

**Supporting Data for the Article**

**VEGAN BURGERS FORTIFIED WITH AGRI-FOOD BY-PRODUCTS:  
NUTRITIONAL ENHANCEMENT, ENERGY CONSUMPTION AND LCA  
ASSESSMENT**

Ingredient	Value CTRL	Value Carrot peels	Value Turnip tops by-products	Value Broccoli by-products	Value Artichoke by-products	Value Prickly pear peels	Unit	Source	Name of the data used in the database	Reference
Beans	596,54	544,35	532,7	373,02	551,31	421,94	g/kg	University of Foggia		Environdec (2024)
Carrot	143,8	0	128,42	89,93	132,91	101,72	g/kg	University of Foggia	Carrot	CONCITO (2021)
Onion	66,58	60,75	59,45	41,63	61,53	47,09	g/kg	University of Foggia	Onion	CONCITO (2021)
Parsley	2,4	2,19	2,14	1,5	2,22	1,7	g/kg	University of Foggia	Parsley	CONCITO (2021)
Salt	9,59	8,75	8,56	6	8,86	14,66	g/kg	University of Foggia	Salt, table	CONCITO (2021)
Oil	23,97	21,87	21,4	14,99	22,15	16,95	g/kg	University of Foggia		Environdec (2023)
Water	0	97,2	71,34	249,79	41,35	126,58	g/kg	University of Foggia	Tap water {Europe without Switzerland}   tap water production, conventional treatment   Cut-off, S	Ecoinvent (2024)
By-product	0	121,51	35,67	124,9	34,46	158,23	g/kg	University of Foggia	Electricity, medium voltage {IT}   market for   Cut-off, S	Ecoinvent (2024)
Potato flake	157,12	143,38	140,31	98,25	145,21	111,14	g/kg	University of Foggia	Potato	CONCITO (2021)

**Table S1.** The table presents the inventory data and corresponding data sources for each ingredient used in the preparation of different vegan burger formulations, both with and without by-products. Values are expressed in grams per functional unit (1 kg of vegan burgers).

**Table S2: Sensory evaluation form**

**Raw - scale 1-9**

Color	Odor	Appearance	Consistency	Global quality

**Cooked - scale 1-9**

Color	Odor	Appearance	Consistency	Chewiness	Sandiness	Taste	Global quality

Attribute	Definition
Color	Intensity and uniformity of the typical color.
Odor	Intensity of the characteristic aroma of the ingredients and absence of off-odors.
Appearance	Visual evaluation of the surface, presence of visible fibers/pieces, and shape integrity.
Consistency	Resistance and structural integrity perceived when cutting the sample with a knife.
Chewiness	Effort required to masticate the sample before swallowing.
Sandness	Perception of small fiber particles during chewing.
Taste	Perception of balanced flavor.
Global Quality	Overall pleasantness and balance of all perceived sensory attributes.

DESCRIPTION RAW PARAMETERS					
<i>Score</i>	<i>COLOR</i>	<i>ODOR</i>	<i>APPEARANCE</i>	<i>CONSISTENCY</i>	<i>GLOBAL QUALITY</i>
1-2	Extremely faded, uneven, or showing severe oxidation.	Odorless or entirely overwhelmed by strong off-odors (rancid, acidic).	Collapsed shape, damaged surface, or invisible fibers.	Extremely soft/mushy or excessively hard/leathery when cut.	Defective product; severe failures across almost all attributes
3-4	Weak color intensity with noticeable irregularities.	Very weak aroma; ingredients are difficult to identify.	Irregular surface and poorly defined shape.	Weak structure; lacks the expected firmness.	Mediocre quality; does not meet the standard profile.
5	Sufficient intensity and acceptable uniformity.	Clear perception of ingredients; absence of off-odors.	Intact shape with sufficient visibility of fibers/pieces.	Adequate resistance and structural integrity.	Meets minimum quality and balance requirements.
6-7	Vibrant, bright, and well-distributed typical color.	Intense, fresh, and frank fragrance of the ingredients.	Attractive appearance; smooth surface and well-structured pieces.	Compact and elastic structure; provides proper resistance.	Good overall quality; harmonious sensory profile.
8-9	Ideal color: perfect brightness and absolute chromatic uniformity.	Excellent olfactory profile: maximum purity and aromatic complexity.	Perfect appearance: ideal shape integrity and flawless surface.	Optimal consistency: perfect balance between resistance and plasticity.	Excellent quality: absolute balance and absence of sensory defects.

DESCRIPTION COOKED PARAMETERS								
<i>Score</i>	<i>COLOR</i>	<i>ODOR</i>	<i>APPEARANCE</i>	<i>CONSISTENCY</i>	<i>CHEWINESS</i>	<i>SANDINESS</i>	<i>TASTE</i>	<i>GLOBAL QUALITY</i>
1-2	Extremely faded, uneven, or showing severe oxidation.	Odorless or entirely overwhelmed by strong off-odors (rancid, acidic).	Collapsed shape, damaged surface, or invisible fibers.	Extremely soft/mushy or excessively hard/leathery when cut.	Extremely rubbery (excessive effort) or completely disintegrates.	Massive presence of coarse, hard, or bothersome particles.	Tasteless, excessively salty/bitter, or with chemical off-tastes.	Defective product; severe failures across almost all attributes
3-4	Weak color intensity with noticeable irregularities.	Very weak aroma; ingredients are difficult to identify.	Irregular surface and poorly defined shape.	Weak structure; lacks the expected firmness.	High effort required to form a bolus or lacks structure.	Evident perception of sandy or fibrous particles.	Weak flavor or poorly balanced ingredients.	Mediocre quality; does not meet the standard profile.
5	Sufficient intensity and acceptable uniformity.	Clear perception of ingredients; absence of off-odors.	Intact shape with sufficient visibility of fibers/pieces.	Adequate resistance and structural integrity.	Typical effort required for the product type.	Fine grain; acceptable perception of particles.	Balanced flavor typical of the ingredients.	Meets minimum quality and balance requirements.
6-7	Vibrant, bright, and well-distributed typical color.	Intense, fresh, and frank fragrance of the ingredients.	Attractive appearance; smooth surface and well-structured pieces.	Compact and elastic structure; provides proper resistance.	Easy to chew while maintaining a pleasant bite.	Very fine texture; particles are almost imperceptible.	Full, harmonious, and persistent taste.	Good overall quality; harmonious sensory profile.
8-9	Ideal color: perfect brightness and absolute chromatic uniformity.	Excellent olfactory profile: maximum purity and aromatic complexity.	Perfect appearance: ideal shape integrity and flawless surface.	Optimal consistency: perfect balance between resistance and plasticity.	Perfect chewiness: disintegrates exactly at the point of swallowing.	Perfect texture: total absence of any sandy or grainy perception.	Exceptional taste: perfect balance and maximum expression of flavor.	Excellent quality: absolute balance and absence of sensory defects.

**Panelist code:**

**Gender and age:**

**Date:**

## References

CONCITO, 2021. The Big Climate Database, v 1.2. <https://denstoreklimadatabase.dk/en>

Ecoinvent, 2024. Ecoinvent database version 3.

Environdec, 2023. “Environmental Product Declaration: Extra Virgin Olive Oil”

<https://api.environdec.com/api/v1/EPDLibrary/Files/d7e05ffc-fb2d-41ca-265c-08db259f9365/Data>

Environdec, 2024. Environmental Product Declaration: Borlotti beans.

<https://api.environdec.com/api/v1/EPDLibrary/Files/0ef35481-8e12-415a-a17f-08dd7e7fd370/Data>