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Peptide and Oligosaccharide Nutraceutical Feeding in the Upper Rumen Stomach and Lower GI Tract in Livestock: A Commentary

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ABSTRACT

Nutraceuticals can affect transactions immunologically for health and endocrinologically for production and reproduction, specifically, referring to bioactive peptidomemics and saccharomemics in disease resistance and immunlogical balance. The nutraceuticals: Vit D2/D3, fructans and WSCs, PUFAs, alpha-lactoferrin and polysaccharides can affect SCI and as indicated by blood biomarkers. The functional amino acids (FAAs): histidine (HIS), arginine (ARG), lysine (LYS) and leucine (LEU) can affect lean body mass (LBM) accretion and milk production with bovine growth hormone (bGH)/bovine growth-releasing hormone (bGRH) and prolactin. The two prebiotic nutraceuticals referred to can be applied to "designer" oligomers from enriched seed proteins and polysaccharides to improve feed nutritive value (NV). High non-fibrous carbohydrate (NFC) and water-soluble carbohydrate (WSC) grasses can also provide higher-end energy forages. There are, thus, proteinogenic approaches that can be used for supplemental feeding. It is suggested that lower quality residual feedstocks can be converted to food-feed applications and can involve pretreating of fibrous carbohydrates (FC) and NFC, conversion to natural sugars and sweeteners, and "shuffling" copolymerization. Applications can be made to fishmeal for production and health. Slowed reaction enzymes (SRE) can be used with so-called osmolytic resins to study behaviour of pre-formed amino acids (PFAAs) in the rumen milieu to fit rumen protein solubility with use of inhibitors to both plant and microbial proteases, modulating as a result the MCP and "escape" protein flows to the lower GI tract. Clean tech can produce seed-derived proteins using "bulk" cell culturing (processed and unprocessed) and extracted/enriched yeast culturing. There is a need to verify the prebiotic binding receptors in the small intestines (SI) (e. g. gut-associated lymphoid tissues, GALT, and as speculated the SI's jejunum).

Key words: proteinergic, rumen stomach, lower GI tract, peptides, Oligosaccharides, nutraceuticals, livestock production.

INTRODUCTION

Metabolically, nutraceuticals fed can affect transactions for digestion for productive function in the rumen stomach and the animal's lower GI tract immunologically to fight disease, maintaining immunological balance and health and leading endocrinologically to further stimulate productive and reproductive functions.

To follow is the discussion specifically of nutraceuticals, in particular, peptidomemics and saccharomemics, that is, the bioactive peptides and oligosaccharides, respectively, unique but

not modified in amino acid (AA) residues in their structures of interest in ligand-receptor binding to substrates.

IMMUNOLOGICAL AND ENDOCRINOLOGICAL EFFECTS ON LIVESTOCK PRODUCTION

The following aspects are involved with nutraceuticals and the whole GIT as an immune organ: 1) immunity, viz. adaptive immunity, for disease resistance and for gut health, and 2) immune balance and maintenance of its health status and involving the condition of the systemic chronic inflammatory (SCI) response from nutraceutical-SCI interactions.

There is an added dimension with immune function, gut health and further systemically and that is with new conjectures regards nutritional and health benefits from nutraceuticals such as: a) Vitamin D2/D3, b) fructans amongst the other WSCs, c) omega-3 fatty acids or polyunsaturated fatty acids (PUFAs), d) alpha-lactoferrin from milk, and e) polysaccharides from algae. They can have far-reaching physiological effects in regards the SCI condition as assessed by immuno biomarkers from blood plasma. FAAs as: HIS, ARG, LYS and LEU can have production benefits from increased hormonal levels, for e. g., bGH/bGRH and prolactin for LBM accretion and milk production.

