



# Apple and carrot industrial wastes as enhancers of the intestinal health in piglets after weaning

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**Background:** In piglets, weaning transition affects especially the gastrointestinal tract, resulting in intestinal inflammation, oxidative stress and perturbation of intracellular signalling pathways. The current focus in piglets' nutrition is to enhance their health status, by positive modulation of intestinal inflammation, integrity and functionality, intestinal immunity as well as the gut microbiota.

**This paper aims** to describe nutritional studies on the effects of bioactive compounds from apple and carrot wastes in main aspects affected by weaning transition in piglets (growth performances, intestinal morphology, oxidative stress and inflammation markers and gut microbiota). These bioactive compounds could reduce the oxidant and inflammatory processes and positively modulate the microbiota, enhancing the intestinal health in piglets after weaning.

**Materials and methods:** The literature data used for this paper was retrieved from PubMed®, Google Scholar and Feedipedia: An on-line encyclopedia of animal feeds website (<https://www.feedipedia.org/>). Literature was summarized according to the main topics of this review, namely the composition of apple and carrot wastes; weaning disturbances; effects of apple and carrot wastes on intestinal health in weaning piglets; effects of apple and carrot wastes on microbiota in weaning piglets.

## Results and discussions:

Table 1. The basal composition of apple fruit, apple pomace, whole carrot and carrot pomace

Components*	Apple	Apple pomace	Carrot	Carrot pomace
Total protein (%)	0.19 - 3.3	2.4 - 11	0.7 - 0.9	6.21 - 12.87
Crude fibre (%)	2.00 - 2.97	11.6 - 44.5	1.2 - 2.4	8.8 - 28
NDF (neutral detergent fiber) (%)	0.9 - 1.6	42.07	-**	12.07
ADF (acid detergent fiber) (%)	1.0 - 1.5	34.27	-**	11.87
Cellulose (%)	0.43	12.0 - 23.2	35 - 48	-**
Lignin (%)	15.3	6.4 - 19.0	15.2	-**
Hemicellulose (%)	19.2	5.0 - 6.2	13.0	-**
Pectin (%)	1.0 - 1.5	3.5 - 18	-	-
Sugars	10.4 - 12.34	54.4	2.71 - 5.6	64.3
Fructose (%)	4.4 - 6.9	14 - 35	-**	-**
Glucose (%)	1.4 - 3.4	2.5 - 13	-**	-**
Sucrose (%)	1.7 - 7.4	3.4 - 24	-**	-**
Crude fat (%)	0.1 - 1.9	2.7	0.2 - 0.5	1.23 - 2.72
Ash (%)	0.19 - 1.7	1.48 - 4.00	1.1	6.18 - 7.67
Macroelements				
K (%)	0.09 - 1.18	0.449	0.24	0.27
P (%)	0.13 - 0.84	0.070 - 0.149	0.25	0.39
Ca (%)	2.48% - 7.8	0.06 - 0.15	0.34	0.34
Mg (%)	0.27 - 3.46	0.02 - 0.45	0.9	0.12
Microelements				
Fe (%)	0.15% - 0.28	31.8 - 38.3	0.4	11.6 - 22.3
Mn (%)	0.04 - 0.06	8.75	0.2 - 0.8	13.1
Zn (%)	0.006% - 0.02	6.9	0.2	28.4
Cu (%)	0.03 - 0.04	1.36	0.02	4.24

\*The composition is expressed as g/100g dry matter

\*\* Data not found

Table 2. The composition in bioactive compounds of apple, carrot and their pomaces

Bioactive compounds*	Apple	Apple pomace
Total polyphenols (%)	66.2 - 434.4	262 - 856
Total flavonoids (%)	57 - 338.6	94.3
Total anthocyanins (%)	0.19 - 2.30	2.11
Vitamin E (%)	0.14 - 0.25	22.4
Vitamin C (%)	4.60 - 77	5.5
Bioactive compounds*	Carrot	Carrot pomace
Total polyphenols (%)	15.9 - 25.9	13.8
Sum of anthocyanins (%)	1.75	4.32
Vitamin E (%)	19.1 - 70.3	41.5
Vitamin C (%)	1.0 - 4	30 - 70
Carotenoids (%)	5.33	3.32 - 15.35
Lutein (%)	1.9	0.023 - 1.61
Beta-carotene (%)	1.7	3.26 - 13.44
Astaxanthin (%)	-**	0.0147

\*The composition is expressed as g/100g

\*\* Data not found

### APPLE / APPLE WASTES

Bioactive compounds:  
polyphenols (flavonoids),  
vitamin C



- ✓ **Effects on animal performance:** promotion of animal growth; improvement of the average daily gain; no effect on average feed intake, feed:gain ratio and diarrhea rates
- ✓ **Effects on the intestinal barrier structure and function:** improve the mucosal-epithelial integrity, intercellular junctions between the epithelial cells, and mucus layer in weaned piglets
- ✓ **Antioxidant effects:** mitigating oxidative stresses at local (intestinal) and systemic (plasma) levels
- ✓ **Anti-inflammatory effects:** decrease of pro-inflammatory cytokines genes and proteins expression;
- ✓ **Role in regulation of the in-depth signalling pathways related to inflammation and oxidative stress:** decrease of NF-Kb/MAPK activation; increase the activation of the Nrf2 signaling pathway
- ✓ **Microbiota modulation:** increased the abundance of beneficial bacteria Lactobacillaceae, Faecalibacterium, Catenibacterium (reported to be reduced in intestinal inflammation); reduced the Clostridiaceae abundances



### CARROT / CARROT WASTES

Bioactive compounds:  
carotenoids, vitamin E



- ✓ **Effects on animal performance:** no effect on the weight gain and feed intake, but reduced the diarrhea incidence.
- ✓ **Effects on the intestinal barrier structure and function:** restored the intestinal wall architecture (villus, crypts)
- ✓ **Antioxidant effects:** reduced lipid peroxidation, oxidative DNA damage and increased antioxidant enzymes activities
- ✓ **Anti-inflammatory effects** reduced the pro-inflammatory mediators in serum and intestine
- ✓ **Role in regulation of the in-depth signalling pathways related to inflammation and oxidative stress** decreased the activation of JNK/p38 MAPK and up-regulated the expression of Nrf2
- ✓ **Microbiota modulation:** increased the abundance of Firmicutes, Lactobacillus and Parabacteroides and reduced Dialister and Enterobacter

## Conclusions

The scientific information indicated that apple wastes could be used in weaning piglets' nutrition, whereas for carrot by-products more studies should be developed. In the context of the development of the circular economy emphasized by European Union, these by-products are inexpensive source of beneficial bioactive compounds and can be use in weaning piglets feeding as valuable in-feed antibiotic replacers.

**Acknowledgement:** This research was supported by funds from the Core Program (PN-III 23-20-02.01 project), granted by the Romanian Ministry of Education and Research.