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A SUSTAINABLE APPROACH TO NEW GENERATION FOOD THICKENERS: APPLE FIBRE IN MEAT AND VEGETABLE BURGERS

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Abstract: At the 8th Environment Action Programme, the EU agreed on an environmental policy up to 2030 with a zero-emission ambition. The food production sector is credited with a significant impact on environmental pollution: e.g. agriculture accounts for 70% of global freshwater use. Therefore, it is extremely important to promote technological solutions that reduce the negative impact of food production to an absolute minimum. A perfect example of a sustainable approach is a patented method that uses extrusion to produce functional food fibres that act as food thickeners. The possibilities of using the apple fibre preparation (Lutkala Multifunctional) are wide. The aim of this study was to assess the impact of apple fibre preparation on selected physical properties of beef, pork, and vegetable pea protein burgers. The following methods were used: the gravimetric method to calculate weight loss and shape stability during heat treatment, texture profiling according to Texturometer TA.XT2, and colour measurement. The use of Lutkala in meat and vegetable burgers gives a number of benefits: technological (reduced water loss during thermal processing), organoleptic (obtaining a more delicate consistency), health (increased fibre content and reduced calories), and also gives the advantage of a clean label product and has a positive impact on the environment. The addition of apple fibre preparation reduced the hardness of beef burgers, making them more tender, while the plant-based substitute had the lowest cohesiveness, springiness, and chewiness. The inclusion of apple fibre preparation in the formulation composition of burgers significantly differentiated the surface colour parameters of the products. Based on the results obtained, it has been determined that the inclusion of Lutkala Multifunctional in the burger mixture, as per the prescribed recipe composition, should not surpass a maximum limit of 1.5%. The use of apple fibre preparation in burgers is an excellent example of the benefits of using next-generation sustainable hydrocolloids in the food industry.

Key words: apple fibre, extrusion, sustainable, clean label, burgers, thickener

INTRODUCTION

At the 8th Environment Action Programme, the European Union agreed on an environment policy until 2030, pursuing a zero-pollution ambition, including for air, water, and soil, as well as protecting the health and well-being of Europeans. The long-term priority objective is that, by 2050 at the latest, Europeans will live well, within planetary boundaries, in a well-being economy where nothing is wasted [1].

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The food production sector is credited with having a major impact on environmental pollution – for example: agriculture is responsible for 70% of global freshwater use. It is also responsible for biodiversity loss, the production of harmful food waste, and a large proportion of greenhouse gas emissions [2].

It is, therefore, vital that we all, no matter on which industry level we are, look for solutions that really make a difference to our environment, and that we make the Union's postulates a value that guides our decisions, both professional and private. Only then do we have a chance to be successful and have a real impact on the environment.

This study shows how our choices can contribute to achieving these goals using the example of hydrocolloids. These products are a large and very diverse group of food additives, used widely across the food industry. They can come from natural sources such as plants or animals, fungi or even bacteria. They can be minimally processed like raw fibre or highly processed, as modified starches or amidated pectin. They can be highly specialised or very general. They can also be responsible for various functions in food, such as texture, cohesion, consistency, taste, shelf life, stability, and many more [3].

What they have in common is the fact that they are irreplaceable functional additives in industrially produced food. The size of the hydrocolloid market was estimated at USD 10.24 billion in 2021, and the category growth is estimated at USD 13.36 billion in 2024 [4].

The size of this category shows that even a small percentage change in the types of products used can have a real impact on the environment. Therefore, it is worth considering the choice not only in terms of functionality, but also carefully looking at their origin and method of production.

Replacing popular hydrocolloids with sustainably produced functional fibres is one way to achieve this goal. Making this change is possible in most applications, although sometimes it requires adjustments to recipes or production lines. However, the environmental benefits far outweigh the contribution made when these raw materials are put into industrial production.

