Supplementary Information (SI) for Sustainable Food Technology.

Supplementary Material

UPCYCLING OF TOMATO BY-PRODUCTS IN FOOD: QUALITY IMPROVEMENTS AND LIFE CYCLE ASSESSMENT

Table S1. Sensory characteristics of raw pasta samples with and without TPS

Sample	Color	Odor	Homogeneity	Appearance	Breaking resistance	Overall quality
Ctrl	9.00 ± 0.00[a]	9.00 ± 0.00[a]	8.83 ± 0.26[a]	8.83 ± 0.26[a]	9.00 ± 0.00[a]	9.00 ± 0.00[a]
Pasta-L	8.83 ± 0.26[a]	8.92 ± 0.20[a]	8.83 ± 0.26[a]	8.80 ± 0.27[a]	6.17 ± 0.26[b]	8.33 ±0.26[b]
Pasta-M	8.83 ± 0.26[a]	8.9 2± 0.20[a]	8.83 ± 0.26[a]	8.80 ± 0.27[a]	5.25 ± 0.27[c]	7.83 ± 0.26[b,c]
Pasta-H	8.83 ± 0.26[a]	8.92 ± 0.20[a]	8.83 ± 0.26[a]	8.80 ± 0.27[a]	5.07 ± 0.19[c]	7.58 ± 0.38[c]

Data are reported as means ± SD. Data in each column with different superscript letter are statistically different ($p<0.05$).

Table S2. Sensory characteristics of cooked pasta samples with and without TPS

Sample	Color	Odor	Elasticity	Bulkiness	Stickiness	Firmness	Grittiness	Taste	Overall quality
Ctrl	9.00 ± 0.00^{a}	9.00 ± 0.00^{a}	9.00 ± 0.00^{a}	8.83 ± 0.26^{a}	9.00 ± 0.00^{a}	9.00 ± 0.00^{a}	9.00 ± 0.00^{a}	9.00 ± 0.00^{a}	9.00 ± 0.00^{a}
Pasta-L	8.25 ± 0.27^{b}	8.92 ± 0.20^{a}	7.67 ± 0.26^{b}	8.80 ± 0.27^{a}	8.25 ± 0.27^{b}	8.42 ± 0.20^{b}	6.75 ± 0.27^{b}	7.50 ± 0.32^{b}	7.25 ± 0.27^{b}
Pasta-M	8.25 ± 0.27^{b}	8.92 ± 0.20^{a}	7.33 ± 0.26^{b}	8.80 ± 0.27^{a}	7.75 ± 0.27^{c}	7.67 ± 0.26^{c}	6.33 ± 0.27^{b}	6.75 ± 0.26^{c}	6.67 ± 0.26^{c}
Pasta-H	8.2 5± 0.27^{b}	8.92 ± 0.20^{a}	7.2 5± 0.27^{b}	8.80 ± 0.27^{a}	7.75 ± 0.27^{c}	7.67 ± 0.26^{c}	5.83 ± 0.26^{c}	6.00 ± 0.32^{d}	5.83 ± 0.26^{d}

Data are reported as means ± SD. Data in each column with different superscript letter are statistically different ($p<0.05$).

Table S3. Sensory characteristics of raw gnocchi samples with and without TPS

Sample	Color	Odor	Appearance-Homogeneity	Breaking resistance	Overall quality
Ctrl	9.00 ± 0.00[a]	9.00 ± 0.00[a]	9.00 ± 0.00[a]	9.00 ± 0.00[a]	9.00 ± 0.00[a]
Gnocchi-L	8.80 ± 0.27[a]	8.80 ±0.27[a]	8.80 ± 0.27[a]	6.17 ± 0.26[b]	8.80 ± 0.27[a]
Gnocchi -M	8.80 ± 0.27[a]	8.80 ± 0.27[a]	8.80 ± 0.27[a]	5.25 ± 0.27[c]	8.80 ± 0.27[a]
Gnocchi -H	8.92 ± 0.20[a]	8.83 ± 0.20[a]	8.83 ± 0.26[a]	5.07 ± 0.19[c]	7.75 ± 0.27[b]

Data are reported as means ± SD. Data in each column with different superscript letter are statistically different ($p<0.05$).

