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# THE PROPERTIES OF POULTRY BATTERS DEPENDING ON THE AMOUNT OF WATER AND *PLANTAGO OVATA* HUSK

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## ABSTRACT

**Background.** *Plantago ovata* is a medicinal plant, rich in fibre. Its seed-husk (psyllium) is used to control constipation, obesity, diabetes and cholesterol levels etc. In the presented study, it was incorporated into poultry meat formulations and the quality parameters of the cooked samples were tested.
**Materials and methods.** Ground thigh meat from chicken was mixed with water and powdered *Plantago ovata* husk. The amount of water and husk ranged between 0–40% and 0–3%, respectively. The proximate composition of raw batters and cooked samples was tested. Production yields were calculated after cooking the samples in a water bath. Water activity, texture and colour parameters were analysed in the cooked samples.
**Results.** Fat content was lower in the samples with higher water addition. Water activity was lower in the samples with psyllium, but increased in the case of the highest water addition. Production yields were the highest while hardness was the lowest in the sample with both 3% of *Plantago ovata* husk and 40% of water. Lightness decreased when psyllium was added while redness decreased with both psyllium and water addition.
**Conclusion.** The formulation with 40% of water and 3% of psyllium was chosen as the best, due to high production yields. Further tests should be conducted to test microbiological stability, shelf-life and consumer acceptance of products manufactured according to the abovementioned parameters.

**Keywords:** poultry, psyllium, *Plantago ovata*, fibre, functional meat product

## INTRODUCTION

The term “functional product” is used, among other terms, for foods fortified with ingredients which have beneficial effects on health. It is used for products which have other advantageous qualities improving human well-being, despite their regular nutrition functions (Arihara and Ohata, 2011).

Introducing meat products fortified with fibre to the market may improve the health and well-being of many people (Kausar et al., 2019). Meat products can be modified with various ingredients. Using natural components is preferred by consumers who seek so called “clean label” products (Powell et al., 2019). Despite numerous scientific publications on health-promoting ingredients, functional meat products are still rare on the market. Many examples concerning the industrial application of various fibre sources can be found in the scientific literature, to mention only a few – apple pomace, tomato, citrus, rye bran or pea (Fernandez-Gines et al., 2003; Kehlet et al., 2020; Yadav et al., 2016). Fibres are mainly added to increase production yields and improve texture (Cofrades et al., 2000). It has been proved that they may be used as phosphate (Powell

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et al., 2019) or fat replacers (Berizi et al., 2017; Glisic et al., 2019). However, various quality changes in meat formulations occur. They depend on the amount and the method of incorporation of the fibre source. It was observed that incorporation of inulin in a gel form (16% of pork fat replacement) into fermented sausages decreased sausage hardness and springiness and increased adhesiveness (Glisic et al., 2019). While in the emulsion type sausages the quality of the modified product (33% of fat replacement) was comparable to the control (Berizi et al., 2017). Chicken sausages incorporated with sugarcane fibre up to 3% had higher lightness values and their hardness was higher (Fang et al., 2019). Moreover, the results of fibre addition depend on the type of product. In a study by Kehlet et al. (2020), it was proved that water binding and textural properties are different for sausages and meatballs at the same fibre addition level. Creating new products by incorporating functional ingredients leads to quality modifications in meat products. These are preceded by technological adjustments associated with changes in meat batters (Das et al., 2020). Due to this, careful analysis should be conducted of both the properties of the ready-to-eat products and of the batter to verify the extent of changes in the production when a new additive is applied.

One source of fibre that can be used in meat formulations is *Plantago ovata*, which is a medicinal plant commonly found in Western and Southern regions of Asia but also cultivated in America, the Mediterranean region of Europe and several former Soviet Union countries (BeMiller et al., 1993). It is cultivated for its seeds. The seed coats contain colourless mucilage treated as a good source of fibre. It has been proved to increase the satiety effect and, as a result, to control obesity. The study showed that the best results (the highest satiety) were obtained after serving a dose of 6.8 g before breakfast (Brum et al., 2016). High amounts of arabinoxylans with good gelling properties were identified in the mucilage (Guo et al., 2008). *Plantago ovata* husk (psyllium) is used in the treatment of constipation, in the reduction of cholesterol levels, and to control glucose levels in diabetes (Anderson et al., 1999; Anderson et al., 2000). Psyllium has been used to improve the dietary value of bakery products (Beikzadeh et al., 2017; Mariotti et al., 2009; Raymundo et al., 2014). However, to the best of the author's knowledge, data on the incorporation of psyllium into meat formulations are scarce.

