Valorization of Chicken Deboner Residues: Gelatin Extraction and its Application for Jellies and Films

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Summary

In recent decades, global food industry waste has significantly increased, with food waste categorized into human consumption and non-edible industrial by-products, including animal by-products. This study aims to reduce these by-products by repurposing chicken tissue for gelatin extraction. The gelatin extraction process from mechanically deboned chicken meat residues was optimized using food enzymes, and the physicochemical and rheological properties of the gelatins were analyzed. Temperature and extraction time, as independent factors, were examined using the Taguchi experimental design. Under optimal conditions, the resulting gelatins exhibited high gel strength (196 – 353 Bloom) and viscosity (3.2 – 7.6 mPa·s), making them suitable for gelling agents in jelly confectioneries. Furthermore, low Bloom-value chicken gelatins were used to create edible films, and tests on their sorption and desorption behavior revealed temperature- and humidity-dependent characteristics, with improved plasticity and reduced sorption hysteresis at higher temperatures. This environmentally friendly processing technology for mechanically deboned chicken meat residues aligns with zero-waste principles.

***Keywords**: animal by-products, gelatin, gelling properties, yield, surface properties, mechanically deboned chicken meat residue, multi-stage extraction, sorption isotherms, films, jelly*

Introduction

Two significant issues currently facing developed countries are the high level of food waste and the increase in animal husbandry, both of which have significant environmental impacts. Addressing these problems is essential for the planet's and its inhabitants' well-being.

Animal production and consumption contribute to increased greenhouse gas emissions (GHGEs), land use and degradation, water scarcity, nutrient pollution (e.g., acidification and eutrophication), the use of fertilizers and pesticides, and food waste along the entire supply chain, which exacerbates climate change and leads to further environmental deterioration, such as natural disasters, habitat and biodiversity loss, and freshwater scarcity in food systems.[1]

The most significant portion of food waste comprises vegetables and fruits (39%), followed by dairy products (17%) and meat (14%). In the European Union, nearly one-third of food produced for human consumption is wasted annually.[2] Discarding food also wastes the water, energy, and labor invested in growing, processing, packaging, and transporting it while increasing GHGEs, eutrophication, cropland use, and disposal costs.[1] Besides food waste intended for human consumption, other types of waste are not edible for humans. This summary will focus on a specific kind of inedible food waste: animal by-

products (ABPs), specifically chicken deboner residues (CDRs), which are primarily generated in slaughterhouses during meat production and can be further processed into high-quality, protein-rich products such as gelatin. The reusage of these ABPs promotes the reduction of food waste and provides new potential for the sustainable food industry.[3,4]

Poultry meat consumption continues to grow, with projections indicating an increase to 12,568 million tons by 2033 (currently around 12,386 million tons), leading to a rise in the production of high-protein ABPs.[5] In 2021, 677,200 tons of gelatin were produced from pork and beef. It is anticipated that the consumption of gelatin will increase by 8% annually. By 2035, porcine and bovine gelatin production is expected to be insufficient to meet global demand, making the production of gelatin from alternative collagen sources desirable. Prioritizing the valorization of animal by-products from slaughterhouses will be essential for managing solid waste. Additionally, porcine and bovine gelatin products are prohibited or have limited permission in Jewish and Muslim areas, whereas poultry (chicken), fish, frog, and insect-origin gelatins can be used without complications worldwide. Poultry gelatin is preferable to fish gelatin due to its lack of unpleasant odor.[6]

The production of gelatin from CDRs is a relatively unexplored area, with only a few studies conducted. Consequently, our research is pioneering in this field. Before delving deeper, it is essential to define what CDRs are. CDRs are chicken parts obtained from chicken waste through mechanical deboning operations. During this process, pressure is applied to separate the chicken meat from a slurry of ground meat and bones in a mechanical deboner. The resulting waste material, CDRs, contains a high percentage of bone, skin, and connective tissues, with its composition depending mainly on the raw input material. Typically, CDRs consist of about 20% protein, of which approximately 30 – 40% is collagen.[7]

