ISSN: **2959-6386** (Online)
Journal of Knowledge Learning and Science Technology, Vol. 2, Issue 1, April 2023
Journal Homepage: http://jklst.org/index.php/home
DOI: https://doi.org/10.60087

A REVIEW ON STRUCTURE AND BLOOD LIPID REDUCING ACTIVITY OF FUCOIDAN

Hai Lam The

Ho Chi Minh City University of Food Industry, Vietnam

Correspondence Author: Hai, Lam The **E-mail:** hailt@hufi.edu.vn

| Abstract

Seaweed is rich in biologically active substances, and fucoidan is of most interest because of its diversity in activity and structure. In Vietnam, 3 out of 10 adults have high blood cholesterol (accounting for 39%), and over 50% of women aged 50-65 have hypercholesterolemia. Blood fat index is one of the health indicators, especially in people who are overweight, obese, or have cardiovascular disease. Too much fat in the blood will lead to the risk of dangerous diseases such as myocardial infarction, coronary artery disease, and cerebrovascular accident. Currently, many fucoidan products have been launched. Therefore, the paper presented fucoidan with its structure and lipid-lowering activity so that people can use them in decrease the disease.

| Keywords

Activity, blood, fucoidan, lipid, seaweed, brown alage

| Article Information:

Accepted: 25/04/23 **Published:** 30/04/23 **DOI:** https://doi.org/10.60087/ncyxnb22

1. Structure of fucoidan

Fucoidan is a sulfated polysaccharide composed of the main components such as fucose, sulphate and simple sugars such as galactose, glucose, manose, xylose, ... and uronic acid [3]. Their structures are diverse, complex, and heterogeneous [9] with changes in binding patterns, branching, sulfate group positions, and sugar moieties [4] in the molecule. Currently, there have been many studies on the structure of fucoidan from different seaweed species such as: *Dictyota dichotoma* [2], *Ascophyllum nodosum* [5], *Bifurcaria bifurcata, Himanthalia lorea, Padina pavonica* [11], *Fucus vesiculosus* [8], *Chorda filum* [3], *Fucus evanescens* [9], *Fucus distichus* L. [4],,.... In general, fucoidan consist of a main chain with L-fucose linked at positions 1→2, 1→3, 1→4, and a sulfate group at position C-2, C-3, and C- 4, varies according to different species. In the fucoidan molecule, there may or may not be a number of other sugar radicals and the acetyl radicals are distributed irregularly [10]. The fucoidan structure of the seaweed *L. digitata* studied by Lunde et al. (1937) is: $(R.R_1.O.SO_2.O.M)_n$, where R is fucose (33÷37%); What R_1 is unknown; M is Na^+, K^+, (½)Ca^{2+} or (½)Mg^{2+}, total sulphate 35÷38% [1]. The fucoidan structure of the seaweed *Fucus vesiculosus* has a main vascular framework consisting of α-L-fucose (1→2), the branched chain position is the α-L-fucose sugar base (1→3) and the sulfate group is mainly attached at the position C-4 position of the sugar radical L-fucospynanose (Figure 1) [8].

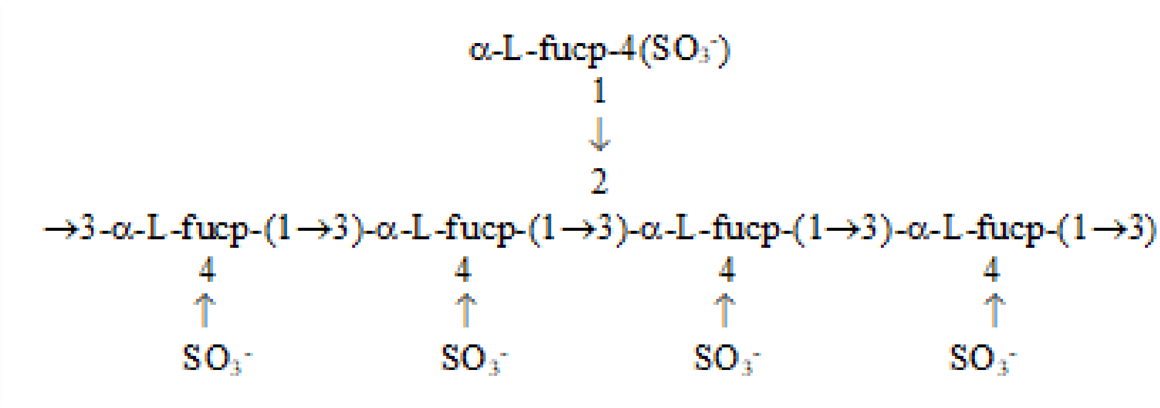

Figure 1. Structure of fucoidan from *F. vesiculosus* [8]