Table S4. Sensory characteristics of cooked gnocchi samples with and without TPS

Sample	Color	Odor	Stickiness	Grittiness	Taste	Overall quality
Ctrl	9.00 ± 0.00[a]	9.00 ± 0.00[a]	9.00 ± 0.00[a]	9.00 ± 0.00[a]	9.00 ± 0.00[a]	9.00 ± 0.00[a]
Pasta-L	8.80 ± 0.27[a]	8.92 ± 0.20[a]	8.25 ± 0.27[b]	6.75 ± 0.27[b]	7.50 ± 0.32[b]	7.25 ± 0.27[b]
Pasta-M	8.80 ± 0.27[a]	8.92 ± 0.20[a]	7.75 ± 0.27[c]	6.33 ± 0.27[b]	6.75 ± 0.26[c]	6.67 ± 0.26[c]
Pasta-H	8.92 ± 0.20[a]	8.92 ± 0.20[a]	7.75 ± 0.27[c]	5.83 ± 0.26[c]	6.00 ± 0.32[d]	5.83 ± 0.26[d]

Data are reported as means ± SD. Data in each column with different superscript letter are statistically different ($p<0.05$).

Table S5. Total Polyphenol Content (TPC) and Total Flavonoid Content (TFC) of pasta samples with and without TPS

Sample	TPC [mg GAE/g dw]	TFC [mg QE/g dw]
Ctrl	0.404 ± 0.101[a]	0.25 ± 0.03[a]
Pasta-L	0.459 ± 0.126[a]	0.31 ± 0.05[a]
Pasta-M	0.499 ± 0.078[a]	0.35 ± 0.08[a]
Pasta-H	0.505 ± 0.085[a]	0.36± 0.04[a]

Data are reported as means ± SD. Data in each column with different superscript letter are statistically different ($p<0.05$).

Table S6. Total Polyphenol Content (TPC) and Total Flavonoid Content (TFC) of gnocchi samples with and without TPS

Sample	TPC [mg GAE/g dw]	TFC [mg QE/g dw]
Ctrl	0.407 ± 0.053[a]	0.28 ± 0.03[b]
Gnocchi-L	0.479 ± 0.076[a]	0.55 ± 0.08[a]
Gnocchi-M	0.503 ± 0.049[a]	0.58 ± 0.07[a]
Gnocchi-H	0.570 ± 0.031[a]	0.62 ± 0.10[a]

Data are reported as means ± SD. Data in each column with different superscript letter are statistically different ($p<0.05$).

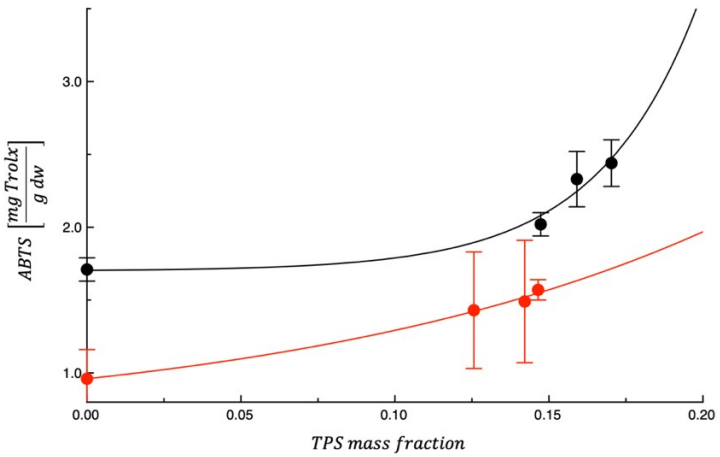
Table S7. Ingredients (g/1 kg pasta) used for pasta preparation, along with the corresponding sources of environmental impact data.

Ingredient	Value CTRL	Value Pasta-L	Value Pasta-M	Value Pasta-H	Unit	Source	Name of the data used in the database	Reference
Semolina	690	535.01	522.67	510.89	g/kg	University of Foggia		Environdec, (2022)
Water	180	139.56	136.35	133.27	g/kg	University of Foggia	Tap water {Europe without Switzerland}| tap water production, conventional treatment | Cut-off, S	Ecoinvent (2024)
Fresh Egg	130	100.80	98.47	96.25	g/kg	University of Foggia		Leinonen et al. (2012)
CMC	0	0.43	0.44	0.44	g/kg	University of Foggia	Carboxymethyl cellulose, powdered {RoW} production | Cut-off, S	Ecoinvent (2024)
By-product	0	147.32	159.07	170.29	g/kg	University of Foggia	Electricity, medium voltage {IT}|market for | Cut-off, S	Ecoinvent (2024)
Water to hydrate by-product	0	76.86	82.99	88.85	g/kg	University of Foggia	Tap water {Europe without Switzerland}| tap water production, conventional treatment | Cut-off, S	Ecoinvent (2024)