TWO MAJOR NUTRACEUTICALS FOR THE UPPER TRACT RUMEN STOMACH

There are two possible major nutraceutical factors of significance proposed for the improvement with rumen gut performance:

Peptidomemic Prebiotics

Amongst topics with new lower-yielding forage feeding regimens, the author presents here the so-called Protein-Energy Theory of rumen digestion which could involve prebiotic agents to microbial digestion with proteins, peptides and amino acids and polysaccharides, oligosaccharides and sugars. Practical application to this theory are proposed for the manufacture commercially of “designer” or “bioactive” peptides and oligosaccharides and enriching feeding regimens, for e. g., from extracted or enriched seed sourced proteins of exceptionally high nutritional quality to increase feed nutritive value (NV), cf. the latter for nitrogen status in regards to LBM accretion or lactation, intake with increased N status and energy balance regulation, less physical limitations to rumen and whole tract digestibility, and the overall productive output from the animal, for further commercialization with R&D. It should be added also that there are non-fibrous carbohydrate (NFC) fractions in addition to WSCs from grass-type forages for higher-end energy nutrition. These nutritional features are part of the proteinergic mechanism to be employed for supplemental functional feeding of ruminants including both classes of small and large animals.

Saccharomemic Prebiotics

Recent developments for the Protein-Energy Theory (Flores, 2024) for rumen gut digestion with the hypothetical saccharomemic prebiotics are with polysaccharides, both FC and NFC and WSC for energy to support maintenance and productive and reproductive functions such as for beef production and lactation for dairy. There are also other possible matters in lower gut digestion where there could be digestive endproduct-gut interactions for various immunological, endrocrinological and nutritional effects by such classes of prebiotic agents.

FUNCTIONAL SEED PROTEINS AND CARBOHYDRATE SUPPLEMENTS WITH LOWER-QUALITY FEEDS

It is recommended to consider replacing food-feed competing resources or feedstuffs (e. g. cereals, whole fish, vegetable oils and pulses) with potential circular food system byproducts and residues and it is therefore suggested that there is a need for use of upcycled feeds to expand on global food supply be to be used with animal feeding (V. Sandstrom et al., 2022).

As pretreatment and value-added processing proceeds with these classes of feed resources there is a need to consider in farming and industry supplemental feeding that is both functionally and economically competitive such as oilseed supplements (e. g. canola and sunflower) for further manufacturing.

Two stages prior to full commercialization scale-up for production is predicted for this type of industrial activity. There would be pilot-plant testing for products of business partners or collaborators to provide commercial services including consultancy for analytical testing and eventual set-up for their commercial operations. And another semi-works facility towards company-owned production processing to start development of manufacturing.

Future R&D would involve:

1. Further exploratory characterization of potential seed sources and their proteins (e. g. cereals or grains as in canola).
2. The consideration of seed anatomy of seed proteins from their plant biology.
3. Technology to boost production of specific proteins by non-GMO direct-applied (DA) for gene-based regulatory organismal (GRO) cropping for field and Clean tech bioreactor applications.
4. Extraction and purification of bioactively valuable peptides and other nutritional proteins in bulk and also specific oligosaccharides and their complex carbohydrates yet to be further researched and identified.
5. Bioinformatics research for proteins and gastroenterological studies with intestinal digestion and bioassays as to their functionality and quality to develop direct-applied (DA) technologies in the field and with biofermentation.
6. The following components for commercial, or at this stage, pilot-scale extraction and purification process development of plant protein substrates include: aqueous protein extraction, clarification and separation (e. g. cold pressing of oilseeds), membrane filtration-microfiltration, ultrafiltration, nanofiltration and reverse osmosis (MF. UF, NF, and RO), solid/liquid and liquid/liquid separation, drying (heat treatment, spraying and freeze-drying) and end process blending and upscaled value-added ingredient isolation.

