HEMP BY-PRODUCT VALORIZATION

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INTRODUCTION

The hemp industry had a big increase in recent years. Multiple reasons and interests created this boom: agricultural diversification; new flourishing markets like food, drinks, oils containing CBD extract; new insulation material for building derived from biomass feedstock with low environmental impact, the extraction of THC and other cannabinoids for pharmaceutical purposes etc. The cultivation of hemp in Italy is having a second golden age, the first started in the late Middle Ages and it ended between WWI and WWII and it was mainly focused on hemp fiber production. Hemp fiber produced in the Emilia Romagna Region, Northern Italy, had an incredible quality recognized all over the world.

Today, agriculture techniques are completely changed from the last century. Also hemp industry followed the recent mechanization in agriculture, but further improvements should be applied to have a sustainable growing from economical and environmental point of views. First of all, depending of the final purposes of the hemp cultivation, several hemp by-products are not well recycled in the farm in a proper way. For example, considering hemp for seeds or CBD extraction, the 90-95% of the plants is not used and left in the field or burned in wildfires. The productivity of the plant is awesome, literature reports an annual productivity in cold climate conditions of about 10 ton per hectare of dry matter and only 5-10% is used for the final products. In many cases this biomass residues can be reused follow the circular economy in the farm.

This paper investigates possible circular economy pathways which can be applied in different hemp agriculture regimes using hemp by-products. Not only open field hemp cultivation but also the case of hemp growing in indoor greenhouses is presented. Several valorization technologies has been applied to achieve economic and environmental advantages for the farmer: composting of green and wet residues, combustion and gasification of hemp stalks and hurds, co-composting of hemp green residues (leafs and branches) and biochar obtained from hemp ligneous residues (stalk and hurd). Every pathways is discussed from the practical point of view and also considering the entire framework including all the stakeholder involved in the process.

MATERIALS AND METHODS

Hemp martek by-products

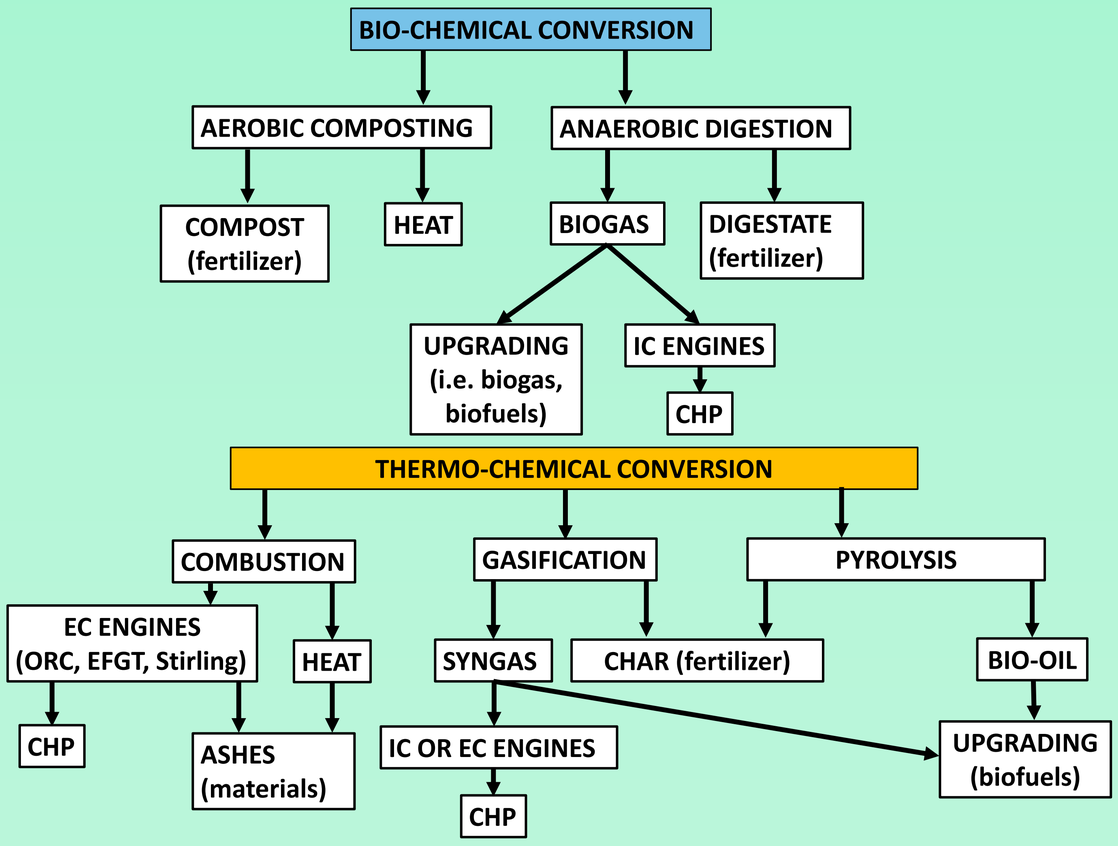
Table 1: Italian hemp markets

Market	Customers sector	Market dimensions	Growing mode	By-product types	By-products use
Hemp fiber	Textile	Big	Outdoor	Hurd, flowers, leaves	Hurd for construction materials, the others are left in the field
Hemp seeds	Food	Small	Outdoor	Stalks, flowers, leaves	Stalks are left in the field, leaves and flowers are disposed as green waste
Hemp flowers for CBD or THC extraction	Pharmaceutical	Medium	Indoor	Stalks, leaves	Disposal as green waste