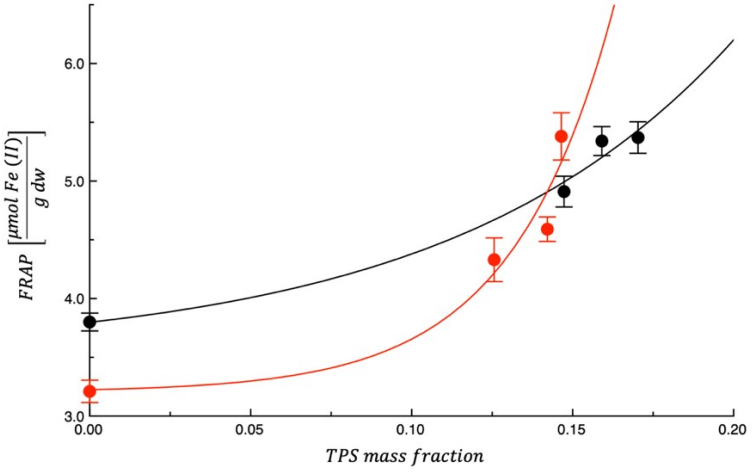
Table S8. Ingredients (g/1 kg gnocchi) used for gnocchi preparation, along with the corresponding sources of environmental impact data.

Ingredient	Value CTRL	Value Gnocchi-L	Value Gnocchi-M	Value Gnocchi-H	Unit	Source	Name of the data used in the database	Reference
Semolina	258,36	186.94	177.67	183.09	g/kg	University of Foggia		Environdec, (2022)
Water	574,14	415.42	394.83	406.88	g/kg	University of Foggia	Tap water {Europe without Switzerland}| tap water production, conventional treatment | Cut-off, S	Ecoinvent (2024)
Potato flakes	63.15	45.70	43.43	44.76	g/kg	University of Foggia	Potato {RoW}| potato production | Cut-off, S	Ecoinvent (2024)
Potato starch	91.86	66.47	63.17	65.10	g/kg	University of Foggia	Potato starch {RoW}| potato starch production | Cut-off, S	Ecoinvent (2024)
Salt	7.18	5.19	4.94	5.06	g/kg	University of Foggia	Salt {GLO}| market for salt | Cut-off, S	Ecoinvent (2024)
Lactic acid	4.30	3.12	2.96	3.05	g/kg	University of Foggia	Lactic acid {RoW}| lactic acid production | Cut-off, S	Ecoinvent (2024)
Sorbic acid	0.72	0.52	0.49	0.51	g/kg	University of Foggia	Citric acid {RoW}| citric acid production | Cut-off, S	Ecoinvent (2024)

Safflower	0.29	0.21	0.20	0.20	g/kg	University of Foggia	Sunflower seed {RoW}| sunflower production | Cut-off, S	Ecoinvent (2024)
CMC	0	2.49	2.37	2.44	g/kg	University of Foggia	Carboxymethyl cellulose, powdered {RoW} production | Cut-off, S	Ecoinvent (2024)
By-product	0	125.63	142.14	146.48	g/kg	University of Foggia	Electricity, medium voltage {IT}|market for | Cut-off, S	Ecoinvent (2024)
Water to hydrate by-product	0	148.31	167.80	142.41	g/kg	University of Foggia	Tap water {Europe without Switzerland}| tap water production, conventional treatment | Cut-off, S	Ecoinvent (2024)



(a)



(b)

Figure S1. ABTS (a) and FRAP (b) values for gnocchi and pasta samples as function of TPS mass fraction. ● Gnocchi, ● Pasta, ——— Gnocchi, ——— Pasta. The curves shown in the figure are intended solely to highlight the trend of the data.

