Potensi Tepun Bulu sebagai Bahan Pakan Ternak

Mata kuliah Ilmu dan Teknologi hasil Ikutan

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Pendahuluan

- Pelestarian fungsi lingkungan hidup→ pemanfaatan limbah peternakan dengan prinsip *zero waste*→ mengurangi atau meminimalisasi pencemaran lingkungan dengan cara pemanfaatan limbah.
- Bulu ayam sekitar 6% dari total bobot ayam→sebagai by product yang berpotensi sebagai sumber pencemaran.

Potensi bulu ayam

- Sebagai sumber protein pakan alternatif pengganti sumber protein konvensional seperti kedelai dan tepung ikan.
- Mengurangi impor bahan baku pakan yang harganya relatif mahal.
- Permasalahan dalam pemanfaatan limbah bulu ayam karena adanya kandungan keratin→protein fibrous yang kaya sulfur dan banyak terdapat pada rambut, kuku dan semua produk epidermal.
- Kecernaan yang rendah karena tepung bulu ayam mengandung ikatan sistin disulfida, ikatan hidrogen, dan interaksi hidrofobik molekul keratin.
- Keratin tidak larut dalam pemanasan alkali dan tidak larut oleh kelenjar saluran pencernaan atau pankreas.

Komposisi nutrien Hidrolisat Bulu Ayam

Nutrien		Kandungan Nutrien
Bahan kering	(%)	91,37
Protein kasar	(%)	79,88
Lemak kasar	(%)	3,77
Serat kasar	(%)	0,32

Perbandingan Komposisi Kandungan Asam Amino antara Tepung Bulu Ayam, Tepung Ikan dan Bungkil Kedelai

Asam amino (%)	Tepung bulu ayam	Tepung ikan	Bungkil Kedelai
Arginin	5,57	4,21	3,14
Histidin	0,95	1,74	1,17
Isoleusin	3,91	3,23	1,96
Leusin	6,94	5,46	3,39
Lisin	2,28	5,47	2,69
Methionin	0,57	2,16	0,62
Penil alanin	3,94	2,82	2,16
Treonin	3,81	3,07	1,72
Triptofan	0,55	0,83	0,74
Valin	5,93	3,90	2,07

Sumber: *National Research Council* (1994)

Pengolahan limbah bulu ayam

- Perlakuan Fisik
  - Perlakuan fisik dengan penggilingan→ proses perombakan bentuk fisik bahan ransum menjadi partikel yang lebih halus sehingga mudah dikonsumsi ternak.
  - Bentuk fisik bahan ransum akan mempengaruhi tingkat kesukaan makan (palatabilitas) ternak.
  - Tepung bulu ayam sebelum difermentasi harus diautoklaf supaya steril dan bebas dari kontaminan mikrobia lain.
  - Penggilingan dilakukan untuk memperkecil partikel bahan ransum→semakin halus akan semakin mudah dikonsumsi oleh ternak→ proses pencernaan berjalan lebih cepat.

- Perlakuan Biologis
  - Fermentasi menggunakan mikrobia (bakteri / jamur) yang dapat meningkatkan kecernaan bahan ransum
  - Pada proses fermentasi terjadi proses perombakan/perubahan kimia dari senyawa organik komplek (karbohidrat, lemak, protein, dan bahan organik lain) baik dalam keadaan aerob maupun anaerob melalui bantuan enzim yang berasal dari mikrobia menjadi komponen yang lebih sederhana dan memiliki tingkat kecernaan yang relatif lebih tinggi.
  - Hasil fermentasi mempunyai nilai nutrien yang baik dari asalnya karena mikrobia bersifat katabolitik atau memecah komponen yang kompleks menjadi lebih sederhana sehingga mjudah untuk dicerna oleh hewan ternak.

