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ANTISERA POTENTIAL OF INDIGENOUS NIGERIAN PLANT LECTINS: A REVIEW

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Abstract

Lectins are carbohydrate-binding proteins ubiquitous in nature, particularly abundant in plants. Indigenous Nigerian plants represent a vast untapped resource for novel lectins with diverse biological properties. This review explores the potential of these lectins as anti-sera agents. We will discuss the isolation, purification, and characterization of lectins from Nigerian plants. Additionally, we will explore the in vitro and in vivo studies evaluating their agglutination activity against various blood types. The review will highlight the advantages of utilizing indigenous lectins for therapeutic applications due to their potential specificity and reduced immunogenicity. Finally, we will address the challenges and future directions for research in this field, emphasizing the need for further exploration and development of these promising anti-sera agents from Nigeria's rich botanical heritage.

Key words: Lectins, anti-sera agents, agglutination activity, indigenous plants, applications.

Introduction

Lectins, a diverse group of carbohydrate-binding proteins (CBPs) widely distributed throughout nature, play a crucial role in various biological processes [1]. Primarily found in plants, particularly seeds and legumes, lectins exhibit specific binding affinities towards glycans (saccharide moieties) on cell surfaces [2]. This selective binding property has garnered significant interest in the field of biomedicine, particularly for their potential applications in blood typing, diagnostics, and therapeutics [3].

Nigeria, a nation blessed with exceptional biodiversity, boasts a rich botanical heritage encompassing over 8,000 documented plant species [4]. This vast and largely unexplored plant kingdom holds immense potential for the discovery of novel lectins with unique characteristics. In recent years, there has been a growing focus on exploring the therapeutic potential of indigenous Nigerian plant resources [5, 6]. There are no such pronounced research endeavours, regarding applicability of lectins in Blood Group Serology. This review delves into the anti-sera potential of lectins derived from Nigerian plants, highlighting their prospects for blood typing and transfusion medicine applications.

Lectins: A Versatile Group of Carbohydrate-Binding Proteins

Lectins, also known as agglutinins, are a heterogeneous group of proteins or glycoproteins non-covalently bound to carbohydrates [7]. They are ubiquitous in nature, found in plants (phytolectins), animals (animal lectins), microorganisms (bacterial and fungal lectins), and even viruses [8]. Notably, plant lectins are the most extensively studied group, with a vast array of structures and functions [9].

The defining characteristic of lectins is their ability to bind reversibly and specifically to specific carbohydrate moieties on glycoconjugates (molecules containing carbohydrates linked to proteins or lipids) [10]. This selective binding is mediated by one or more carbohydrate recognition domains (CRDs) within the lectin structure. CRDs are typically composed of amino acid residues that form hydrogen bonds, hydrophobic interactions, and van der Waals forces with the functional groups on the carbohydrate ligand [11]. The specificity of lectin-carbohydrate interactions is influenced by several factors, including the lectin's primary, secondary, and tertiary structure, the type of sugar residues present on the ligand, and the spatial arrangement of these sugars [12].

Lectins exhibit a wide range of biological functions, playing crucial roles in plant defense mechanisms, seed recognition, symbiosis, and cell-cell adhesion [13]. In plants, lectins can agglutinate (clump) pathogenic microorganisms, thereby preventing infection [14]. They can also participate in seed development and germination by mediating interactions between the seed coat and symbiotic bacteria [15]. Additionally, lectins have been implicated in plant-pollinator interactions, where they may guide pollen towards the ovule for fertilization [16].

Significance of Blood Typing in Blood Transfusion Science

Blood typing, a fundamental procedure in transfusion medicine, involves determining an individual's blood group (ABO type) and Rh factor (positive or

negative) [17]. This information is critical for ensuring safe and compatible blood transfusions, as incompatible blood types can lead to severe and potentially fatal reactions [18].

The ABO blood group system, the most widely recognized blood typing system, classifies blood into four main groups: A, B, AB, and O [19]. This classification is based on the presence or absence of specific carbohydrate antigens (A and B) on the surface of red blood cells (RBCs) [20]. Individuals with type A blood have A antigen on their RBCs, while those with type B blood have B antigens. Type AB individuals possess both A and B antigens, and type O individuals lack both A and B antigens [21].