The technological aspects of meat product modifications are of equal importance to dietary issues. From a producer's point of view, cooking losses related to water holding capacity and fat binding ability, gelling properties or emulsion stability are important production factors. Therefore, the aim of this study was to analyse the properties of poultry batters with variable amounts of water and *Plantago ovata* seed husk in order to indicate the optimal addition quantities of this type of fibre in meat products.

## MATERIALS AND METHODS

### Meat batter preparation

Boneless and skinless thigh meat from chicken obtained from a local retailer was ground (MADO, Germany) using a 5 mm plate and mixed with cold water, salt and powdered *Plantago ovata* seed husk (Targroch, Poland) in the proportions presented in Table 1. *Plantago ovata* husk was used as it was prepared by the producer – in the form of a powder. There were 2100 g of meat used in each batch – 300 g used for each variant.

Each of the seven variants was homogenized for 3 minutes (Robot Coupe R2, France) reaching a final temperature of 15°C ±1°C. Raw batter (50 g) was placed in plastic test tubes – diameter 25 mm (using a hand sausage filler (Biowin, Poland)), which were closed with plastic screw cups to avoid contact with water. The cooking procedure was conducted according to Fang et al. (2019) with modifications – in a water bath (90°C/20 minutes). Afterwards, it was cooled (4°C) in a laboratory refrigerator (Liebherr, Switzerland) and analysed the next day after pouring out the leakage. Two independent production batches with 3 replicates of each variant for one batch were prepared.

### Proximate composition

The proximate composition was analysed in the raw batters and cooked samples according to AOAC (2007). The cooked samples were ground using the MPW – a 120 laboratory homogenizer (Poland) prior to further analyses. All the analyses were conducted in duplicate.

**Table 1.** Composition of meat batters with variable water content and *Plantago ovata* husk

| Variant | Amount of water mL | Chicken thigh meat g | Salt NaCl g | *Plantago ovata* husk g |
|---|---|---|---|---|
| W0/H3 | 0 | 100 | 1.8 | 3 |
| W20/H3 | 20 | 100 | 1.8 | 3 |
| W30/H3 | 30 | 100 | 1.8 | 3 |
| W40/H3 | 40 | 100 | 1.8 | 3 |
| W30/H0 | 30 | 100 | 1.8 | 0 |
| W30/H1 | 30 | 100 | 1.8 | 1 |
| W30/H2 | 30 | 100 | 1.8 | 2 |

### Production yields

The cooked samples were dried gently with paper towel prior to weighing. Production yields were calculated using the equation:

$$\text{Production yields} = (W_a / W_b) \times 100\%$$

where:

$W_a$ – indicates the mass of the product after thermal treatment,

$W_b$ – indicates the mass of meat used for production.

### Water activity

Water activity was measured using a LabMaster $a_w$ – Novasina analyser (Novasina, Switzerland). Five grams of each sample were placed in a plastic container and analysed after stabilising them at room temperature (20°C).

### Texture Profile Analysis

Texture Profile Analysis (TPA) was conducted as described by Zajac et al. (2019). Samples (14 mm × 15 mm) were measured at room temperature. A cylindrical probe P100 was used. Instrument settings were as follows: probe travel rate before testing 5 mm/s, during and after testing 2 mm/s, final strain 50%, and time interval between first and second stroke of 3 s. Six independent readings were taken for each sample.

### Colour measurements

The colour of the samples was determined using a spectrophotometer (CM-3500d, Konica Minolta, Japan). CIE $L^*$, $a^*$ and $b^*$ values were calculated as the average for six random readings of the ground sample (standard illuminant D65, observer angle 10°). The instrument was calibrated on black glass and then on a white enamel tile according to the manufacturer's specifications.