This article presents how the method of hydrocolloid production affects the environment using the example of Lutkala (a product of Lutkala Sp. z o.o., Poland). Figure 1 illustrates the potential contributions of Lutkala to various areas of the 8th Environment Action Programme of the EU. The raw material used to produce Lutkala is an apple pomace, i.e. a by-product from another production process. Therefore, it is a production that fits in with the aims of the Union's program relating directly to waste and recycling: ("EU action on waste management, treatment, and recycling"), as well as to the circular economy ("The EU's transition to a circular economy with a focus on green growth"), through the possibility of using in locally occurring raw materials. Moreover, Lutkala not only uses waste as a raw material, but its production process does not generate any solid or liquid waste. Therefore, it is a response to the next point on the agenda relating to water ("EU action on water issues to protect water resources"). This is because the production method is based on extrusion, an exclusively physical process that does not use any chemical reagents. For the part of the programme related to chemicals, "action to ensure chemicals are safe, for health and the environment," in this case, it is not only implemented 100% but even exceeded. This technology also supports the part about industry, which is "action to make industry more sustainable and reduce industrial emissions" [1, 5, 6].

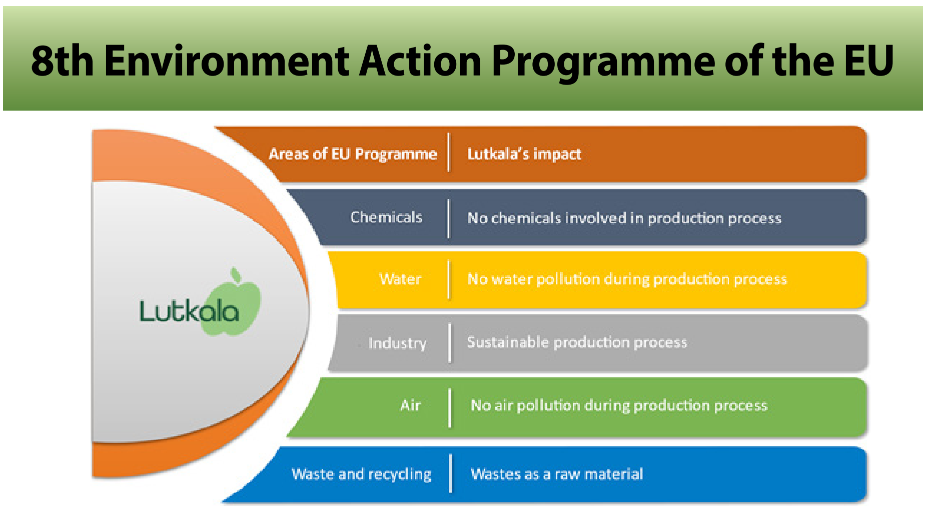

Figure 1. The possible contribution of Lutkala on different areas of the 8th Environment Action Programme of the EU
Source: own elaboration.

The aim of this study was to assess the impact of apple fibre preparation produced through a sustainable process on selected physical properties of meat and vegetable burgers.

MATERIAL AND METHODS

The research material was an apple fibre preparation produced in a patented extrusion method (Patent number: 241316) [7]. Lutkala Multifunctional (LM; 100% extruded apple pomace) is a powder with a caramel colour and aroma of dried apple. The physical and chemical parameters are shown in Table 1. The possibilities of using the product are wide. The above publication presents the effect of using LM in burgers prepared from various types of meat, and vegetable products based on pea protein (25%).

Table 1. Physical and chemical parameters of LM

Shelf life	18 months
Moisture	<10.0 %
pH*	3.7
Rheology	
Viscosity*	from 4000 to 4500 mPas
WHC (water holding capacity)	7.0 g/g
OBC (oil binding capacity)	2.8 g/g
Swelling index	21.0 ml/g
Chemical parameters	
Dietary fibre	60.0–76.0 w/w d.m.
Total sugars	12.5–21.0 w/w d.m.
Protein	6.1–9.4 w/w d.m
Fat	0.9–3.0 w/w d.m.
Ash	1.2–2.3 w/w d.m.