Collagen, the most abundant structural protein in animals and humans, constitutes about 30% of the total protein content. It is primarily found in connective tissues, providing strength and flexibility. Although collagen is indigestible by humans, gelatin, produced through the partial hydrolysis of collagen, is a digestible, water-soluble, odorless, and transparent polypeptide with a high molecular weight. The properties of gelatin are significantly influenced by factors such as the raw material, the age of the animal, the type of collagen, the processing method, the tissue type, and the species involved. However, gelatin consists of various collagen fractions and peptide chains, which differ in size and weight. These variations contribute to gelatin's low melting temperature below 35 °C.[8,9]

Gelatin is one of the most versatile biopolymers, and it is utilized across multiple industries due to its properties. In the cosmetic industry, it is a gelling agent in products such as bath salts, shampoos, sunscreens, body lotions, hair sprays, and facial creams. In the food industry, gelatin is used as a gelling, foaming, clarifying, and stabilizing agent in canned meats, wine and beer brewing, and confectionery items like fruit salads, ice cream, foam, and cottage cheese. Its film-forming capability allows it to be used as a coating material or edible film to extend the shelf life of products. They enhance the quality of tropical fruits, berries, and vegetables by reducing weight loss, preventing color changes, slowing respiration rates, controlling ethylene production, and delaying ripening. This approach has gained significant attention recently, driven by the growing interest in healthier food options and dietary habits. In the medical and pharmaceutical sectors, gelatin is employed in soft and hard capsule shells, hydrogels, nano microsphere containers, nanofibers, absorbable sponges, pharmaceutical additives, matrices for intravenous infusions, injection drug delivery microspheres, implants, and cell transplantation carriers. Emerging medical applications include using ink for 3D/4D printing, tissue engineering, and gelatin-based 3D scaffolds. In the photographic industry, gelatin is an adhesive additive to silver salts. In forensic science, gelatin is applied as a gelatin-lifter for shoe print lifting, fabric imprints, and fingerprints.[10,11]

The processing of collagen comprises a sequence of technological steps like chemical, thermal, physical, and mechanical techniques. These various treatments affect the properties of the nascent collagen, such as its solubility, physical stability, DNA content, and colony-forming units. The chemical extraction of gelatin through partial acid-controlled hydrolysis of collagen is known as type A gelatin, while partial alkaline-controlled hydrolysis produces type B gelatin. Traditional acid and alkaline hydrolysis methods are slow, costly, energy- and water-intensive, and significantly impact the environment.[6,12]

In contrast to chemical agents such as alkalis and acids, enzymes are more environmentally friendly because they are biodegradable and do not produce unwanted by-products. Additionally, they are cost-effective by reducing production expenses and helping achieve the desired functional properties of gelatin. During enzymatic protein hydrolysis, proteins are broken down into soluble forms through the catalytic action of proteases. Commonly used enzymes include industrially produced microbial enzymes, animal enzymes like trypsin and pepsin, and plant enzymes such as papain.[6]

Aims of the study

Our research team has been focusing on minimizing the volume of inedible ABPs in the food industry by exploring the potential of a lesser-studied ABP—the CDRs, as an alternative secondary raw material for gelatin production.

The first goal of this paper was to prepare gelatins from CDRs using biotechnological methods. Secondly, to test the gelling and surface properties of prepared gelatins. These most critical physicochemical properties are the gel strength (GS), yield (Y), dynamic viscosity (DV), ash content (AC), gelling point (GP), melting point (MP), water-holding capacity (WHC), fat-binding capacity (FBC), foaming capacity (FC), foaming stability (FS), emulsifying capacity (EC), and emulsifying stability (ES). Gelatin yield was also determined, as it is a key factor in calculating the overall financial viability of gelatin production.[13] Further, high Bloom-value gelatin was tested for the preparation of jellies. Finally, low Bloom-value gelatin film preparation and testing of their sorption characteristics were conducted.

Methodology

The raw material underwent analysis to determine its moisture, ash, protein, and lipid content. Moisture and ash levels were measured gravimetrically[14], with ash content specifically assessed after sample incineration[15]. Lipid content was quantified using Soxhlet extraction[16], while nitrogen content was evaluated using the Kjeldahl method[17].

