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Special issue: Opportunities and challenges of EU farm-to-fork strategy

Operationalizing circular economy. Reflections on a by-product upcycling value chain construction in the brewing sector

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Table S1. Summary of the interviews carried out for this study.

	Date	Durée	Ca	Fr	Script	Urban	Rural	Semi	Resto
3 Brasseurs CA	29-mai-19	22'56"	●		●	●			●
3 brasseurs Nantes	12-sept-19	56'12"		●				●	●
9 Mondes	30-juil-19	34'22"		●	●			●	
Alafût	31-mai-19	29'26"	●		●		●		●
AMBQ	30-mai-19	54'04"	●		●				
Baribale	19-juin-19	44'23"		●	●	●			
Beaux Prés	21-mai-19	14'01"	●		●		●		●
Bellechasse	31-mai-19	31'09"	●		●		●		●
Boswell	28-mai-19	40'45"	●		●	●			●
Bouffay	25-juin-19	1h02'33"		●	●			●	
Brassés	24-juin-19	47'28"		●	●	●			●
Brewmakers	01-août-19	23'56"		●	●			●	
Bubar	18-juin-19	30'44"		●	●	●			
Charlotte	26-juin-19	35'34"		●	●	●			
Copo	03-août-19	14'07"		●	●			●	
Emporium	21-mai-19	47'56"	●		●	●			●
Griendel	21-mai-19	26'48"	●		●	●			●
Hold hop	01-août-19	24'47"		●				●	
Ile d'Orléans	31-mai-19	48'05"	●				●		●
La Conviviale	21-juin-19	1h03'01"		●	●		●		
Ma Brasserie	24-mai-19	27'03"	●		●	●			●
Normandy beer factory	30-juil-19	25'26"		●	●			●	
Réservoir	27-mai-19	21'58	●		●	●			●
Sœurs grises	27-mai-19	19'29"	●		●	●			●
Tête haute	26-juin-19	45'08"		●	●		●		
Trompe souris	26-juin-19	1h03'05"		●	●		●		
	3 months	**37'**	**46%**	**54%**	**88%**	**42%**	**27%**	**27%**	**50%**

Table S2. Value proposition of a circular valorization of brewer's spent grain.

<table>
<tr>
<th>Key partners</th>
<th>Key activities</th>
<th>Value proposition</th>
<th>Customer relationships</th>
<th>Customer segments</th>
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The state and its institutions (e.g. the region) that support the project (financial, budgetary, cognitive support)
Research institutes that help optimize processes (for example, heating)
Individual shareholders following a participatory fundraising
Downstream production value chain (in particular, producers and logistics companies) because the construction of a sector requires a strong commitment to cooperation

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Spent grain production
Distribution of spent grain in a local network
Production of food formulated with spent grain (breads, cookies, granola, flour, etc.)

Key resources

Brewing cereals (including phytosanitary products)
Physical flows supplying production sites (energy, water)
Labor: brewers and workers in collection and processing companies
Infrastructure and transport fleet

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Consumer: nutritional value of products formulated with spent grain rich in vegetable proteins and fibers
Brewer: cost (labor or subcontracting) avoided for the treatment and internal storage of the spent grain
Producer of spent grain products (e.g. baker): differentiation strategy for its products, possibility of offering a range of products (customer loyalty)
Environment: local circuit aimed at intensifying the use of nutrients in human food
Society: potential for creating local jobs that cannot be relocated

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Partnership relationship among the spent grain producer (also the brewer), the logistician in charge of multisite pooled collection, and the producer of spent grain-based food products (e.g. baker)
Consumer loyalty through the proposal of an innovative range of products (competitive advantage)

Distribution channels

Production continuously distributed in a local area
Possibility of cooperative governance for the distribution actor

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Proposal of local and accessible products
Consumer values: proximity (local roots), sustainability, transparency (labels), naturalness

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Costs architecture

Search for economies of scale by pooling collection (addition of small volumes from small urban breweries)
Search for donation of spent grain by brewers who, through this operation, can remove the logistical problem of spent grain or even save the cost of treatment by an external actor (waste recovery)

Costs:

Salaries of the employees of the actor in charge of collecting and of the actor in charge of stabilization/processing of spent grain- investments to be made for the installation of a semi-industrial site for stabilization/processing of spent grain, including in particular drying equipment
Research and development for the optimization (in particular energy) of the stabilization/transformation processes of spent grain
Maintenance of equipment and buildings

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Sources of revenue

Sale of spent grain: For brewers, the possibility of an additional source of income through the sale of spent grain alongside the sale of beer, compared to the case of a linear sector where the treatment of spent grain represents a cost. Variable price depending on production and the market (seasonality also to be taken into account)
Sale of spent grain-based food products: an additional cost) plan for the purchase of spent grain flour compared to conventional flour, at least during the early days of operation of the sector
Energy: possibility of recovering waste heat from production sites to limit the use of virgin energy

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