USE OF LOWER-QUALITY RESIDUAL FEEDS FOR FOOD-FEED

Lower-quality Feeds or Feed Crop Residual (FCR) Conversion to Food-Feed

a) Pretreatments of FC and NFC to remove lignocellulose components. Enzymatic: lignocellulases- including lacasses, proteases. Chemical: H2SO4, HCl, NaOH and NH3. Physical: milling and steam explosion (SE) of fibrous substrates.
b) Separation of carbohydrates and sugars: washing, filtration, drying of the raw substrate and enzymic conversion and separative precipitation using enzyme-

derived enantiomeric crystallization. Racemization, follows with exclusive conversion of purified natural sugars and other sweeteners.

c) Prep separation intake based on a stochiometric mix made at set point. This is followed by enzymatic synthetic "shuffling" with copolymeric synthesis to oligomers. The enzymes are in proportional control as to their "endpoint" as per stage of polymerization and then repeated in cycle. The value as a nutraceutical of complex sugars are to be evaluated from converted monomeric units to bioactive saccharomemics or oligosaccharides.
d) Specifically, fishmeal feed applications are to be investigated for their role in immunity and health, and for better growth and development, in the gut of fish, as with the salmon hatcheries in newly established land-based facilities situated upstream from their spawning rivers and their tributary streams. The above use in fishmeals of polymerics for fish are in addition to use of yeast single-cell protein (SCP) and various functional amino acids (FAA).

Slowed Reaction Enzymes (SREs) in the Rumen Upper GI Tract with Feeding

The Protein-Energy Theory earlier discussed by D. A. Flores (1991), restated in essence here: controlling accessibility of protein in the rumen to provide adequate support for MCP synthesis is key to optimizing the output from the rumen stomachs for protein nutrition from its metabolic and physiological digestive process.

Technology with osmolysis of particular resins has been proposed to study the availability of PFAAs from the rumen milieu dosed with 15N label using rumen accessible cannulated sheep. Proposed are the uses of proteases attenuated to tailor-fit feed protein solubility and with respect to the uptake of microbial cells measured by the efficiency of nitrogen uptake (ENU) parameter earlier by Thompson and Beever (1980) measuring ratios of microbial amino acid-N to the total N digested for uptake including PFAAs or peptide-N plus free amino acid-N, amine-N, amide-N and NH3-N. SREs as they are termed here, will be employed at enzymatic rates of addition, along with protease enzyme competitive inhibitors (i. e. to the active site itself) and non-competitive inhibitors (i. e. allosterically) for both feed plant and rumen microbes. Readjusting effectively the proteolytic capacity pegged to protein solubility in the rumen would be the objective at modulating rumen protein digestion for both MCP and "escape" protein flows to the lower tract (i. e. to the duodenum) or the SI.

CONCLUDING REMARKS

Nutraceuticals such as the class of prebiotics are definable, using in particular the peptidomemics or peptides and their enzymic "targets" of which three are known by e. g.: 1) SREs in the rumen with plant protease digestion, 2) in the internal microbial machinery of rumen MCP synthesis and, finally, 3) antibiotic growth promoters (AGPs). In fact, the application of peptidomemics are potentially widespread at the level of the lower GI tract in animal models for health benefits related to stress, disease resistance, heart health and Cancer.

As mentioned earlier in Flores (2024) Clean Tech is predicted to succeed in providing the following functional feed nutraceuticals from peptidomemics in the plant feed substrate, thus: 1) a "bulk" matrix of either seed proteins from cell culture (unprocessed) and seed protein from

cell culturing (processed), and 2) as well as “neat” extracted/enriched from biofermentation in yeast culturing.

Much is to be explored further as to our prebiotics and their capacity to bind to receptors in the GALT or some nearby section in the small intestines (e. g. jejunum) and to study their effect on metabolism within the inner lumen of the intestines and post absorptively across the luminal intestinal barrier.

As of now, there is no clear, definitive picture comprehensive enough to describe a new role of the whole gut organ in the animal model as to their immunological and endocrinological significance and what this means for animal health and production.

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Conflict of Interest Declaration

The author declares here no conflict of interest in the preparation of this paper.

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