Our study utilized an innovative biotechnological approach that involved conditioning collagen with a microbial endoproteinase (Protamex®) at 0.4% addition (based on the dry collagen weight) in the case of jelly production and at 0.5% addition in the case of edible film preparation. Protamex® is a versatile, cost-effective *Bacillus*-based protease that efficiently breaks down collagen under milder conditions (pH 5.5 – 7.5, low temperature) without excessive degradation while minimizing short-chain peptide formation and meets JECFA and FCC food-grade standards. The enzyme conditioning was followed by a three-step hot-water extraction to control collagen's chemical and thermal denaturation for gelatin preparation. The three-step extraction is preferred to obtain a higher yield of gelatin.[13,18]

In the case of CDR gelatin aimed to prepare jelly, the experiments were designed using the Taguchi method with two factors at three levels: factor A represented extraction time (20, 40, and 60 minutes) at the 2nd fraction, and factor B represented extraction temperature (60 ± 0.2 °C, 64 ± 0.2 °C, and 68 ± 0.2 °C) at the 2nd fraction. The 1st fraction was extracted at 56 ± 0.2 °C for 2 minutes and then 85 ± 0.3 °C for 7 minutes, while the 3rd fraction was extracted at 80 ± 0.3 °C for 60 minutes. The tenth experiment was a control, conducted without enzymes.[13]

Gelatin's properties were analyzed using methods including gel strength measurement at 6.67% concentration by depressing the solution by 4 mm, dynamic viscosity calculation at 60 °C ± 0.5 °C based on flow time, yield determination as a percentage of gelatin weight relative to defatted raw material, and additional tests for pH in a 1–2% solution and ash content through gravimetric analysis after burning the sample.[19] The prepared jellies were evaluated through sensory testing to compare their key characteristics with commercially available products. Thirteen lay assessors, aged between 26 and 65 and all from Central Europe, participated in the evaluation. They assessed the jellies on the following attributes: 1) appearance, 2) chewiness, 3) color, 4) aroma, 5) taste, and 6) overall acceptability. The sensory attributes were rated on a 7-point scale, where 1 indicated "I extremely like this product" and 7 indicated "I extremely dislike this product."

To prepare edible films from CDR gelatin, a three-step extraction process was employed with the following parameters: the first fraction was extracted at 60 ± 0.2 °C for 3 minutes, followed by 85 ± 0.3 °C for 7 minutes; the second fraction was extracted at 70 ± 0.3 °C for 60 minutes, then at 85 ± 0.3 °C for 7 minutes; and the third fraction at 80 ± 0.3 °C for 60 minutes.[18]

Gelatin films from each fraction were prepared using the solution casting method. The gelatin samples were dissolved in water to prepare a 14% concentration solution, poured into 70 × 125 mm^2 film-shaped molds, and dried in an oven at 35 ± 0.7 °C. The water content of the films was measured using Karl Fischer Titration. Water activity (a_w) was determined using an equilibrium moisture content equation (1), adapted for the Modified Halsey model to analyze gelatin films' sorption and desorption behaviors. These measurements were conducted at temperatures ranging from 20 to 40 °C and relative humidity (RH) levels from 40 to 75%, increasing in 10% RH steps, with an equilibration time of 240 minutes at each step. For desorption studies, the process was conducted in reverse. The gelatin films were placed on aluminum trays during the experiments to ensure no overlap between samples.

$$X_e = \left[\frac{\exp(a-bT)}{-\ln(a_w)}\right]^{\frac{1}{c}} \quad (1)$$

Where X_e Is the equilibrium moisture content (%), aw is the water activity (decimal), T is the temperature (°C), and a, b, and c are coefficients that depend upon the product.[20]

Results and discussion

Parameters of gelatin preparation

The CDR raw material consists of 38.15% dry matter, with its composition based on dry matter including 28.59% ash, 25.97% lipid, 6.45% nitrogen, 40.31% total protein (calculated as nitrogen content × 6.25), and 68.3% collagen within the total protein content.