Production of feather protein concentrate

Feathers

⇓

Alkaline treatment (0.3 M NaOH, pH 8, 80°C)

⇓

Increase of reaction temperature to 180°C (pH 8.5)

⇓

Alkaline protease treatment (1.25 g, 55°C, 120 rpm for 2 h)

⇓

Neutralization (pH 7.0)

⇓

Enzyme activity stopped (95°C for 15 min)

⇓

Freeze-drying

⇓

Feather protein concentrate

Pemberian pada unggas

- Pemberian tepung bulu dengan level 0; 2,5; 5; 7,5 dan 10%:
  - Rata-rata konsumsi ransum pada minggu pertama mengalami penurunan (132, 131, 130, 123, 111 gr/ekor/minggu I)
  - Rata-rata konsumsi ransum pada minggu ke-2 mengalami penurunan (231; 231; 231; 200; 201 gr/ekor/minggu ke-2
  - Demikian juga dengan minggu ke-3, ke-4, dan ke-5

- Data rata-rata konsumsi ayam broiler umur 0-6 minggu (gram/ekor/minggu):

Konsentrasi tepung bulu	Total konsumsi (gr/ekor)	Rerata (gr)
0	1552	388^{C}
2,5%	1534	383^{C}
5%	1554	388^{C}
7,5%	1444	361^{B}
10%	1413	353^{A}

Pertambahan berat badan

- Pemberian tepung bulu dengan level 0; 2,5; 5; 7,5 dan 10%:
  - Rata-rata berat badan pada minggu pertama mengalami penurunan (87, 84, 85, 64, 61 gr/ekor/minggu I)
  - Rata-rata berat badan pada minggu ke-2 mengalami penurunan (133, 131, 134, 135, 130 gr/ekor/minggu ke-2)
  - Demikian juga dengan minggu ke-3, ke-4, dan ke-5

- Data rata-rata pertambahan berat badan ayam broiler umur 0-6 minggu (gram/ekor/minggu):

Konsentrasi tepung bulu	Total konsumsi (gr/ekor)	Rerata (gr)
0	820	205^{C}
2,5%	827	206^{C}
5%	830	207^{C}
7,5%	667	166^{B}
10%	609	152^{A}

Data Feed Conversion Ratio

Konsentrasi tepung bulu	Data FCR (total 4 minggu)	Rerata
0	7,3	1,84^{A}
2,5%	7,2	1,81^{A}
5%	7,2	1,80^{A}
7,5%	9,14	2,29^{B}
10%	10,10	2,52^{C}

Keratinase Enzime

Purification and biochemical characterization of a detergent-stable keratinase from a newly thermophilic actinomycete *Actinomadura keratinilytica* strain Cpt29 isolated from poultry compost

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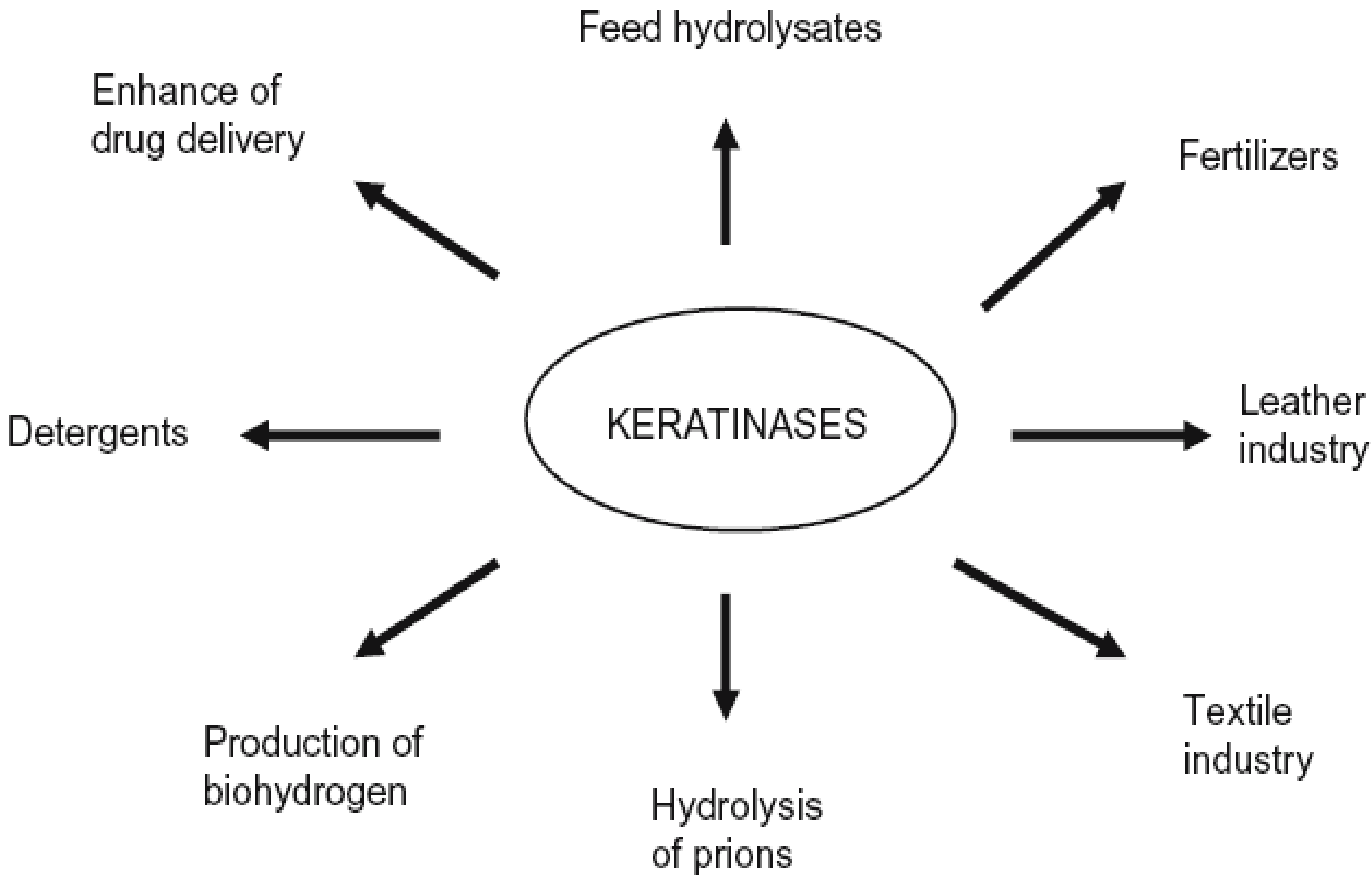
Feed hydrolysates
Enhance of
drug delivery
Fertilizers
Detergents
KERATINASES
Leather
industry
Production of
biohydrogen
Hydrolysis
of prions
Textile
industry