### Statistical analysis

All data were subjected to a two-way analysis of variance where water and psyllium addition were fixed factors (Statistica, Tibco, USA). Two way ANOVA was conducted where water and psyllium addition were fixed factors. The Tukey *post-hoc* test was used to determine significant differences between means ($P < 0.05$). The differences between raw and cooked samples were analysed using the t-Student test. The results are presented as average values ±standard deviation.

## RESULTS AND DISCUSSION

### Proximate composition

An analysis of the basic chemical constituents was conducted to determine which components were lost during the cooking procedure. The results of the proximate composition are presented in Table 2.

Some of the anticipated results were obtained: water content in the raw batters was the highest in sample W40/H3, to which the highest amount of water was added; the lowest moisture content was noted for the sample to which water was not added (W0/H3). Similar results were noted in the cooked samples, but the values were lower due to water loss. The differences between the raw and cooked samples were determined using the t-Student test. In all of the variants, the water content

**Table 2.** Proximate composition of raw and cooked samples, g/100 g

| Variant | Moisture content | | Ash | | Protein | | Fat | |
|---|---|---|---|---|---|---|---|---|
| | | | | Raw | | | | |
| W0/H3 | 70.26$^{d}$ | ±0.18 | 2.60$^{a}$ | ±0.01 | 18.38$^{a}$ | ±0.35 | 7.86$^{a}$ | ±0.48 |
| W20/H3 | 74.94$^{c}$ | ±0.16 | 2.21$^{b}$ | ±0.02 | 15.67$^{b}$ | ±0.27 | 6.17$^{b}$ | ±0.02 |
| W30/H3 | 76.69$^{b}$ | ±0.44 | 1.98$^{bc}$ | ±0.04 | 13.14$^{c}$ | ±1.12 | 5.05$^{c}$ | ±0.54 |
| W40/H3 | 78.65$^{a}$ | ±0.05 | 1.86$^{c}$ | ±0.02 | 13.21$^{c}$ | ±0.30 | 5.49$^{bc}$ | ±0.17 |
| W30/H0 | 77.54$^{b}$ | ±0.07 | 1.99$^{bc}$ | ±0.05 | 14.51$^{bc}$ | ±0.30 | 5.80$^{bc}$ | ±0.10 |
| W30/H1 | 77.03$^{b}$ | ±0.07 | 2.00$^{bc}$ | ±0.01 | 12.10$^{c}$ | ±0.18 | 6.07$^{bc}$ | ±0.35 |
| W30/H2 | 76.58$^{b}$ | ±0.03 | 2.07$^{bc}$ | ±0.30 | 12.88$^{c}$ | ±0.45 | 5.57$^{bc}$ | ±0.25 |
| | | | | Cooked | | | | |
| W0/H3 | 68.86$^{d}$ | ±0.05 | 5.85$^{a}$ | ±2.01 | 20.18$^{a}$ | ±0.39 | 7.12$^{a}$ | ±0.09 |
| W20/H3 | 73.57$^{c}$ | ±0.08 | 2.36$^{b}$ | ±0.02 | 16.80$^{ab}$ | ±0.76 | 6.49$^{ab}$ | ±0.04 |
| W30/H3 | 75.55$^{b}$ | ±0.28 | 2.32$^{b}$ | ±0.37 | 17.57$^{ab}$ | ±2.31 | 5.75$^{b}$ | ±0.57 |
| W40/H3 | 77.08$^{a}$ | ±0.34 | 2.00$^{b}$ | ±0.00 | 14.66$^{b}$ | ±0.23 | 5.76$^{b}$ | ±0.03 |
| W30/H0 | 74.84$^{b}$ | ±0.91 | 2.04$^{b}$ | ±0.02 | 19.64$^{a}$ | ±0.41 | 5.90$^{b}$ | ±0.30 |
| W30/H1 | 75.50$^{b}$ | ±0.33 | 2.06$^{b}$ | ±0.01 | 19.01$^{a}$ | ±0.45 | 6.32$^{ab}$ | ±0.04 |
| W30/H2 | 75.72$^{b}$ | ±0.12 | 3.74$^{ab}$ | ±1.54 | 20.08$^{a}$ | ±0.78 | 5.73$^{b}$ | ±0.12 |