The main properties of gelatin that we tested and evaluated included Y on dry matter content, GS, DV, FC, FS, GP, MP, AC, WHC, FBC, EC, ES, and temperature interval of viscous state. Among these properties, GS is the primary attribute that most significantly indicates the quality of gelatin. The obtained results are presented in Table 1. Some parameters could not be measured due to the lack of a gelatin sample. The data were statistically processed and analyzed at a 95% significance level.[13]

Properties of gelatin jelly production

The obtained results identified two optimal conditions: the highest yield with a Bloom value suitable for the confectionery industry (260 Bloom) and the highest Bloom value gelatin fraction. The highest yield was achieved in the 9th experiment (68 °C extraction temperature and 60 minutes extraction time), where the Bloom value in the 2nd fraction was 289 Bloom, and in the 3rd fraction, it was 268 Bloom. The highest Bloom value was obtained in the 2nd fraction of the 8th experiment (68 °C extraction temperature and 40 minutes extraction time), with a value of 341 Bloom.[13]

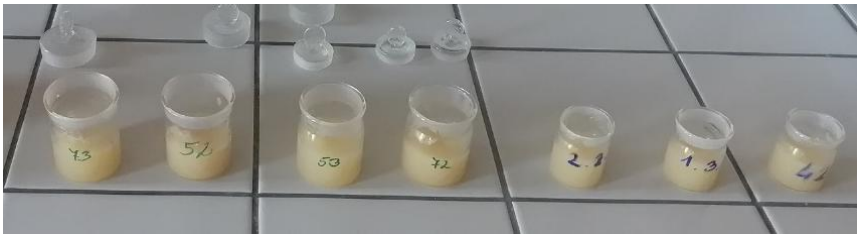

Figure 1: The prepared gelatin gels, from left to right: 7th experiment third fraction, 5th experiment second fraction, 5th experiment third fraction, 7th experiment second fraction, 2nd experiment second fraction, 1st experiment third fraction, and 4th experiment second fraction.[13]

Table 1: Parameters of all 2nd and 3rd gelatin fractions in each experiment: gel strength (GS), yield (Y), dynamic viscosity (DV), water-holding capacity (WHC), fat-binding capacity (FBC), emulsification capacity (EC) and stability (ES), ash content (AC), foaming capacity (FC) and stability (FS), gelling point (GP), melting point (MP), and temperature interval of viscous state. Some parameters could not be measured due to the lack of a gelatin sample. The 1st fractions did not form a gel and were therefore not tested.[13]

Number of experiments	Number of extractions	GS [Bloom]	Y [%]	DV [mPa·s]	WHC [%]/ WHC [mL/g]	FBC [mL/g]	EC [%]	ES [%]	AC [%]	FC [%]	FS [%]	GP [°C]	MP [°C]	Temperature interval of viscous state [°C]
1. [60°C, 20 min]	2nd	208	2.54	3.2	–	6.9	43.3	96.2	–	–	–	15.6	35.2	19.6
	3rd	231	4.51	5.0	–	7.2	46.6	94.5	–	–	–	22.1	35.5	13.4
2. [60°C, 40 min]	2nd	241	3.67	3.6	–	7.7	48.1	98.1	–	54	12	18.9	35.0	16.1
	3rd	297	5.36	6.9	33.2/ 8.3	5.0	44.1	96.2	–	60	4	22.2	34.2	12.0
3. [60°C, 60 min]	2nd	334	9.02	4.5	38.4/ 9.6	4.6	44.1	100.0	0.01	36	2	19.9	37.8	17.9
	3rd	281	6.50	5.6	36.8/ 9.2	4.2	45.8	92.6	–	52	2	22.8	37.2	14.4
4. [64°C, 20 min]	2nd	217	3.10	3.9	-	5.4	45.6	100.0	–	–	–	21.8	36.4	14.6
	3rd	295	4.80	7.6	32.4/ 8.1	5.3	50	94.7	–	42	0	23.8	34.6	10.8
5. [64°C, 40 min]	2nd	256	5.36	4.1	37.2/ 9.3	5.6	44.8	100.0	–	32	0	19.9	37.0	17.1
	3rd	200	7.61	4.4	41.6/ 10.4	7.6	45.8	100.0	–	36	0	19.9	35.4	15.5
6. [64°C, 60 min]	2nd	278	7.05	4.9	37.6/ 9.4	7.8	45.8	100.0	–	50	4	21.8	35.3	13.5
	3rd	267	7.33	7.2	38.9/ 9.7	8.3	43.9	100.0	–	30	0	23.7	35.5	11.8
7. [68°C, 20 min]	2nd	271	5.64	4.4	37.7/ 9.3	8.8	47.5	96.4	–	42	0	19.3	37.5	18.2
	3rd	217	7.89	4.4	30.9/ 7.7	7.6	46.6	92.6	–	40	0	19.1	35.7	16.6
8. [68°C, 40 min]	2nd	341	5.36	4.5	39.3/ 9.8	9.5	45.6	96.2	–	44	4	20.9	32.3	11.4
	3rd	274	6.76	5.0	24.2/ 6.1	8.7	46.6	98.1	–	44	2	20.2	35.5	15.3
9. [68°C, 60 min]	2nd	289	11.56	3.4	34.3/ 8.6	8.1	44.8	96.2	0.004	42	4	18.0	34.4	16.4
	3rd	268	7.05	4.0	21.7/ 5.4	7.7	44.8	100.0	–	44	4	22.4	32.8	10.4
10. [64°C, 40 min]	2nd	304	5.07	4.2	36.0/ 9.0	6.2	46.6	96.3	–	46	2	20.6	35.5	14.9
	3rd	308	8.17	5.5	30.3/ 7.6	7.9	44.8	96.2	–	46	0	18.8	32.4	13.6