- Keratins are insoluble structural proteins found in skin, hair, wool, feathers, and nails. Compared to other soluble proteins, they are known to show high mechanical stability and resistance to the action of proteolytic enzymes such as pepsin, trypsin, and papain
- The mechanical stability of keratins stems from the tight packaging of proteins in a-helix (a-keratin) or b-sheet (b-keratin) structures and their high degree of cross-linkages by disulfide and hydrogen bonds
- Poultry feather contains more than 90% of crude protein in the form of keratin. The crude protein content in feather waste has a high nutrient value and may be used as a protein alternative to more expensive dietary ingredients for animal feed

- Worldwide, commercial poultry processing generates 5 millions of tons of feathers per year, which are currently converted to feather meal through steam pressure and chemical treatment.
- Though making keratin waste more digestible, this chemical treatment process is both costly and destructive to certain amino acids.
- The nutritional upgrading of feather meal with the treatment of microbial keratinase might lead to a significant increase in the availability of amino acids in feather keratin.

- In fact, keratinases have been successfully applied in several biotechnological processes, including the introduction of enzymatic dehairing in the leather industry, production of slow-release nitrogen fertilizers in the agricultural industry, and synthesis of biodegradable films and coatings in the biomedical industry.
- Keratinases have been purified from different microorganisms including fungi, such as *Microsporum* and *Chryseobacterium indologenes* TKU014, and bacteria, such as *Bacillus* spp. and *Streptomyces*.

- Serine peptidases have been isolated, purified, and characterized from various *Streptomyces* species, including *Streptomyces griseus*, *Streptomyces fradiae*, *Streptomyces thermoviolaceus* SD8, *Streptomyces graminofaciens*, and *Streptomyces* sp. strain AB1

