estimates in this study, the overall potential source of organic waste is around 60 million tons per year produced by the sectors studied. Agricultural biomass has the largest share which stands at 92% of total volume.

The Moroccan production of organic waste is estimated at 1.57 ton/inhabitant/year compared to 0.17 ton/inhabitant/year for household waste. Hence the interests that the waste management policy should not be limited to household waste and should also include specific strategies for organic waste for more efficient use of this resource.

Current management of organic waste

In general, crop residues (green or dry) are often exported outside the fields for livestock feed or as fertilizer soil material. Indeed, the residues of cereals, mainly straw, are in high demand by farmers to satisfy the needs of livestock in dietary fiber. However, residues of legumes and vegetable crops can be used as fertilizer to improve the soil structure. This latter choice of use is favored by humid conditions and warm temperatures of irrigated land by fostering residues mineralization and degradation of the soil content in organic matter.

According to the results of this study, 65% of the mass of crop residues is marketed in domestic market. These are mainly wheat straw and barley straw. The rest of these crop residues are not sold but they play an important role in the agricultural production process.

Manure is mainly used for soil fertilization. The manure quality differs depending on animal, diet and treatment efficiency. Its marketing is not organized and is in uncontrolled circuits. Thus, statistics on sales and selling prices are quite variable and non-official (FAO, 2006).

Organic waste from the agro-industrial sector are byproducts of processing that can be used to feed livestock including dry beet pulp, sunflower meal, molasses, wheat bran, ... Etc. Others are used as fuel to produce energy namely olive pomace and bagasse. These by-products often have economic value and are marketed nationally.

As for organic household waste and sewage sludge, it should be noted that the only mode of their management is their disposal in landfills in urban periphery.

Thus, the organic waste in Morocco can be divided into biowastes with no value or use at present and bioresidues with an economic value to the operators of the process. The use of organic waste valorization methods can be applied even to the second type of biomass corresponding to the residues economically valuable. There are often ways of improving the processes and find new options for final added value products. This is also seen in many of the cases studied.

Results of organic waste characterization analysis

The characterization of organic waste has been evaluated, in the context of this study, by the realization of laboratory analysis for determination of their composition. Given the large number of organic wastes, a short-listing was made to retain the main potential waste across Morocco. Thus, biomasses having been selected for their characterization are as follows:

- Banana crop residues,
- Corn crop residues,
- Faba-bean crop residues,
- Sugarcane crop residues,
- Cattle manure,
- Dried beet pulp,
- Olive pomace,
- Tomato pulp,
- Orange pulp.

Table 4 shows the characterization results of all samples. High ash content indicates that there are nutrients in the sample. Nutrients here mean all inorganic components such as mineral elements (K, Ca, S, Fe, Cu, etc ...) and also organic components other than sugars including proteins, lipids and vitamins.

The ash content parameter was considered as indicator to the nutrient content because it measures the percentage of inorganic elements, in which some can also be part of the constituent of organic nutrients such as nitrogen for protein and sulfur for lipids.

The categorization of the samples in the "Nutrient rich" column was done based on the following principle; below 2.5 no cross, 2.5-8 ash 'x', 8-12 ash 'xx' and 12-above is assigned 'xxx' (Gustavsson *et al.,* 2014).

Glucose content is more or less the sum of the content of starch and cellulose and has been used to assess the sugar richness of the feedstock.

Sugars are divided into "simple sugars", "starch rich" and "lignocellulosic". The first two categories here are typically associated with first generation biofuel technologies, while "lignocellulosic" sugars typically require second generation technologies to be utilized to access the sugars (see for example Luque *et al.,* 2008). Hence, with today's technology, feedstock that is rich in starch or simple sugars will be easier to convert to added value products than feedstock rich in lignocellulosic materials (Gustavsson *et al.,* 2014).

Sugar rich feedstock

Sugar rich feedstocks category are organic waste with low ash content (indicating low levels of nutrients) and high glucose content. Many of these feedstocks are the result of processing or treatment in industrial processes such as orange pulp from the processing of oranges for juice production. Thus, it is apparent from table 4 that feedstock considered as rich sugar are: corn crop residues, faba bean crop residues, sugarcane crop residues, dried beet pulp, olive pomace, tomato pulp and orange pulp.

Nutrient rich feedstock

The nutrient rich feedstocks category corresponds to organic waste with high ash content (indicating high levels of nutrients) and with varied degrees of sugars. Generally, these nutrient rich feedstocks are frequently used as soil

Table 4: Characterization results of potential organic waste in Morocco.