Explanatory notes: *7% water solution, RPM 100, temp. 25°C.

Source: own elaboration.

Apple fibre preparation was used as an additive to produce meat and vegetable burgers (characteristics of burgers shown in Table 2).

Table 2. Characteristics of prepared burgers

Main ingredient	Fat content [%]	Collagen to meat ratio [%]	Addition of apple fibre preparation [%]
Beef	<20.0	15.0	control; 1.5; 3.0
Pork	<7.0	11.0	control; 1.5; 3.0
Vegetable products based on pea protein (25%)	13.2	not applicable	control; 1.5; 3.0

Source: own elaboration.

The regular ground (mesh with a hole diameter of 4.5 mm) beef and pork, vegetable base, and LM were mixed to obtain a homogeneous mass and then shaped into disc-shaped patties with a diameter of 6.7 cm and a thickness of 1.0 cm. The burgers were subjected to heat treatment in an oven (Hendi, H90S) at a temperature of 165°C for 12 minutes, using forced air circulation. Subsequently, the burgers were set aside for 30 minutes to cool down at room temperature (20°C). Burgers without the addition of LM served as the reference material.

The cooking loss (*CL*) of the burger during heating was expressed as a percentage using the following formula:

$$CL = \frac{mi - mf}{mi} \times 100$$

where:
mi – the weight before heating
mf – the weight after heating.

The shape stability (*SS*) during heating was expressed as a percentage using the following formula:

$$SS = 100 - \frac{6.7 - d}{6.7} \times 100$$

where:
d – the diameter of the burger after heating.

The texture profile was determined using a TA.XT2 universal texturometer equipped with a cylindrical measuring probe with a diameter of 20 mm. The most popular test, TPA, known as the "double bite", was performed. The form of the sample was round. The tested samples were compressed at a speed of 0.5 mm/s to a depth of 5 mm; then, the probe was retracted by 5 mm and reinserted to a depth of 5 mm. Several textural parameters were obtained automatically after testing, including hardness, cohesiveness, springiness, elasticity, and chewiness.

Colour measurement was performed using a trichromatic colourimeter CR-310 (Minolta) under the following measurement conditions: observer 2°, illuminant D65, CIE Lab colour space (values: L – lightness, a and b for the red and yellow values). Additionally, the overall colour difference (ΔE) was calculated by the programme with reference to the burgers without the addition of LM.

The results were evaluated by one-factor analysis of variance, followed by the Tukey test in order to identify the difference among the mean values (p <0.05).

RESULTS AND DISCUSSION

Dietary fibres present in the skin of the fruit are considered functional ingredients in the formulation of meat products due to their water-holding capacity and low cooking loss [8]. The addition of fibres to meat products can cause the following technological effects: increase the moisture-retaining capacity of minced products, improve the stability of emulsions, substitute fat, reduce fat content, increase the yield of the product, improve the texture of meat products, retain the shape of the product after heat treatment, and stabilises fats and proteins, which leads to increased storage stability [5, 8].

Table 3 presents the values of cooking loss and the shape of the burgers, depending on the type of meat used and the concentration of LM. The tested burgers significantly differed (p < 0.05) in shape as a result of heating, which was associated with the type of meat used in their production. Both 1.5 and 3.0% additions of LM did not significantly affect the change in size of the burgers. However, a significant improvement in burger mass retention was observed with the use of a 1.5% addition of LM. Increasing the dose to 3.0% resulted in further improvement in mass retention only in the case of beef, which had the highest weight loss among the analysed raw materials. Additionally, beef contained the highest amount of fat. Hydrocolloids often possess emulsifying properties that can improve fat retention during technological processes. The plant-based meat substitute exhibited the lowest weight loss, which could be attributed to the absence of other water-binding substances in its composition, such as methylcellulose and citrus fibre.