INTRODUCTION

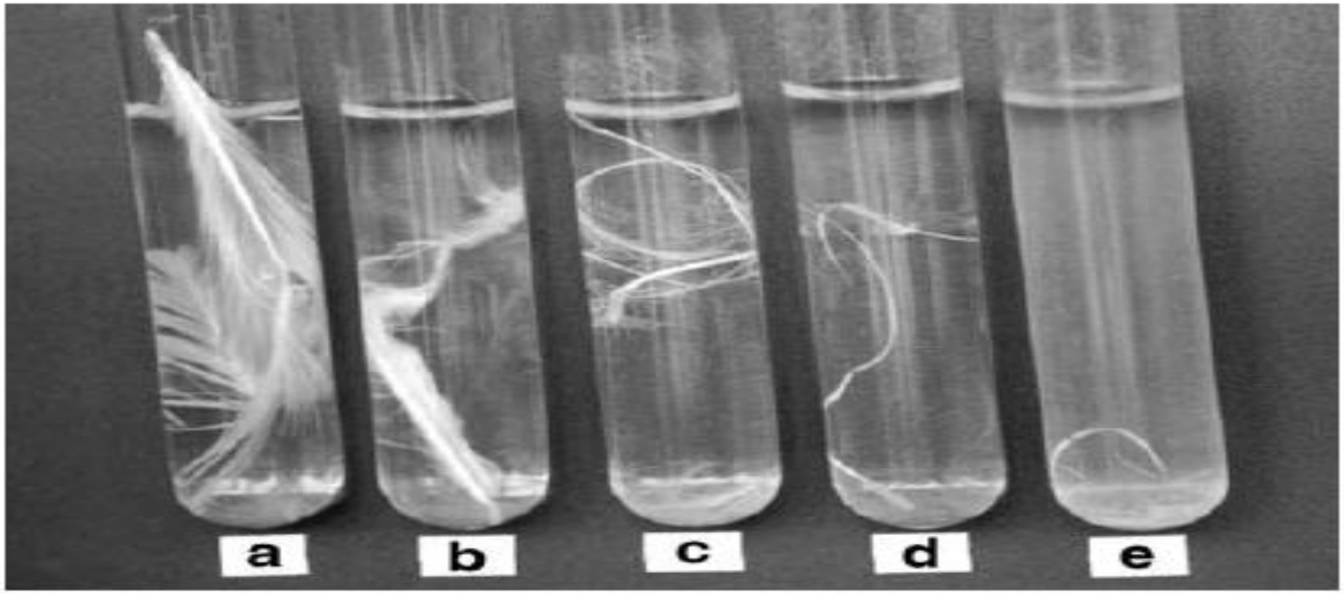

Fig. 2 Feather degradation by *Microbacterium* sp. kr10 after *a* 2, *b* 24, *c* 48, *d* 72, and *e* 96 h

- The keratinous wastes largely comprising of the insoluble structural protein “keratin” is increasingly accumulating in the environment mainly in the form of feathers, hair generated from various industries.
- Today, it is also becoming a part of solid waste management since it is told to degrade due to the highly rigid structure rendered by extensive disulfide bonds and cross-linkages.
- Hence, there is a demand for developing biotechnological alternatives for recycling of such wastes.

(A) (B)

Fig. 4. Keratin(feather)-degradation by *B. pumilus* strain CBS and SAPB. (A) Feathers were incubated for 24 h at 37°C under shake culture condition with 2.8×10^{8} cells/ml as an initial inoculum density of the strain CBS (right flask) and with autoclaved inoculum as control (left flask). (B) SABP was incubated for 24 h at 37°C with chicken feather.

Fig. 4 Dehairing activity of keratinase kr6 on bovine pelts. *a* Control with heat-denatured keratinase, *b* keratinase treatment, *c* and *d* keratinase treatment followed by gently scrape

- Keratin forms a major component of the epidermis, hair, feathers, nails, horns, hoofs, and wool.
- On the basis of secondary structural confirmation, keratins have been classified into:
  - (α-helix of hair and wool)
  - β (β-sheets of feather)