Sugar rich feedstock	Dry matter (DM) (%)	Ash content (%)	Glucose Content (% of DM)	Xylose Content (% of DM)	Arabinose Content (% of DM)	Klason Lignin Content (% of DM)	Non cell wall material Content (% of DM)	Sugars			Nutrient rich **
								Rich in simple sugars	Starch rich	Ligno cellulosic *	
Crop residues of sugarcane	94.24	6.26	35.68	20.61	2.81	21.72	12.92	x		xxx	x
Crop residues of maize	94.97	5.32	34.21	17.51	3.01	21.3	18.65			xxx	x
Dried beet pulp	88.54	5.23	24.51	7.99	16.25	16	30.02	x		xxx	x
Orange pulp	90.3	4.17	18.53	9.03	6.71	18.47	43.09	x	x	xx	x
Crop residues of faba bean	96.06	4.63	16.75	9.33	3.97	15.01	50.31			xxx	x
Tomato pulp	95.18	4.09	15.1	8.47	5.29	22.43	44.62	x		xxx	x
Pomace from oil processing	94.3	2.26	15.75	10.49	5.8	27.56	38.14	x	x	xx	
Cattle manure	93.88	20.02	27.61	18.06	2.51	24.14	7.66			x	xxx
Crop residues of banana	94.29	14.69	19	14.69	3.53	24.17	23.92			xxx	xxx

** Sugars have been classified based on the content of glucose (lignocellulosic is given crosses according to 10-15 glucose 'x', 15-30 is 'xx' and 30-45 is 'xxx' and 45-above is 'xxxx')*

*** Nutrients are seen in the ash content and the following thresholds have been used to assign numbers of crosses: below 2.5 no cross, 2.5-8 ash 'x', 8-12 ash 'xx' and 12-above is assigned 'xxx'.*

fertilizers. Two feedstocks were identified in this category i.e. crop residues of banana and cattle manure. Thus, the results of ash of these two biomasses were given high values which are 15% and 20% respectively of banana crop residues and cattle manure.

Other research work confirms the categorization of these two biomaterials as nutrient rich. Indeed, crop residues of banana can give high ash content between 12% to 27% with protein content about 2% to 8% (Olivera *et al.*, 2007). Similarly, the cattle manure is a bioresource rich in nutrients especially minerals which can be in significant content relative to dry matter of manure as follows: 5% nitrogen, 2.5% phosphorus, 5% of potassium and 4% calcium (FAO, 2006).

Valorization potential of nutrient and sugar rich feedstock

Depending on the nature of organic waste, rich in sugar or nutrient, its use as feedstock in the upgrading process can be performed with different techniques to produce various added value product. A simplified framework is found in figure 4 showing the feedstock and possible categories of value added products.

From figure 4, it's noted that increase in retail price per volume of products depends on organic waste input and the added-value of derived products. Pharmaceuticals will hold a high value per volume while bulk chemicals and energy carriers have a relatively lower value per unit etc (Gustavsson *et al,* 2014).

Valorization of nutrient rich feedstock

In the context of Morocco, biogas production by anaerobic digestion process of nutrient waste will be a very interesting solution given that Morocco's energy needs are satisfied by imports of petroleum products. This solution may be effective especially for nutrient rich feedstock. Indeed, the Moroccan potential volumes of biogas production from nutrients rich feedstcok retained in this study totaled 1,165,000 m^3 of CH_4 for cattle manure and 4,536 m^3 of CH_4 for banana crop residues (Table 5).

The valorization of this type of biomass could participate in the satisfaction of the country's energy needs. A ton of nutrient waste such as cattle manure can provide 48 Kwh of electricity corresponding to a global production of 746 GWh if we consider the entire quantity of cattle manure produced annually in Morocco.