The Rh factor is another important determinant of blood compatibility. The Rh factor refers to the presence or absence of the Rh 'D' protein on the RBC membrane [22]. Individuals with the Rh 'D' protein are Rh 'D'-positive, while those lacking it are Rh'D'-negative. Transfusion of Rh 'D'-positive blood to a Rh 'D'-negative recipient can trigger the production of anti-Rh 'D'antibodies, which can cause hemolytic transfusion reactions in subsequent transfusions with Rh 'D'-positive blood or haemolytic disease of newborn in progenies of a lady [23].

Therefore, blood typing plays a vital role in ensuring safe and compatible blood transfusions by preventing hemolytic reactions, febrile reactions, and other potential complications [24]. Traditionally, blood typing relies on the use of commercially available antisera, which are blood products containing antibodies specific for A, B, and Rh antigens [25]. However, these antisera can be limited in terms of availability, cost, and potential for infectious disease transmission [26].

Plant Lectins in Nigeria

Nigeria, a nation brimming with biodiversity, boasts a rich botanical heritage encompassing over 8,000 documented plant species [4]. This vast and largely untapped plant kingdom harbors immense potential for the discovery of novel lectins with unique characteristics and potential applications in various fields, including blood typing. Plant lectins, with their inherent ability to bind specifically to carbohydrates, have emerged as promising alternatives to traditional antisera for blood typing [27]. Listed below are some of the common plant lectins found in Nigeria, highlighting their potential as anti-sera agents.

1. Ricinus communis (Castor bean) Lectin

One of the most extensively studied plant lectins globally is *Ricinus communis* agglutinin (RCA), also known as castor bean lectin, readily obtainable from the castor bean (*Ricinus communis*) seeds [28]. This ubiquitous lectin exhibits high hemagglutinating activity towards human erythrocytes, particularly A positive and B positive blood types due to its specific binding affinity towards galactose and N-acetylgalactosamine residues [29, 30]. While RCA holds promise for blood typing applications, its inherent toxicity necessitates careful purification and detoxification protocols before potential use in clinical settings [31]. This plant lectin holds potential to serve as anti-A+B in a Blood Group serology laboratory.

2. Canavalia ensiformis (Jack bean) Lectin (ConA)

Another widely recognized plant lectin is Concanavalin A (ConA), isolated from the jack bean (*Canavalia ensiformis*) seeds [32]. ConA exhibits a strong affinity for mannose and glucose residues, making it a potential candidate for blood typing, particularly for distinguishing between Rh-positive and Rh-negative blood [33]. However, similar to RCA, ConA possesses some degree of toxicity, requiring proper purification and handling procedures for safe application [34].

3. Dioscorea species (Yam) Lectins

Yams (Dioscorea spp.) are a staple food crop widely cultivated across Nigeria. Interestingly, several yam species have been shown to harbor lectins with diverse carbohydrate-binding specificities [35]. Studies have reported the presence of lectins in water yam (*Dioscorea alata*) exhibiting hemagglutinating activity towards human A and B blood types [35]. Additionally, lectins isolated from other yam species, such as *Dioscorea rotundata* (white yam) and *Dioscorea bulbifera* (air potato), have demonstrated varying degrees of agglutination activity against different blood groups [36]. Further research is necessary to explore the specific carbohydrate-binding properties of these yam lectins and their potential for blood typing applications.

4. Parkia biglobosa (African locust bean) Lectin

The African locust bean (*Parkia biglobosa*) is a leguminous tree native to tropical Africa, including Nigeria. Studies have identified a lectin from *Parkia biglobosa* seeds (PBL) with hemagglutinating activity towards human erythrocytes. PBL exhibits preferential binding towards A and B blood types, suggesting its potential utility in blood typing procedures [37]. Investigation is required to elucidate the specific carbohydrate specificities of PBL and its suitability for clinical applications.

5. Abrus precatorius (Jequirity bean) Lectin (ABL)

The jequirity bean (*Abrus precatorius*) is a climbing vine found in tropical regions, including parts of Nigeria. Abrus agglutinin (ABL), a lectin isolated from jequirity beans, possesses potent hemagglutinating activity towards human erythrocytes [38]. However, similar to RCA and ConA, ABL is highly toxic and requires rigorous purification and detoxification steps before potential use in blood typing applications [39].

6. Other Potential Sources

Nigeria's diverse plant life offers a treasure trove of potential lectin sources beyond the species mentioned above. Plants belonging to families such as Leguminosae (Fabaceae), Moraceae, Euphorbiaceae, and Solanaceae have been reported to harbor lectins with varying hemagglutinating activities [40]. Further exploration of these plant families within the Nigerian context might unveil novel lectins with unique carbohydrate-binding specificities suitable for blood typing applications.