Parameters of gelatin jellies

The average results of each sample sensory results are shown in Table 2. Sample **A** was the jelly made from 260 Bloom porcine skin gelatin in a bottom-like shape; sample **B** was also from 260 Bloom porcine skin gelatin in a sea creature form; sample **C** was made from 289 Bloom CDR gelatin (9th experiment, 2nd fraction) in a bottom-like shape; and sample **D** was made from 268 Bloom CDR gelatin (9th experiment, 3rd fraction) in a bottom-like shape, shown in Figure 2.[13]

Table 2: The arithmetic average results of sensory testing of each sample at each criterion.[13]

Jelly	Appearance	Chewiness	Color	Smell	Taste	Overall acceptability
A	2.3	2.8	1.8	2.9	2.5	2.4
B	1.7	2.9	1.8	2.2	2.5	2.3
C	4.8	2.7	4.5	3.8	3.1	3.8
D	4.8	4.6	4.3	3.9	3.5	4.8

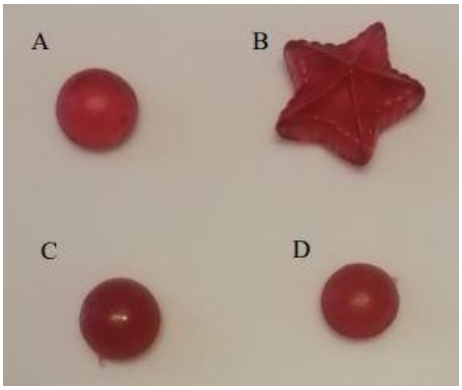

Figure 2: Samples: A) sample was the jelly from 260 Bloom porcine skin gelatin in a bottom-like shape; B) sample was also from 260 Bloom porcine skin gelatin in a sea creatures form; C) sample was made out of 289 Bloom CDR gelatin in a bottom-like shape; and D) sample was out of 268 Bloom CDR gelatin in a bottom-like shape.[13]

Parameters of gelatin film production

The parameters of the gelatin films are summarized in Table 2. The samples' initial water activity (aw) ranged from 0.38 to 0.40, with moisture content (measured at 103 °C for 4 – 5 hours) between 10 and 12%. The gel strength of the samples varied from 20.2 to 76.3 Bloom.[18]

Thickness is a critical characteristic of edible films, as it significantly influences coated food products' biological properties and shelf life. The thickness for edible films must be under ≤0.30 mm.[21] The water content in food influences its stability, appearance, texture, and taste and plays a critical role in controlling microbial growth. Edible films with low water content are more effective in minimizing damage and extending the shelf life of food products.

Table 3: The properties of each type of edible film.

