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Relationships between probiotic lectins and postbiotics

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Abstract

The ways within metabolic axes (from intestine biotopes to another body types of biotopes) and experimental approaches in study of postbiotics in connection to probiotic lectin system functioning are proposed, described and discussed. The own data on functioning of the mucosal biotope probiotic compartment (probiotic cells plus probiotic lectins) serve the basis to systematize, detail, and simplify the search, characterization, and application of postbiotics of potential therapeutic significance. Probiotic lectin system shows itself as an important source and regulator of postbiotic system recognizing glycoconjugates needed for a deeper mucosal immunity. Probiotic lectins possess potential of the direct and indirect conversion into synergistic sets of postbiotics. Consideration of relationships between probiotic lectins and postbiotics is important for increasing microbiocenose health support, makes reliable event forecasting, and justifies further algorithms of recognition processes in connection with prognostic mucosal immunity.

Keywords: Probiotics; Postbiotics; Probiotic lectins; Glycoconjugates; Health; Diseases.

1. Introduction

Postbiotics (PB) include metabolites of the vital functioning probiotics, early or late products of the probiotic cell surface envelope and cell wall molecules and their complexes resulting in a broad spectrum of useful for human activities which normalize, stimulate and support processes directed against infections, tumors and other pathologies when function in mucosal biotopes, tracts and organs. PB are represented as products of bacterial cell wall hydrolysis (peptidoglycans and lipopolysaccharides), cell surface or secreted proteins and polysaccharides, derivatives of amino acids (Trp and others) and short-chain fatty acids, vitamins which participate in supporting healthy status of organism (preferentially mucosal open cavities) [1, 2]. Therapeutic PB (TPB) are factors supporting health and directing against infectious processes and diseases [2-9]. Objects of PB therapy include pathological cases and diseases of children and adults that accompany alterations of mucous (enterocolitis, diarrhea [also of rotavirus nature], pharyngitis, laryngitis), antibiotic resistant infections, Non-Alcoholic Fatty Liver Disease (NAFLD), neurologic pathologies, others [3].

It was shown by us that probiotic lectin systems (PLS recognizing and reversibly binding carbohydrates and glycoconjugates [GC] but are different from antibodies and true enzymes) are new perspective factors of immunity support. They are widely distributed in the human body, participate in innate immunity and co-function with other protective systems. PLS serve the supra-molecular basis for assembling effectors, involve in forming healthy dynamic reversible infrastructure and signaling network, and are directed against pathologies; they operate within the framework of organism lectin super-system with probiotic action and results [10-14].

According to both own and literature data, relationships between cell surface (glyco) proteins-containing recognition structures of lectin type are now obvious. The latter is also confirmed in case of the whole probiotic compartment in biotope (PLS and probiotic cells) in reactions influencing functional status of the mucosal epithelial barrier – advanced post of the mucosal immunity at the level of mucosal organs [15-19]. PLS participate in infrastructure organization and

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signaling within mucosal biotope; they function as metabolomebiotics and carriers of metabiotic drugs of GC type, protect mucous, contribute to contraction diseases of microbiocenoses, reveal similar to cytokines functions of supporting healthy biotope status [20-23]. The aim – to propose theoretical justification and experimental approaches for study of TPB in direction of pathological targets as it takes place in cases of interaction between PLS and GC; to evaluate contribution and prospects of TPB as additional factor of mucosal immunity.

2. Pathway relationships between PLS and PB

2.1. Pathways of probiotic lectins conversion to PB [24-33]

Possible mechanism of such conversion includes shedding cell surface associated PLS into liquid surrounding. Further early and delayed transformation and degradation of secreted proteins and their complexes into more widely repertoire of GC-recognizing components with lower molecular masses and increased traffic, permeability and availability to targets took place and indicated more pronounced adaptive molecular potential of PB. We established the strain-specific protease systems (proteinases plus peptidases) functioning in multistrain probiotic microbiocenosis (Acilact) as well as (probiotic bifidobacterial strain)-dependent depolymerases. These hydrolases play an important role in conversion and truncating/limiting hydrolysis of the original products. Using visual imagination in a real time, on example of bifidobacterial cultures we showed that depolymerases are localized within contact region between substrates - cationic exopolysaccharides (EPS) and enzyme forms (possessing lower pI compared to EPS), and process of hydrolysis (as parallel one to PB accumulation) is revealed and increased in the late and long-stored probiotic cultures. Another possible mechanism of the peptide PB effectors involves interaction of effectors with probiotic bacterial biosurfactants (BS) [26].

2.2. Pathways of co-functioning and synergism of PLC and other type effectors and factors [25-28, 34, 35]

Such pathways include co-functioning PLS and BS or EPS of the probiotic strains of bifidobacteria and lactobacilli. Delivery of PLS and/or GC (those who enter into synergetic functioning not only among themselves but also with other categories of anti-pathogens such as antibiotics, chemotherapeutic agents, other drugs) as well as PLS-GC complexes (complexes with a new extended recognition potential and biological activities) to the mucosal biotopes are improved.

2.3. Other factors increasing PB levels

2.3.1. Cultural peptide formulas for evaluation of PB

On example of Acilact system, peptide formulas were proposed using estimation of partially hydrolyzed protein in culture, [36, 37]. It is possible to use proposed approaches and peptide formulas in study of potential PB sets, kits and their combinations.