Table 3. The cooking loss and shape stability of burgers after heating

Contents [%]	CL [%]	SS [%]
Vegetable products based on pea protein [25%]		
0.0	14.8 ±0.6a	88.06 ±1.49d
1.5	11.9 ±1.3a	91.54 ±0.86d
3.0	11.9 ±2.3a	90.55 ±0.86d
Pork		
0.0	27.7 ±1.0cd	76.62 ±4.56bc
1.5	22.2 ±1.3bc	79.60 ±1.72c
3.0	21.0 ±0.8b	80.10 ±1.72c
Beef		
0.0	32.9 ±2.1d	69.65 ±2.28a
1.5	28.1 ±1.8cd	73.13 ±1.49ab
3.0	24.9 ±1.3bc	74.63 ±1.49abc

Explanatory notes: mean value ± standard deviation. Values labelled with the same letter in the column do not differ statistically significantly (ANOVA, Tukey HSD, p <0.05).

Source: own elaboration.

Baioumy and Abedelmaksoud [9] show that cooking loss during heat treatment in beef burgers with orange albedo was a quarter lower than in the control sample. Shape stability was better in the case of burgers with a higher addition of LM. Younis and Ahmad [10] obtained similar results in their study where, as the pomace powder was increased in patties, the shrinkage in diameter was less than that of the control burgers.

Similarly to previous studies, the selected texture parameters of the burgers were strongly dependent on the origin of the raw material (Table 4). Burgers prepared from pork meat were assigned the highest values for all tested parameters of the universal texture profile. Beef meat enabled the production of burgers with lower hardness, while the plant-based substitute had the lowest cohesiveness, springiness, and chewiness. With a 1.5% addition of LM to the plant-based substitute, a decrease in cohesiveness and springiness was observed, while increasing the dose to 3% resulted in a reversal of these changes. The observed results may indicate texture relaxation at low doses, which is associated with improved water retention. Further increasing the LM dose does not improve water retention, resulting in stronger water binding manifested by a subsequent increase in texture parameter values. No statistically significant changes in the texture profile were observed in pork meat due to the addition of LM. This was likely associated with improved water retention, which was observed with both 1.5% and 3.0% additions of LM. The initial strong texturising properties of pork meat also played a significant role. In the case of beef meat, the addition of LM led to a decrease in hardness, springiness, and chewiness, allowing for a less "gummy" and more delicate texture of the burgers.

Table 4. Selected texture parameters of burgers with the addition of LM

Content of LM [%]	Hardness [*N*]	Cohesiveness [-]	Springiness [-]	Elasticity [-]	Chewiness [*N*/cm]
Vegetable products based on pea protein [25%]					
0.0	33.43 ±0.90c	0.53 ±0.01a	0.72 ±0.02a	0.29 ±0.01a	12.82 ±0.38bcd
1.5	33.45 ±2.00c	0.47 ±0.01a	0.67 ±0.02a	0.22 ±0.01a	10.49 ±0.46abc
3.0	35.65 ±2.76c	0.49 ±0.01a	0.69 ±0.02a	0.28 ±0.03a	12.18 ±1.41bcd
Pork					
0.0	33.74 ±4.47c	0.60 ±0.02b	0.80 ±0.01b	0.39 ±0.03b	16.11 ±1.92d
1.5	31.80 ±4.07bc	0.60 ±0.00b	0.83 ±0.02bc	0.43 ±0.00b	16.07 ±2.48cd
3.0	33.86 ±5.72c	0.61 ±0.01b	0.80 ±0.02b	0.43 ±0.01b	16.44 ±2.63d
Beef					
0.0	21.11 ±6.35b	0.62 ±0.01b	0.88 ±0.05c	0.52 ±0.02c	11.44 ±3.34b
1.5	16.55 ±4.45ab	0.60 ±0.01b	0.83 ±0.02bc	0.45 ±0.02b	8.19 ±2.06ab
3.0	10.05 ±1.14a	0.59 ±0.01b	0.82 ±0.02bc	0.44 ±0.03b	4.88 ±0.42a

Explanatory notes: mean value ± standard deviation. Values marked with the same letter do not differ statistically significantly (ANOVA, Tukey HSD, $p < 0.05$).