$^{a,b}$Different superscript letters in the same column indicate significant differences between mean values ($P < 0.05$).

decreased significantly. Only in sample W40/H3, the content of all of the other chemical constituents increased significantly after cooking. The ash content increased in samples W0/H3 and W20/H3, W40/H3 and W30/H1, while in the other samples it remained stable. The protein content increased in all of the samples except for sample W20/H3. The fat content in the batters and the samples resulted only from the content in the raw material as no additional fatty material was used. It was the highest in sample W0/H3. The other variants were comparable in fat content, both for the raw and cooked samples. The increase in fat content in the cooked samples was the result of water loss and proportional dry matter increase during the thermal treatment. The ash content was significantly higher in sample W0/H3 (both raw and cooked). No water was used in this sample along with 3 g of husk addition, which might have influenced these results. The average ash content in thigh meat is 1 g per 100 g of meat (Meluzzi et al., 2009), and additional mineral content comes from salt and the psyllium husk, in which the average ash content is 4 g per 100 g (Guo et al., 2008).

In all of the cooked samples water loss was noted. The highest water loss was observed in sample W30/H1, which did not contain any psyllium. This result clearly indicates that using *Plantago ovata* husk in meat formulations may prevent water loss during cooking. Despite the differences in husk amounts at the same water addition levels (samples W30/H0, W30/H1, W30/H2, W30/H3), the ultimate moisture content in the cooked samples was comparable. Contrasting results were reported by Yadav et al. (2016), who showed decreased moisture levels with the addition of fibre. The fat content increased in all of the samples except for sample W0/H3 (in which it was comparable in the raw and cooked samples), thus it may be concluded that husk addition did not influence fat binding. The fat binding ability of fibre depends on the particle size or the presence of lignin. Increased fat binding of sugarcane bagasse was the effect of lignin destruction in the study by Sangnark and Noomhorm (2003). The same authors showed that the smaller the particle size, the better the water-holding and oil-binding capacity. In research by Leonard et al. (2019), fat release in beef sausages with lupin flour was noted. Higher fat to water separation was observed in a study using citrus fibre to replace phosphates in pork meat formulations (Powell et al., 2019). This was explained by the high pectin content in the citrus fibre used. Clearly the differences in fibre ability to bind water and fat depend on fibre type. *Plantago ovata* husk consists of 85% water – soluble fibre, and 60% of its polysaccharides are arabinoxylans (Guo et al., 2008), which are responsible for the creation of viscous gel (Franco et al., 2020). It was proved that psyllium has a strong water binding capacity but very little information can be found on its fat binding properties (Franco et al., 2020).

## Physical analysis

Water holding capacity (WHC) is the ability of meat to bind its own water as well as that which is added. One of the methods used to analyse WHC is the measurement of cooking losses or production yields. From a technological point of view, control of WHC is one of the most important factors observed (Han and Bertram, 2017). The lowest production yields were detected in product W0/H3 (Table 3). This result was expected, as there was no water added during production. The highest production yields were noted for product W40/H3 with 3% psyllium and 40% water, which proved that psyllium addition can be an effective additive to be used in the industry. The results of production yields in variants W30/H0, W30/H1 and W30/H2 were comparable, although psyllium addition was different at the same amount of water. This could be explained by the fact that meat itself has the ability to hold some amount of added water. In other words, 30% water may be added to poultry thigh meat to obtain an average 20% increase in production yields. Similar results obtained for samples W30/H1 and W30/H2 indicate that 1% or 2% psyllium may be too low to affect production yields (at least in the case of poultry meat). The effects of psyllium addition was observed between samples W30/H3 and W30/H0. Some increase in production yield was noted in sample W30/H0 compared to sample W30/H3, but it was not significant. In many studies analysing the effects of fibre on sausage, production yields increased with the addition of fibre (Fang et al., 2019; Yadav et al., 2016). However, the maximal amount of added water in those studies varied between 15% and 30%. In this study, the maximum water addition was 40% at a husk addition level of 3%. It is probable that only direct