2.3.2. Sources of the Trp catabolism derived PB

On example of cultural purified proteins and PLS of bifidobacterial probiotics and Acilact, the simple sensitive analysis of the Trp and its derivatives presence (using second derivative of absorbance protein spectra or fluorescent spectra) can be performed [36, 38]. The strain-dependence of absolute quantitatives of Trp and other key amino acids which are producing by lactobacilli of Acilact has been established [36]. Effective delivery systems can be developed on Trp derivative based delivery of PB into mucous [39].

2.3.3. Controlled degradation of the probiotic polymers with hydrolases

According to visual chemiluminescent image-analysis in a live regime, the following data allowing biopolymer degradation control were obtained: a) visible changes of the protein patterns due to the action of (multi)strain-dependent presence of proteinase systems in (multi)probiotic cultures were established (on example of Acilact); b) depolymerases are localized in contacts to their targets (EPS) as in cases of probiotic bifidobacterial cultures (the visible destruction within the border of well-visible contact region as the local alteration of the symmetry of EPS image pattern is observed); c) hydrolysis of initial biopolymers can be simply controlled and visually described according to formula proposed by us (on example of bifidobacteria) [25, 40, 41]. The use of PLS as a regulating factor in respect of hydrolases in biotope-like surroundings is promising for modulation [inhibition] of activities up to 60-100%) as in case of using eukaryotic enzymes [42]. The promise of the latter aspect of PLS is confirmed by numerous data on the role of lectins as enzyme modulators and stabilizers (through enzyme carbohydrate moiety) for all enzyme classes [27-31].

2.3.4. Dispersion of a cell mass to enhance microbial metabolism [43-45]

During cultivation of bifidobacteria and lactobacilli when cultures reach a certain concentration of cells with properties of agglutinins (such as cell surface EPS, glycoprotein complexes and PLS) in culture, conglomerates of microorganisms with a property of mini-biofilm conservation are formed. For destruction of the intercellular matrix and resulting increase of release of free colony-forming cells, a method of dispersion (minutes) of culture liquid can be proposed (on example of bifidobacteria *B. adolescentis* MC-42, *B. longum* and *B. bifidum* 791) using ferromagnetic elements of an electromagnetic dispersant [43]. It is shown that an effectiveness of the method depends on both a microbiocenosis species composition and the choice of nutrient type (on examples of casein-yeast and thioglycol culture media). This method allows increasing the number of colony forming cells of bifidobacteria in suspension up to 20 times. High cell concentrations in mixed bifidobacteria-lactobacilli microbiocenoses having cell associates may be considered as a further perspective proposal for formulas of microbiocenosis delivery into mucous of organism open cavities to increase stability and survival of multiprobitics producing PB.

2.4. Ways to evaluate the microbial associates influence [43-47]

Bifidobacterial and lactobacillar cell associates were observed as processes accompanying isolation and storing of microbiocenosis preparations as well as in connection with accumulation of the cultural microbial masses. Effective agents of the cell aggregates dissociation can involve not only combinations of hydrolases, but also BS, EPS, detergents and chelators of metal cations (agents are present in cultures or added to them). Optical density registration of microbial suspensions within first three days cultures in the presence of PL allows tracking and separating processes of cell dissociation and amplification. In case of solid-phased microbiocenoses, there are perspective approaches to visual control of dissociation of PLS-sensitized cells within assembled cell gradients imitating biofilms [47].

2.5. Strategies and algorithms in study of TPB recognizing GC [14, 24, 36, 48-50]

They include the following ones (in brackets – some details):

- *the choice of metabolic axis “intestine—skin/ liver/ brain/ other” for the preferential PB action [3];
- *the choice of microbiocenosis/ microbiome cultures (accenting the role of taxonomic status of composition; the choice of the nutrient media with specific stimulators within microecological network metabolism);
- *evaluation/ monitoring of amino acids, volatile fatty acids, cell wall constituents, other perspective established chemical structures and compositions as well as bio-oligo- and polymers to ensure probiotic pressure and obtaining predicted sets of TPB;
- *further optimization of targeting cell cultures (the use of optimized physical and physico-chemical and chemical stimules and additives) when wishful producers of TPB must reveal a limited but increased profile of action;
- *identification of and sorting PLS (as potential carriers of GC of therapeutic significance) upon screening of multi/mono-probiotic cultures;
- *the choice and optimized conversion procedures PLS-to-PB (using separate or mixed [as in multi-strain probiotics] hydrolases, BS, EPS, detergents, cationic metals, other ingredients/ stimulators needed);
- *identification of leaders in co-existing competitive populations of microorganisms (leader isolates/strains of microbes that can reorganize niche relationships between microbial (sub)species in a considered microbiocenosis [50] to accent production of PB needed;
- *testing targeted TPB (interaction with sets of selected critical GC involving in TBB based reactions of the local [according to the axis “intestinal-another body part”] physiological significance).

3. Conclusion

The prospects of obtaining and study of PB directing against GC-containing targets are indicated. The data presented systematize, detail, and simplify search, characterization, and application of TPB in accompanying therapy. PLS are perspective sources and regulators of production of synergistic sets of TPB. The prospects of forming and designing TPB of lectin recognition type directed against the emergence and development of a wide range of infectious processes and related diseases in the body are open and will be extended.

Compliance with ethical standards

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Disclosure of conflict of interest

Authors declare the absence of conflict of interest statement.

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