Parameters	Fraction 1	Fraction 2	Fraction 3
Weight (mg)	9.6 ± 0.3	9.2 ± 0.3	9.2 ± 0.3
Thickness (mm)	0.28 ± 0.03	0.27 ± 0.02	0.30 ± 0.04
Area (mm^2)	33 ± 3	32 ± 4	31 ± 3
Water content (%)	10.0 ± 0.02	12.0 ± 0.03	11.0 ± 0.02
Gel strength (Bloom)	20.2 ± 0.5	76.3 ± 1.0	50± 0.8
Dynamic viscosity (mPa·s)	1.62 ± 0.03	1.96 ± 0.03	2.33 ± 0.04
Melting point (°C)	29.1 ± 0.5	33.2 ± 0.6	29.8 ± 0.05
Gelling point (°C)	15.6 ± 0.3	15.2 ± 0.3	13.3 ± 0.4
Water activity (decimal)	0.38	0.40	0.40

Tables 4 and 5 show that the moisture content of the samples never exceeded 23% of the equilibrium moisture content, which is considered an acceptable level of water content for edible films.[22] Thus, according to the statistical results, the Modified Halsey model was used to represent the results due to the high protein content of the gelatin samples.[20,23]

Table 4: The kinetic parameters for moisture adsorption of chicken gelatin from 75 to 40% of RH. Equilibrium moisture content: equilibrium moisture content at 75% RH; k: rate constant; Half-time: time to adsorb half of the total moisture content; Span: the difference between the initial and final moisture content of the sample (at 40 and 75% RH).

Moisture adsorption		Fraction 1	Fraction 2	Fraction 3
20°C	**Equilibrium moisture content (%)**	19.90 ± 0.03	20.36 ± 0.06	19.9 ± 0.1
	k (min^{-1})	0.0109 ± 0.0002	0.006 ± 0.0001	0.0037 ± 0.0002
	Half-time (min)	63.6	115.5	187.3
	Span	7.5	7.8	7.2
30°C	**Equilibrium moisture content (%)**	20.54 ± 0.05	22.0 ± 0.1	20.7 ± 0.1
	k (min^{-1})	0.0186 ± 0.0005	0.0142 ± 0.0006	0.01 ± 0.0005
	Half-time (min)	37.3	48.8	69.3
	Span	8.3	9.9	8.6
40°C	**Equilibrium moisture content (%)**	21.4 ± 0.1	22.67 ± 0.06	21.85 ± 0.06
	k (min^{-1})	0.047 ± 0.003	0.039 ± 0.001	0.045 ± 0.002
	Half-time (min)	14.8	17.8	15.4
	Span	9.6	10.9	10.2

Table 5: The kinetic parameters for moisture desorption of chicken gelatin from 75 to 40% of RH. Equilibrium moisture content: equilibrium moisture content at 75% RH; k: rate constant; Half-time: time to adsorb half of the total moisture content; Span: the difference between the initial and final moisture content of the sample (at 40 and 75% RH).

Moisture desorption		Fraction 1	Fraction 2	Fraction 3
20°C	**Equilibrium moisture content (%)**	16.25 ± 0.06	16.18 ± 0.09	15.98 ± 0.07
	k (min^{-1})	0.071 ± 0.004	0.065 ± 0.004	0.061 ± 0.003
	Half-time (min)	9.8	10.7	11.4
	Span	3.8	4.3	3.8
30°C	**Equilibrium moisture content (%)**	14.57 ± 0.06	14.7 ± 0.1	14.3 ± 0.1
	k (min^{-1})	0.092 ± 0.005	0.086 ± 0.005	0.06 ± 0.004
	Half-time (min)	7.5	8.1	11.6
	Span	5.8	7.1	6.0
40°C	**Equilibrium moisture content (%)**	13.21 ± 0.09	13.3 ± 0.1	12.9 ± 0.1
	k (min^{-1})	0.115 ± 0.005	0.10 ± 0.005	0.103 ± 0.005
	Half-time (min)	6.0	6.9	6.7
	Span	8.1	9.1	8.8