**Table 3.** Physical properties of cooked meat samples

| | Production yields % | | Water activity | | Colour parameters | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $L^*$ | | $a^*$ | | $b^*$ | |
| W0/H3 | $100.79^{c}$ | ±1.17 | $0.944^{b}$ | ±0.003 | $64.04^{c}$ | ±0.49 | $2.37^{a}$ | ±0.56 | $11.47^{a}$ | ±1.66 |
| W20/H3 | $119.00^{b}$ | ±2.32 | $0.948^{b}$ | ±0.003 | $64.60^{bc}$ | ±0.89 | $1.50^{b}$ | ±0.10 | $10.15^{a}$ | ±1.15 |
| W30/H3 | $124.35^{b}$ | ±5.37 | $0.948^{b}$ | ±0.001 | $64.14^{c}$ | ±0.89 | $1.35^{b}$ | ±0.33 | $10.17^{a}$ | ±1.48 |
| W40/H3 | $133.23^{a}$ | ±2.62 | $0.952^{a}$ | ±0.004 | $64.39^{c}$ | ±0.25 | $1.19^{b}$ | ±0.14 | $10.18^{a}$ | ±1.20 |
| W30/H0 | $118.01^{b}$ | ±1.54 | $0.954^{a}$ | ±0.001 | $68.15^{a}$ | ±0.14 | $1.54^{b}$ | ±0.06 | $9.89^{a}$ | ±0.15 |
| W30/H1 | $118.80^{b}$ | ±5.80 | $0.952^{a}$ | ±0.001 | $65.73^{b}$ | ±0.38 | $1.09^{b}$ | ±0.46 | $10.67^{a}$ | ±0.86 |
| W30/H2 | $120.19^{b}$ | ±7.58 | $0.947^{b}$ | ±0.000 | $64.73^{bc}$ | ±0.20 | $1.31^{b}$ | ±0.44 | $10.09^{a}$ | ±1.55 |

Mean values ±standard deviations.
$^{a,b}$Different superscript letters in the same column indicate significant differences between mean values ($P < 0.05$).

comparison of various fibres with the same type of meat would allow adequate conclusions to be drawn.

In research conducted on cookies, psyllium addition allowed water activity to be reduced (Raymundo et al., 2014). Cooked meat products are among the group of high water activity foods with values above 0.910. The growth of microbial strains is usually inhibited when water activity is below 0.950. This further depends on the type of product, the level of nitrite and salt, pH and other factors (Leistner, 1985). The water activity was lower in the samples with 3% husk and those with a water level from 0 to 30% (samples W0/H3, W20/H3, W30/H3) as well as in sample W30/H2. When there was no husk, 1% husk (samples W30/H0 and W30/H1 respectively) or when 40% water was added (W40/H3), the water activity values significantly increased. Therefore, in this case the water activity strongly depends on the water content in the sample.

Colour-related properties are important from a consumer point of view, as colour is the first factor considered when making a purchase choice. Colour perception is different depending on the product. Consumers expect a dark red colour when buying beef products and light pink when buying poultry. In the presented studies, significant differences were detected only in brightness and redness ($P < 0.05$). Clearly, husk addition decreased product lightness as the sample W30/H0 was the brightest (Table 3). According to Fang et al. (2019), lightness tends to increase with water addition, which was not observed in our studies. This might have been caused by the husk addition, which could, to some extent, mask the water effect.

The sample to which water was not added (W0/H3) was redder than the others. The colour of the final product depends on the type of fibre and its amount applied in the production process, as observed in several studies. Powell et al. (2019) did not detect any differences between the control and the samples with citrus fibre in *L* and *a** values, but parameter *b** increased due to the yellow colour of the fibre. The addition of roasted lupin resulted in darker sausages with increased *a** and *b** parameters (Leonard et al., 2019). In the sausages with sugarcane fibre, lightness and *b** values increased, while *a** values experienced a decrease (Fang et al., 2019).