Source: own elaboration.

In the study by Younis and Ahmad [10], significantly higher values were obtained for the hardness parameter (from 47.85 to 109.54 N/cm^2) and chewiness parameter (from 17.19 to 29.60) for buffalo meat patties prepared with the addition of apple pomace powder at levels of 0, 2, 4, 6, and 8% [10]. The comparison of results suggests greater functionality of LM. The values of the cohesiveness and springiness parameters were comparable.

The colour of the burgers (Table 5) was strongly dependent on the type of meat used for production, as well as the concentration of LM. All burgers exhibited positive values of colour coordinates a* and b*, corresponding to red and yellow colours, respectively. The addition of LM, regardless of the type of meat used, resulted in a significant decrease in lightness (L*) and, to a lesser extent, chromatic colour coordinates a* and b*. The greatest impact of LM was observed for plant-based meat, as evidenced by high values of the overall colour difference (ΔE). This was largely due to a decrease in the values of both chromatic parameters, making the appearance of the burger similar to those prepared with both types of regular meat. On the other hand, with pork burgers, a decrease in lightness was mainly observed, gradually resembling the appearance of beef-based ones. Significant colour changes were also observed in beef burgers, as even at $\Delta E = 3.5$, consumers could perceive a significant difference between the products [11]. However, acceptance of such changes should not be a problem for consumers, as similar changes occur due to more aggressive heat treatment methods such as frying and grilling.

Comparing the results of the colour measurement to the results obtained by Younis and Ahmad [10], it can be concluded that the results achieved in this publication are slightly lower for all parameters.

Table 5. Results of the colour analysis of the burgers

Content of LM (%)	L*	a*	b*	ΔE
Vegetable products based on pea protein (25%)				
0.0	41.72 ±0.21c	11.58 ±0.49	25.64 ±0.41e	–
1.5	35.08 ±1.32ab	8.38 ±0.41de	16.82 ±1.52d	11.50
3.0	32.21 ±0.28a	7.22 ±0.46bcd	14.01 ±0.45c	15.64
Pork				
0.0	60.69 ±0.93d	7.42 ±0.23cd	12.74 ±0.38abc	–
1.5	53.99 ±0.94d	5.98 ±0.48ab	13.07 ±0.64bc	6.85
3.0	46.42 ±0.48d	5.32 ±0.23a	12.53 ±0.18abc	14.43
Beef				
0.0	40.20 ±0.41c	8.76 ±0.63e	11.68 ±0.82ab	–
1.5	35.99 ±2.08b	7.67 ±0.69cde	11.02 ±0.99ab	4.40
3.0	34.14 ±1.46ab	6.98 ±0.13bc	10.68 ±0.52a	6.39

Explanatory notes: mean value ± standard deviation. Values marked with the same letter do not differ statistically significantly (ANOVA, Tukey HSD, $p < 0.05$); *attributes L – lightness–darkness, a – green–red, b – yellow–blue, ΔE – total colour change.

Source: own elaboration.

In the study, it was demonstrated that the use of hydrocolloids in meat processing is particularly important due to their ability to shape desired rheological properties, often accompanied by improved production efficiency.

Research by Zinina et al. [8] has summarised that by-product from apples has the following technological effect on meat products: modifying moisture, texture, and colour lightness of meat products, as well as improving emulsion stability and cooking yield, increasing shelf-life, and preventing lipid oxidation of chicken products. These conclusions were confirmed in this study.

Some authors evaluated the impact of adding vegetable fibres to chicken burger formulations as animal fat substitutes [12]. Comparing the physicochemical and technological properties of vegetable fibres evaluated by Huber et al., [12] LM is a more functional product. LM has more than two times higher WHC, three times higher swelling capacity, and about two times higher oil holding capacity compared to other fibres.