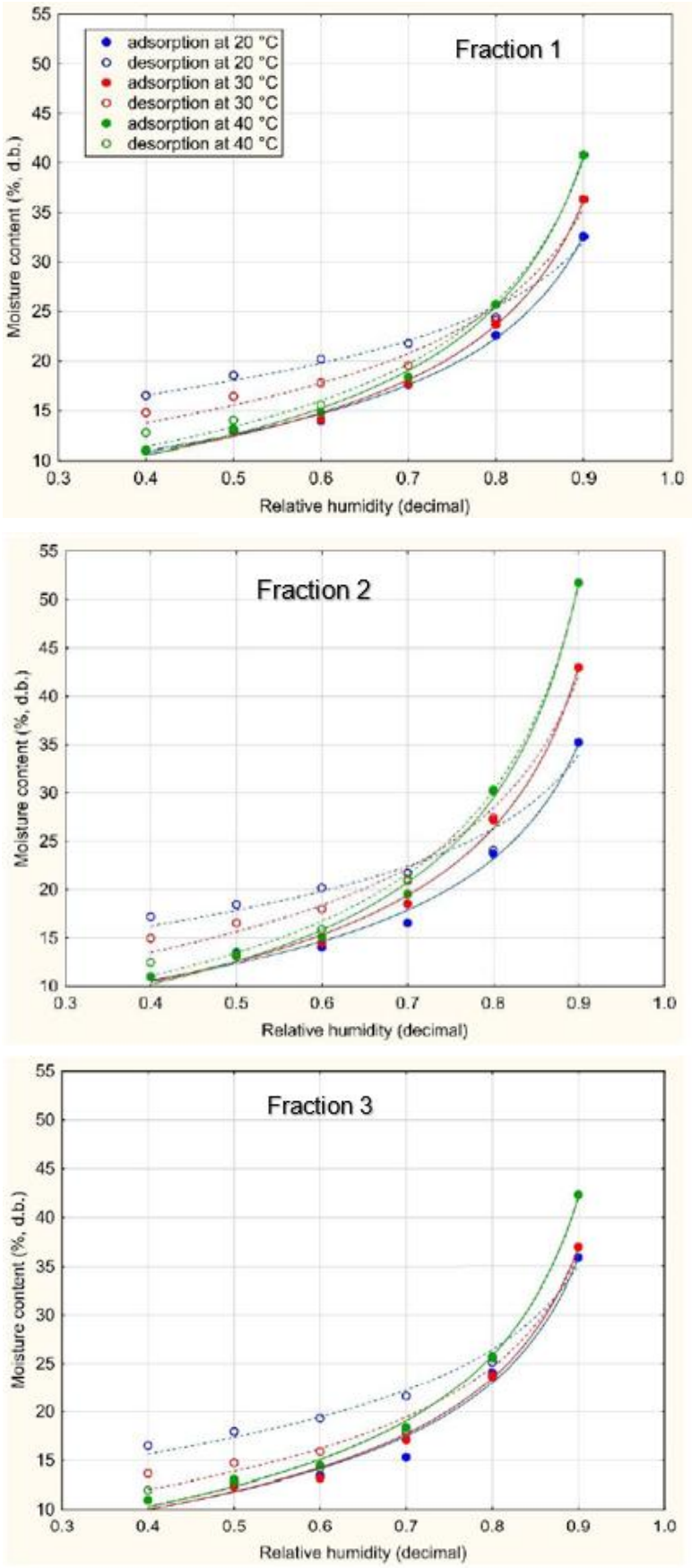

Figure 3: Sorption properties of each fraction at each temperature between 0.4 and 0.9 RH.

The adsorption and desorption behaviors of the samples were significantly influenced by temperature. Adsorption rate constants (k) increased with temperature for all samples, and the Span parameter indicated more significant moisture adsorption at higher temperatures. At 20 °C, Fraction 1 exhibited the fastest adsorption rate, followed by Fractions 2 and 3. This trend was also observed at 30 °C, but at 40 °C, the rate constants became similar across all samples. Moisture desorption was faster than adsorption for all samples and at all temperatures, with desorption rates generally increasing with temperature. However, for Fraction 3, the desorption rate remained constant at 20 °C and 30 °C and increased only at 40 °C. Differences in desorption rates between samples were minimal at a given temperature.

At higher relative humidity (RH) values (0.8 – 0.9), Fraction 2 adsorbed significantly more moisture at 30 °C and 40 °C than the other samples. In contrast, adsorption rates were similar across samples at RH levels of 0.4–0.7, with isotherm crossovers occurring at higher RH, where adsorption increased with temperature (shown in Figure 3 A), B), and C)). Fractions 1 and 2 showed consistent isotherm behavior across all temperatures, while Fraction 3 demonstrated a unique rebound in adsorption at 40 °C.