## Texture profile analysis (TPA)

TPA analysis with two compression cycles was conducted to imitate mastication of a sample while biting and chewing. These results are presented in Table 4. The two-way ANOVA test showed the effects of water as significant, while psyllium addition had no significant effect on hardness. Hardness and chewiness measured using the TPA test were the highest in the sample without the addition of water (W0/H3) and the lowest in the sample with the highest water amount added to the batter (W40/H3). I was expected that in the samples containing the same amount of husk, the increase of water addition would decrease hardness.

**Table 4.** Texture profile analysis of cooked samples

| Variant | Hardness, N | | Adhesion | | Cohesion | | Chewiness, N | | Springiness | |
|---|---|---|---|---|---|---|---|---|---|---|
| W0/H3 | $39.35^{a}$ | ±4.74 | $-23.85^{a}$ | ±19.51 | $0.67^{a}$ | ±0.06 | $22.65^{a}$ | ±4.85 | $0.48^{a}$ | ±0.29 |
| W20/H3 | $18.34^{bc}$ | ±5.74 | $-12.36^{a}$ | ±7.92 | $0.76^{a}$ | ±0.22 | $4.94^{cb}$ | ±5.82 | $0.42^{a}$ | ±0.18 |
| W30/H3 | $21.97^{b}$ | ±3.89 | $-18.64^{a}$ | ±8.50 | $0.62^{a}$ | ±0.09 | $11.78^{b}$ | ±4.24 | $0.66^{a}$ | ±0.34 |
| W40/H3 | $10.65^{c}$ | ±5.26 | $-7.09^{a}$ | ±4.92 | $0.65^{a}$ | ±0.24 | $3.56^{cb}$ | ±2.35 | $0.33^{a}$ | ±0.17 |
| W30/H0 | $25.70^{b}$ | ±5.62 | $-27.63^{a}$ | ±15.47 | $0.74^{a}$ | ±0.06 | $15.08^{ab}$ | ±5.54 | $0.76^{a}$ | ±0.25 |
| W30/H1 | $20.42^{b}$ | ±6.36 | $-4.95^{a}$ | ±3.55 | $0.67^{a}$ | ±0.14 | $11.06^{b}$ | ±4.73 | $0.54^{a}$ | ±0.34 |
| W30/H2 | $22.02^{b}$ | ±4.14 | $-26.06^{a}$ | ±13.71 | $0.63^{a}$ | ±0.14 | $11.17^{b}$ | ±3.77 | $0.50^{a}$ | ±0.32 |

Mean values ±standard deviations.
$^{a,b}$Different superscript letters in the same column indicate significant differences between mean values ($P < 0.05$).

Such a result was obtained by Fang et al. (2019) in a trial on sausages with a 10% water addition. However, no such effect was observed in the research presented here. Moreover, the increase in fibre content at the same water level did not cause any significant changes in hardness as was detected in other studies (Cofrades et al., 2000; Fang et al., 2019; Powell et al., 2019). This effect depends on the type of fibre. Han and Bertram (2017) analysed model meat products with inulin, cellulose, chitosan and CMC (carboxymethyl cellulose sodium salt), and discovered that hardness did not change in products with inulin, but decreased in products with pectin and increased when cellulose or chitosan were added. Another factor affecting texture changes is fat content. In some studies, fibre was used to partially replace animal fat, which led to a reduction in the fat content of the sample. The tighter structure increased the connection between the ingredients and therefore increased hardness, cohesion and chewiness levels (Conroy et al., 2018). Furthermore, different texture values may be obtained depending on the method of fibre incorporation to the meat formulation. In research by Osheba et al. (2013), who used *Psyllium psyllium* seeds in beef sausages, the hardness was lower than in the control product. In this trial, psyllium colloids with water were prepared and as such added to the meat formulation. The results obtained in the studies presented in this manuscript did not suggest any significant differences in the remaining texture parameters (adhesion, cohesion, springiness).

## CONCLUSIONS

*Plantago ovata* husk changes the water content and properties of poultry meat formulations. From the producer's point of view, the formulation to which 40% water and 3% psyllium was added would be the most beneficial, as the production yields were the highest, although the hardness remained at a low level. Lightness was lower in all the samples with psyllium. Further research, including sensory analysis, should be conducted to test if all the detected changes influence consumers impressions of a product. The shelf-life and stability of the product should also be examined.

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