Figure 1: hemp cultivation for seed production (left); hemp stalks derived from hemp plants cutting (center); hemp flowers and leaves derived from flower-seed separation (right)

Figure 2: hemp hurd from fiber (left); hemp indoor facility for CBD rich flower (right)

Valorization tecnologies



RESULTS AND DISCUSSION

By-products valorizaion results

Table 2: Valorization study for by-products from hemp fiber industry

HEMP FIBER MARKET			
By products type		**Hurd**	
		Prons	**Cons**
By-product use	Construction materials	Existing market	• Low earnings • big volumes required
Alternative by-product use	Combustion	• No fuel pre-processing • Mature technology • Low emissions	• Carbon neutral process • Ashes difficult to dispose or re-use
Alternative by-product use	Gasification	• Negative carbon process • High quality char • Ultra low emissions • Syngas upgrading simple and economics	• Fuel pre-processing (i.e. pellettization) • Maintenance cost • Technology not at commercial stage
Alternative by-product use	Pyrolysis	• No fuel pre-processing • High emissions	• Carbon positive process • Low quality char • Bio-oil processing complex and expensive
By products type		**Flowers, leaves, seeds**	
		Prons	**Cons**
By-product use	Left in the field	• Nutrients to the ground • Easy and economic	• Fermentantion with CH_4 emissions • No revenue
Alternative by-product use	Anaerobic digestion	• Mature technology • Economical efficient • Low maintenance	• High cost of investment • Big volumes required • Need of other biomasses to balance the digestor recipe • Digestate difficult to re-use in the field
Alternative by-product use	Aerobic composting	• Easy process • Mix with other residual biomasses accepted	• Low revenues • Big area required • Slow process, however char from gasification and pyrolysis can be used to faster the reaction (COMBI)

Table 3: Valorization study for by-products from hemp seed industry

HEMP SEEDS MARKET			
By products type		**Stalks**	
		Prons	**Cons**
By-product use	Left in the field	• Nutrients to the ground • Easy and economic	• Fermantantion with CH_4 emissions • No revenue
Alternative by-product use	Combustion	• Easy fuel pre-processing • Mature technology • Low emissions	• Carbon neutral process • Ashes difficult to dispose or re-use
Alternative by-product use	Gasification	• Negative carbon process • High quality char • Ultra low emissions • Syngas upgrading simple and economics	• Hard fuel pre-processing (i.e. pellettization) • Maintenance cost • Technology not at commercial stage
Alternative by-product use	Pyrolysis	• Easy fuel pre-processing • High emissions	• Carbon positive process • Low quality char • Bio-oil processing complex and expensive
By products type	**Flowers, leaves**		
		Prons	**Cons**
By-product use	Green waste disposal	Easy process	• Cost of disposal
Alternative by-product use	Anaerobic digestion	• Mature technology • Economical efficient • Low maintenance	• High cost of investment • Big volumes required • Need of other biomasses to balance the digestor recipe • Digestate difficult to re-use in the field
Alternative by-product use	Aerobic composting	• Easy process • Mix with other residual biomasses accepted	• Low revenues • Big area required • Slow process, however char from gasification and pyrolysis can be used to faster the reaction (COMBI)

Table 4: Valorization study for by-products from hemp industry for flower for CBD and THC

HEMP FLOWERS MARKET			
By products type		**Stalks**	
		Prons	**Cons**
By-product use	Green waste disposal	• Easy process	• Cost of disposal (special waste)
Alternative by-product use	Combustion	• Easy fuel pre-processing • Mature technology • Low emissions	• Carbon neutral process • Ashes difficult to dispose or re-use
Alternative by-product use	Gasification	• Negative carbon process • High quality char • Ultra low emissions • Syngas upgrading simple and economics	• Hard fuel pre-processing (i.e. pellettization) • Maintenance cost • Technology not at commercial stage
Alternative by-product use	Pyrolysis	• Easy fuel pre-processing • High emissions	• Carbon positive process • Low quality char • Bio-oil processing complex and expensive
By products type	**Leaves**		
		Prons	**Cons**
By-product use	Green waste disposal	• Easy process	• Cost of disposal (special waste)
Alternative by-product use	Anaerobic digestion	• Mature technology • Economical efficient • Low maintenance	• High cost of investment • Big volumes required • Need of other biomasses to balance the digestor recipe • Digestate difficult to re-use in the field
Alternative by-product use	Aerobic composting	• Easy process • Mix with other residual biomasses accepted	• Low revenues • Big area required • Slow process, however char from gasification and pyrolysis can be used to faster the reaction (COMBI)