Sorption hysteresis, characterized by incomplete moisture desorption, was observed across all samples. The hysteresis effect decreased with increasing temperature and was almost negligible at 40 °C. This behavior is likely due to temperature-induced plasticity in the material, reducing the formation of microstructural gaps that trap water molecules during adsorption. Aguirre-Álvarez et al. also found the same phenomena in the case of bovine gelatin (gel strength 225 Bloom), pig skin gelatin (gel strength 270 Bloom), fish gelatin (gel strength 260 Bloom), and poultry gelatin (gel strength 240 Bloom) and Fikry et al. in case of whitefish skin gelatin at 25 °C, 35 °C, and even at 45 °C.[24,25]

Conclusion

Our study underscores the promising potential of CDRs as an alternative raw material for gelatin production, offering comparable properties to conventional gelatin. Using biotechnological methods, we successfully produced gelatins with desirable physicochemical properties suitable for various applications. Optimal extraction conditions led to high-quality gelatin, with a gel strength of up to 341 Bloom, demonstrating the viability of CDRs in various industries as pharmaceuticals (for nano- and microsphere containers and hydrogels), medicine (as an encapsulating material for drugs or chemicals), and food (for jellies, gelatin desserts, and meat emulsions). Sensory testing on jellies confirmed its potential in the food industry. However, a higher Bloom value (>260) is needed for texture comparable to candies produced with the use of commercial (pig or bovine) gelatins. A higher enzyme concentration revealed that slight changes in protease dosage significantly impact collagen structure, yielding lower molecular weight gelatin with reduced gel strength and viscosity, which is suitable e.g., for edible film production. Low-Bloom CDR gelatin films showed temperature- and humidity-dependent behavior, with enhanced plasticity and reduced sorption hysteresis at higher temperatures. Utilizing even the lower-Bloom value gelatins contributes to a circular economy, reducing inedible ABPs and providing a sustainable, financially viable alternative to traditional gelatin sources. Our findings suggest that CDRs could play a significant role in gelatin substitution, offering a more sustainable approach to gelatin manufacturing and reducing its environmental footprint.

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Využití zbytků po odstraňování masa z kuřat: Extrakce želatiny a její aplikace pro želé a fólie

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Souhrn

V posledních desetiletích došlo k významnému nárůstu odpadů v celém potravinářském sektoru. Odpad z potravin se rozděluje na odpad pro lidskou spotřebu a na nepoživatelné průmyslové vedlejší produkty, včetně nevyužitých živočišných tkání. Cílem této studie je snížit vedlejší živočišné produkty opětovným využitím kuřecího odpadu na extrakci želatiny. Proces extrakce želatiny ze zbytků po výrobě strojně odděleného kuřecího masa byl optimalizován použitím potravinářského enzymu; byly analyzovány fyzikálně-chemické a reologické vlastnosti získaných želatin. Teplota a doba extrakce byly zkoumány jako nezávislé faktory Taguchiho experimentálním schématem. Za optimálních podmínek získané želatiny vykazovaly vysokou pevnost gelu (196 – 353 Bloom) a viskozitu (3,2 – 7,6 mPa·s), což je činí vhodnými pro použití jako gelačních činidel, např. při výrobě želatinových cukrovinek. Želatiny s nízkou pevností gelu byly použity k přípravě jedlých filmů, přičemž testy jejich sorpčního a desorpčního chování odhalily teplotně a vlhkostně závislé vlastnosti; při vyšších teplotách došlo ke zlepšení plasticity a snížení sorpční hystereze. Environmentálně šetrná technologie zpracování zbytků po výrobě strojně odděleného kuřecího masa na želatiny je v souladu s principy oběhového hospodářství s minimalizací nevyužitých produktů vzniklých v průběhu technologického zpracování.

Klíčová slova*: vedlejší produkty živočišného původu, želatina, želírovací vlastnosti, výtěžnost, povrchové vlastnosti, zbytek ze strojně odděleného kuřecího masa, vícestupňová extrakce, sorpční izotermy, filmy, želé.*