Forty years later, the fucoidan structure of *F. vesiculosus* was studied again, and the results showed that there is a difference like the glycoside binding of this fucoidan with the main chain α-L-fucose(1→3) instead of the main chain α-L-fucose(1→3). α-L-fucose(1→2), the sulfate group, is found mainly at position 4 [8]. The difference in fucoidan structure is due to different extraction techniques, methylation methods, and structural analysis methods. The fucoidan structure is made up repeated α-L-fucose radicals (1→3), a sulfate group at the C-2 or C-4 positions. The additional presence of O-acetyl groups and branch chains in the fucoidan molecule further increases their structural heterogeneity, which has been shown in the seaweed *Ascophyllum nodosum* (Fucales) (Figure 2) [7].

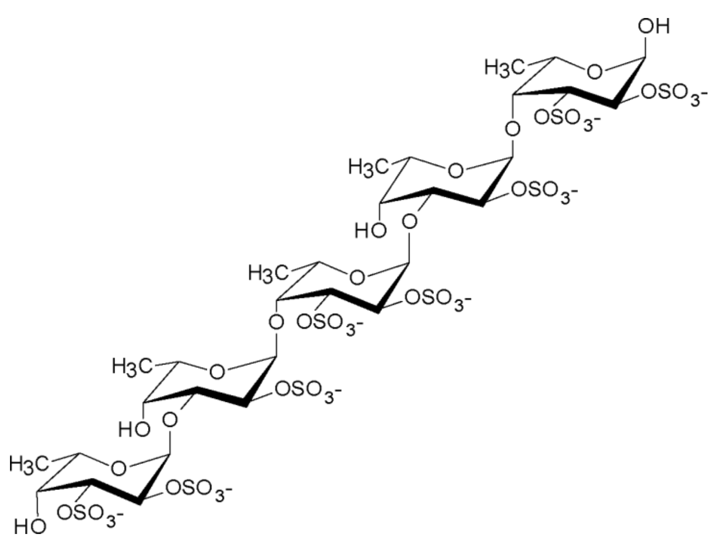

Figure 2. Structure of fucoidan from seaweed A. nodosum, described in the year 1999 [7]

Two fucoidan structures from the seaweed *Fucus distichus* L and *Fucus serratus* are formed by the radicals 1 → 3) α-L-Fucp and 1 → 4) α-L-Fucp linked sequentially, the predominant sulfate group at positions C-2 and C-2,4 (Figure 3), has been reported by Bilan [4], [10]. The structure and chemical composition of fucoidan from temperate seaweeds is generally less complex than that from tropical seaweeds.

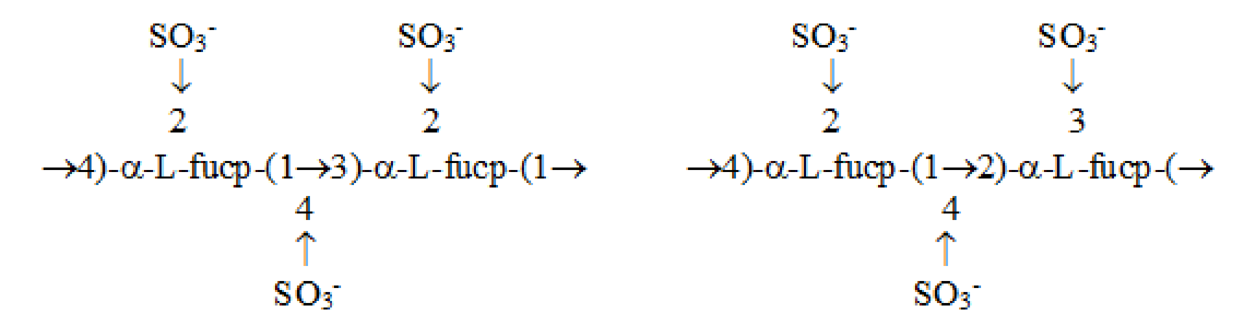

Figure 3. Structure of fucoidan from seaweed *F. distichus* L, described in the year 2004 [4]

The thing makes it very difficult to analyze the structure of fucoidans. It could identify that fucoidan structure has very diverse and complex that depends on the seaweed species, the growth location of the algae, and the time of the algae species studied.