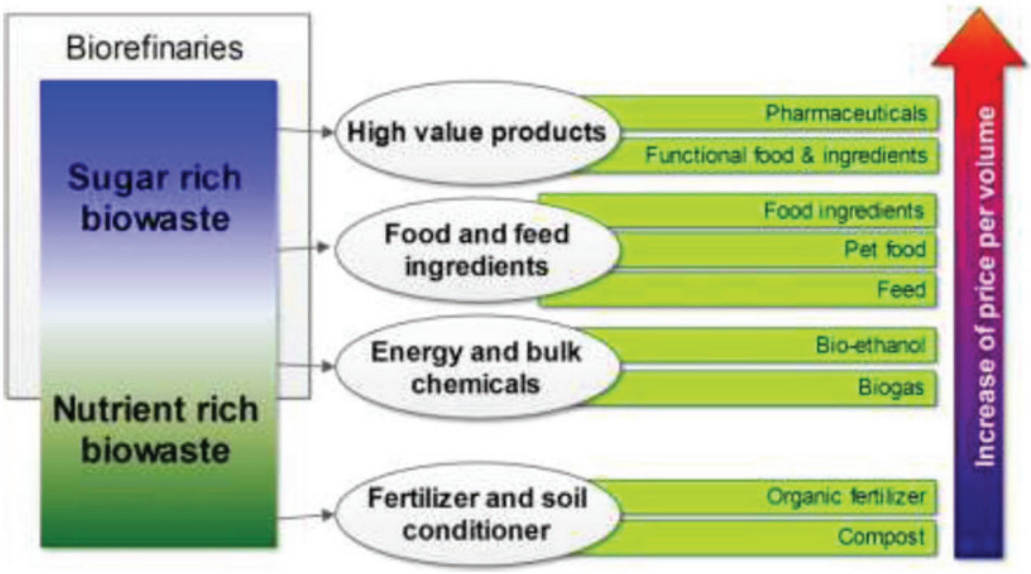

Figure 4: Framework of nutrient and sugar rich feedstock and examples of their respective products **(Gustavsson et al, 2014)**

Table 5: Potential production of biogas and fertilizer from nutrient feedstock: Cattle manure and Banana crop residues.

Biomass	Potential Production (1000 ton/ year)	Dry Matter (% DM)	Ratio of biogas production (*) (m^3 of CH_4/ kg of DM substrate)	Ratio of biofertilizer (g/g substrate)	Potential production of value added product	
					Biogas (m^3 of CH_4)	Fertilizer (1000 ton)
Crop residues of banana	56,7	20	0,40	0,50	4 536	28
Cattle manure	15 540	30	0,25	0,50	1 165 500	7 770

(*): Ratio of biogas production from biomass (Teodorita et al, 2013)

Furthermore, the nutrients may also be used for fertilizers production. In our case, the potential production of fertilizers can reach to 28,000 tons and 7,770,000 tons respectively for banana crop residues and cattle manure (Table 5).These estimates were calculated by considering composting with products weigh 50% lower than substrate. This reduction was mainly due to loss of water and carbon and also to loss of nutrients by volatilization (Agricultural Chamber of Lozère, 2012).

Organic high quality fertilizers and soil conditioners will have a high value and have a market also locally as it can result in improved yields in the agricultural practices. In many cases the effluent or waste from production of other value added products can be used in production of organic fertilizers and soil conditioners in a second stage. This is for example the case in biogas processes, where the biogas is one product from the primary anaerobic digestion process and the effluent from this process can be used as feedstock in a compost facility. The compost facility will provide organic fertilizer as a by-product in a second process. There are thus chains of value-added products that should be considered when assessing the full potential of utilizing a certain biomass (Gustavsson *et al.,* 2014).

Valorization of sugar rich feedstock

Also, other added value products such as ethanol and lactic acid, which are highly demanded in the chemical industry, can be obtained by bioconversion process of sugar-rich substrates (glucose). Table 6 gives the production yields of ethanol and lactic acid from sugar rich feedstock at the national level.

The estimated productions of these value-added products were based on the theoretical yield of sugars conversions as follows:

- For Ethanol: 0.51 g ethanol/g hexose and 0.51 g ethanol /g pentose,

- For Lactic acid: 1 g lactic acid/g hexose and 0.6 g lactic acid/ /g pentose.

CONCLUSION

The overall potential of organic waste was estimated at about 60 millions tons produced annually across Morocco. Agricultural wastes constitute 92% of this organic resource followed by fermentable household waste, representing 4% of the total biomass.

The current use of these biomaterials differs according to their nature. Crop residues are generally either returned to the field to improve soil structure or given as feed for livestock. However, by-products from processing industry with nutritional value are sold as livestock feed. The rest of industrial waste is put into landfills with other types of organic waste including household waste and sewage sludge.

The characterization of this biomass has shown that it is especially lignocellulosic bioresources. This type of organic waste can be used to produce biogas and fertilizer. The bio-residues containing a high content of glucose will be instead more interesting for the production of value added products such as ethanol and lactic acid.

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Table 6 : Potential production of lactic acid and ethanol from sugar rich feedstock

Biomass	Potential Production (1000 ton/year)	Dry Matter (DM) %	Sugars (g/g of DM)			Potential production of value added product	
			Glucose	Xylose	Arabinose	Ethanol (1000 ton)	Lactic acid (1000 ton)
Crop residues of faba bean	275,0	25,0	16,8	9,3	4,0	10,5	17,0
Crop residues of corn	781,0	30,0	34,2	17,5	3,0	65,4	109,0
Crop residues of Sugarcane	141,0	33,0	35,7	20,6	2,8	14,0	23,1
Orange Pulp	40,0	28,0	18,5	9,0	6,7	2,0	3,1
Tomato Pulp	12,0	26,0	15,1	8,5	5,3	0,5	0,7
Olive Pomace	368,0	30,0	15,8	10,5	5,8	18,0	28,2
Dried beet pulp	166,0	85,0	24,5	24,5	24,5	52,9	76,1

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