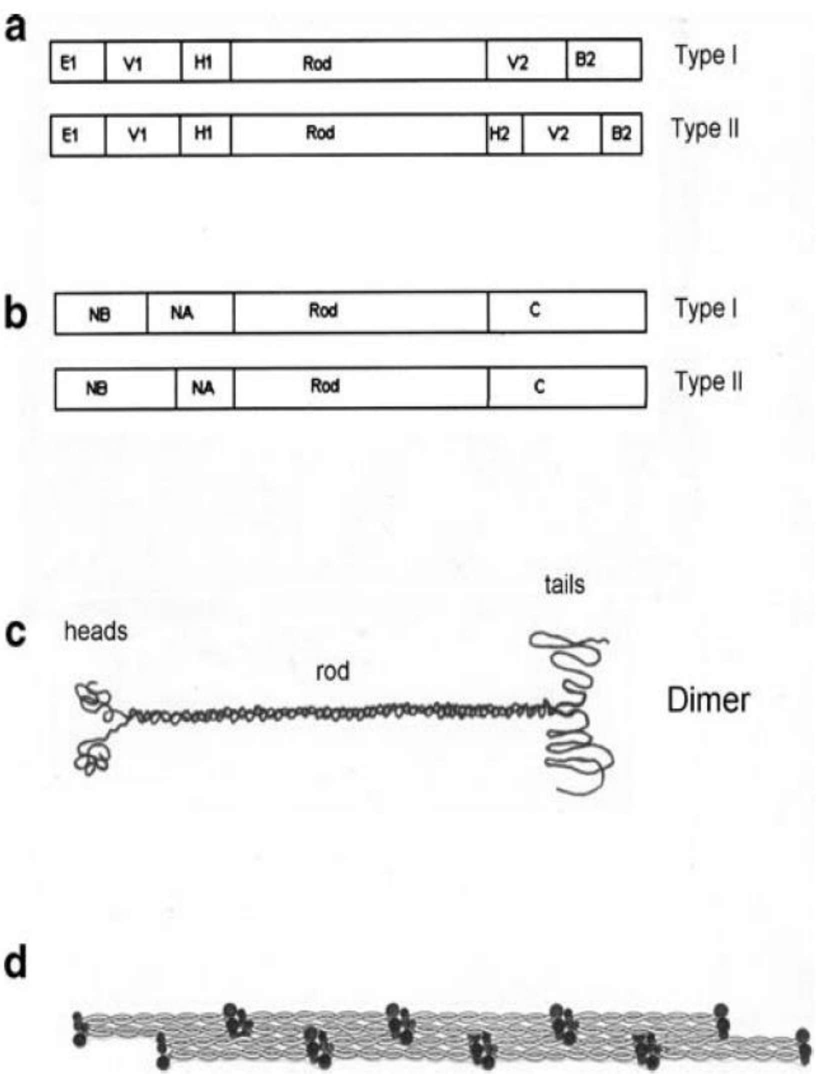

Fig. 1 **a** Subdomain structure of epidermal keratin chains showing the basic short end regions E1 and E2, the variable glycine/serine-rich regions V1 and V2, and the homologous regions H1 and H2 (Steinert 1993). **b** Subdomain structure of hard α-keratin chains showing the basic (*NB*) and acidic (*NA*) regions of the N-terminal domain. The C-terminal domain of the type I chains is characterized by a repeated proline–cysteine–X motif. The C-terminal domain of type II chains contains a periodic distribution of hydrophobic residues (Parry and North 1998). **c** Model structure of keratin coiled-coil dimer, 45 nm in length. The hydrophobic amino acids of the two α-helices are meshed together in a regular interlocking pattern (Cohlberg 1993). **d** Organization of keratin microfibrils, showing the globular head and tail domains (in *black*). The terminal domains can interact with segments in the rod domain and with other C domain in an antiparallel neighboring molecule (Parry and North 1998)

Characteristic of keratin

- The keratin fibrils in both the configurations are twisted in a parallel manner to form micro and macro fibrils that warrant stability to the fiber.
- Keratins are also grouped into hard and soft keratins according to the sulfur content.
  - Hard keratins found in feathers, hair, hoofs and nails have high disulfide bond content and are tough and inextensible.
  - Whereas, soft keratins like skin and callus have low content of disulfide bonds and are more pliable.
- The intensive cross-linkage in keratins block of way their degradation by commonly known proteolytic enzymes like trypsin, pepsin and papain.
- Despite the recalcitrance, keratin wastes can be efficiently degraded by a many of bacteria, actinomycetes and fungi due to the elaboration of keratinolytic proteases—keratinases.

- Keratinases [EC 3.4.21/24/99.11] are by and large serine or metallo proteases capable of degrading the structure forming keratinous proteins.
- Since most of the purified keratinases known to date cannot completely solubilize native keratin, their exact nature and uniqueness for keratinolysis is still an confusing in the world of proteases.
- Although, keratinases in nature have been continuously contributing to valorization
- of voluminous keratin containing wastes in the form of hair, feathers, dead birds and animals (Onifade et al. 1998;
- Farag and Hassan 2004).