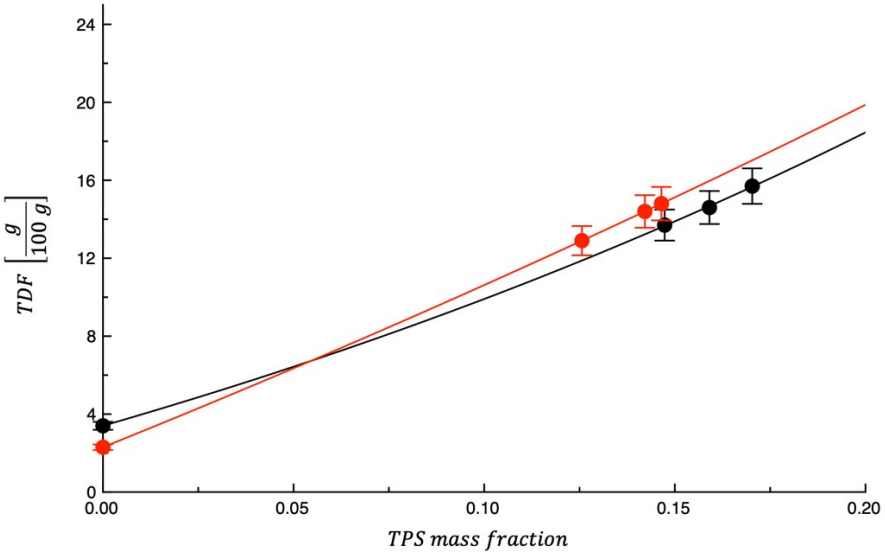


Figure S2. TDF values for gnocchi and pasta samples as function of TPS mass fraction. ● Gnocchi, ● Pasta, ——— Gnocchi, ——— Pasta. The curves shown in the figure are intended solely to highlight the trend of the data.

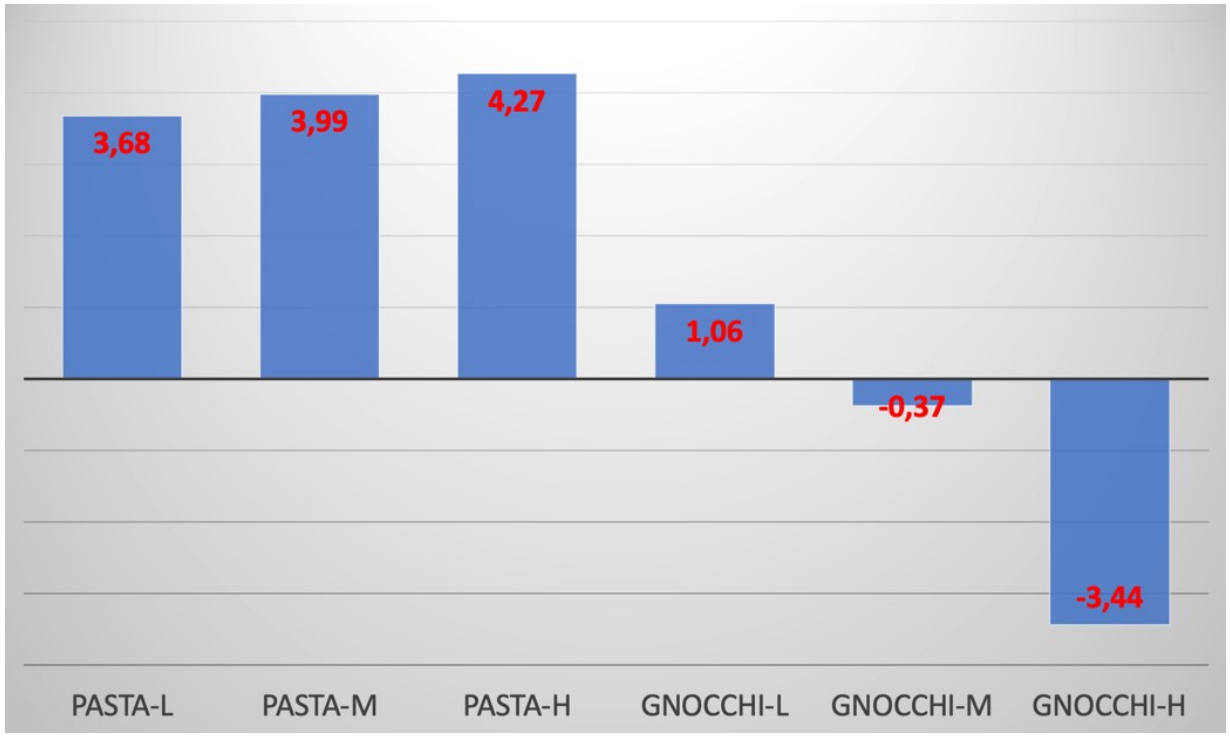


Figure S3. Values of percentage normalized environmental impact calculated using the Equation (1) for pasta and gnocchi samples.

References

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