According to Huber et al., [12] the evaluated plant fibres may be an interesting alternative for the production of meat products with prebiotic and functional appeal. In this way, the use of a mixture of vegetable fibres as fat substitutes in chicken burgers demonstrated a promising option to check the functionality of foods considered unhealthy.

Additionally, Baioumy and Abedelmaksoud [9] show that the use of orange albedo as a functional additive has a major impact on the quality attributes and storage stability of beef burgers.

CONCLUSIONS

The use of Lutkala in meat and vegetable burgers gives a number of benefits: technological (reduced water loss during thermal processing), organoleptic (obtaining a more delicate consistency), health (increased fibre content and reduced calories), and also gives the advantage of a clean label product and has a positive impact on the environment. The addition of apple fibre preparation reduced the hardness of beef burgers, making them more tender, while the plant-based substitute had the lowest cohesiveness, springiness, and chewiness. The inclusion of apple fibre preparation in the formulation composition of burgers significantly differentiated the surface colour parameters of the products.

Based on the results obtained, it has been determined that the inclusion of Lutkala Multifunctional in the burger mixture, as per the prescribed recipe composition, should not surpass a maximum limit of 1.5%.

REFERENCES

[1] **DECISION (EU) 2022/591 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL OF 6 APRIL 2022** on a General Union Environment Action Programme to 2030. Official Journal of the European Union (L14/22, 12.4.2022).

[2] **UGBEM CH. 2023.** "Wpływ produkcji i konsumpcji żywności na środowisko: zrównoważony system żywnościowy" (https://ichi.pro/pl/wplyw-produkcji-i-konsumpcji-zywnosci-na-srodowisko-zrownowazony-system-zywnosciowy-29189740103338, access 20.06.2023). www.ichi.pro.

[3] **MILANI J., MALEKI G., 2012.** "Hydrocolloids in food industry". [In:] Valdez B. (ed.) "Food Industrial Processes – Methods and Equipment" (17–37). In-Tech, Croatia.

[4] **IMR INTERNATIONAL HYDROCOLLOID INFORMATION CENTER**, (www.hydrocolloid.com, access: 20.06.2023).

[5] **CURUTCHET A., TRIAS J., TARREGA A., ARCIA P. 2020.** "Consumer response to cake with apple pomace as a sustainable source of fibre". Foods 10 (3), 499.

[6] **SCHMID V., TRABERT** A., **SCHÄFER J., M., HEIKE P KARBSTEIN, EMIN M.A. 2020.** "Modification of apple pomace by extrusion processing: studies on the composition, polymer structures, and functional properties". Foods 9(10): 1385.

[7] **PATENT NUMBER 241316.** "Use of extruded fruit and/or vegetable waste as an additive increasing the viscosity of food products" (WO/2020/209738).

[8] **ZININA O., MERENKOVA S., TAZEDDINOVA D., REBEZOV M., STUART M., OKUSKHANOVA E., YESSIMBEKOV ZH., BARYSHNIKOVA N. 2019.** "Enrichment of meat products with dietary fibers: a review". Agronomy Research 17(4): 1808–1822.

[9] **BAIOUMY A.A., ABEDELMAKSOUD T.G. 2021.** "Quality properties and storage stability of beef burger as influenced by addition of orange peels (albedo)". Theory and Practice of Meat Processing 6(1): 33–38.

[10] **YOUNIS K., SAGHIR A. 2018.** "Quality evaluation of buffalo meat patties incorporated with apple pomace powder". Buffalo Bulletin 37 (3): 389–401.

[11] **CARPENTER C.E., CORNFORTH D. 2001.** "Consumer preference for beef color and packaging affect eating satisfaction". Meat Science 57(4): 359–363.

[12] **HUBER E., FRANCIO D.L., BIASI V., MEZZOMO N., SALVADOR FERREIRA S.R. 2016.** "Characterization of vegetable fiber and its use in chicken burger formulation". Journal of Food Science and Technology 53: 3043–3052.