Lectins Extraction Processes

Ability of lectins to specifically bind to sugars makes them valuable tools in various laboratory applications, such as cell agglutination, glycan analysis, and protein purification [41].

The process of extraction includes:

1. Plant Material Selection: Choosing the appropriate plant source rich in lectins is the first step. Factors to consider include lectin specificity and ease of accessibility. Seeds are often preferred due to higher lectin concentration [42, 43].

2. Grinding: The plant material (e.g. seed, leaf or stem) should be grinded into a fine powder using a mortar and pestle or a commercial grinder. This increases surface area and facilitates extraction [44].

Defatting (Optional): Certain lectins may require defatting to remove interfering lipids. Techniques like solvent extraction with organic solvents (e.g., chloroform, methanol) can be employed [45].

3. Buffer Selection: Choose a suitable buffer based on the lectin's isoelectric point (pI). Buffers with a pH slightly below the pI can help maintain protein solubility. Common buffers include Tris-HCl, phosphate-buffered saline (PBS), and sodium acetate buffer [41].

4. Extraction Solution: Prepare an extraction buffer containing a suitable salt (e.g., NaCl, KCl) to promote protein solubility. Additionally, reducing agents like dithiothreitol (DTT) may be included to prevent disulfide bond formation and maintain protein structure [42, 43].

5. Extraction Process: Mix the powdered plant material with the extraction buffer and incubate under gentle agitation (e.g., shaking) for a specific time (usually 1-4 hours) at a cool temperature (e.g., 4°C). This allows lectins to leach out from the plant material[41].

6. Centrifugation: Centrifuge the mixture at high speed (e.g., 10,000 x g) to separate the soluble extract (supernatant) containing the lectin from the insoluble plant debris (pellet)[41].

7. Purification: The crude extract may contain various proteins and contaminants besides the lectin of interest. Several purification methods can be employed to isolate the desired lectin, depending on its specific properties. Here are some common techniques:

a. Precipitation: Techniques like ammonium sulfate precipitation or salting-out can be used based on the lectin's solubility at different salt concentrations [41].
b. Chromatography: Various chromatography techniques like affinity chromatography with immobilized sugars specific to the lectin's binding affinity, or ion-exchange chromatography based on the lectin's net charge, can be used for further purification [46].
c. Dialysis: This technique removes salts and other small molecules from the purified lectin solution using a semi-permeable membrane [41].

8. Concentration (Optional): Depending on the application, the purified lectin solution might be concentrated using techniques like lyophilization (freeze-drying) or ultrafiltration [41].

9. Characterization: This can be done either through electrophoresis or hemagglutination.
Electrophoresis: Techniques like SDS-PAGE can be used to assess the purity of the extracted lectin by analyzing its protein profile [41].
Hemagglutination Assay: This assay can be used to determine the lectin's ability to agglutinate red blood cells (RBCs), which can provide information on its carbohydrate-binding specificity [42].

10. Storage: The purified lectin can be stored appropriately, often at -20°C or -80°C, depending on the lectin's stability[41].

Important Considerations

Safety: Certain lectins can be toxic. Handle plant materials and lectin solutions with appropriate personal protective equipment (PPE) like gloves and lab coats [42].
Optimization: The specific extraction and purification protocols might need to be optimized based on the chosen plant source and the desired lectin properties [42].
Scalability: For large-scale lectin isolation, techniques may need to be adapted for increased yield and efficiency.

By following these steps and considering these factors, lectins can be extracted effectively from plant materials for various laboratory applications.

Future Considerations

While the potential of Nigerian plant lectins as anti-sera agents holds promise, there are several challenges that need to be addressed. Rigorous purification protocols are essential to eliminate any inherent toxicity associated with some lectins and ensure a mix of specificity and sensitivity required to guarantee reliability of eventual blood grouping results. Additionally, extensive in vitro and in vivo studies are necessary to evaluate the efficacy and safety of these lectins for blood typing applications. Furthermore, it is crucial to acknowledge that the aforementioned lectins represent only a fraction of the potential resources available in Nigeria's rich botanical landscape. Extensive research efforts are needed to isolate, purify, and characterize lectins from various indigenous plant species. Additionally, in-depth studies are required to evaluate their hemagglutinating specificities towards different blood groups and Rh factors.

Conflicts of interest
Authors hereby declare no conflict of interest.

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