2. Blood lipid-lowering activity of fucoidan

The characteristic properties of the chemical structure with the ratio of different sugar components, other sulfate radicals, different numbers of branched chains, etc., have created the structural diversity of fucoidan and the diversity of fucoidan. The chemical structure has resulted in the biological activity diversity of fucoidan. The chemical structure of fucoidan depends on the species of brown seaweed [6]. Fucoidan can prevent lipid peroxidation in blood serum, liver, and spleen of diabetic rats when fed FeSO4 - ascorbic acid. Fucoidan is one of the agents that act similarly to sialic acid and can increase the negative charge of the cell surface, such as affecting the synthesis of cholesterol in the blood, which subsequently lowers the serum cholesterol level [6]. Fucoidan can lower total cholesterol, triglycerides, and LDL-C, the serum HDLC rise of hypercholesterolemic and hyperlipidemic rats, and effective prevention of hypocholesterolemia formation experimentally in mice. Fucoidan can also reduce cholesterol and triglyceride levels in the serum of hyperlipidemic patients without the side effects that damage the liver and kidneys. Low molecular weight fucoidan (approximately 8,000 Da) markedly reduced blood lipids in hyperlipidemic rats [6]. Oligosaccharide fucoidans have hypotensive effects in rats and can inhibit plasma angiotensin II production.

The structure of fucoidan are complex and heterogeneous, and their biological activities has interesting, so many studies are on them [6]. The results of the bioactivity evaluation of fucoidan showed that it is not easy to determine the relationship between their structure and activities. But, at least, the biological activities depend not only on the molecular weight and content of the fucoidans but also on their structural properties. The bioactivities of fucoidan should be focused with its structure. Brown seaweed is very rich and diverse, found all over the world. Most brown seaweeds are applied in food or food additives, with some applications in new drugs and functional foods. Through modification of the chemical structure of fucoidan, such as sulfate or methylation at the certain positions of fucoidan, the activity of fucoidan increases significantly. Focusing the study on the fucoidans structure and the relationship between bioactivity and structural of them that can provide a theory in medicinal sources and applications of brown seaweed [6].

3. Summary

In conclusion, the structure of fucoidan is known to be a sulfated polysaccharide composed of fucose, sulfate, and various simple sugars. The molecule exhibits structural diversity and complexity, with variations in binding patterns, branching, sulfate group positions, and sugar moieties among different seaweed species. The fucoidan structure may include additional sugar radicals and irregularly distributed acetyl radicals. Furthermore, extraction techniques, methylation methods, and structural analysis approaches can influence the determination of fucoidan structure.

Regarding the blood lipid-lowering activity of fucoidan, its chemical structure plays a crucial role in determining its biological activities. Fucoidan has shown potential in preventing lipid peroxidation and lowering serum cholesterol levels. It can reduce total cholesterol, triglycerides, and LDL-C while increasing HDL-C in hypercholesterolemic and hyperlipidemic animal models. Fucoidan has also demonstrated the ability to lower cholesterol and triglyceride levels in the serum of hyperlipidemic patients without adverse effects on the liver and kidneys. Low molecular weight fucoidan and fucoidan oligosaccharides have exhibited hypotensive effects and inhibition of plasma angiotensin II production.

The relationship between the structure and activities of fucoidan is complex and challenging to determine. However, it is evident that the bioactivities of fucoidan depend not only on its molecular weight and content but also on its structural properties. Exploring the structural features of fucoidan and their correlation with bioactivity is essential for understanding its potential applications in medicine and the development of functional foods. By modifying the chemical structure of fucoidan through sulfate or methylation modifications, its activity can be significantly enhanced.

In summary, further research focusing on the structure-activity relationship of fucoidan can provide valuable insights into the medicinal potential and application of brown seaweed as a source of this bioactive compound. With the abundance and diversity of brown seaweed worldwide, studying fucoidan's structural properties and their impact on bioactivity will contribute to the development of novel drugs and functional food products.

Conflicts of Interest: The authors declare no conflict of interest.

References

[1]. Ale MT, Mikkelsen JD, Meyer AS. (2011). Important determinants for fucoidan bioactivity: a critical review of structure-function relations and extraction methods for fucose-containing sulfated polysaccharides from brown seaweeds. *Marine Drugs*. *9*(10). 2106-2130.

[2]. Abdel-Fattah AF, Hussein MMD, Fouad ST. (1978). Carbohydrates of the brown seaweed *Dictyota dichotoma*. *Phytochemistry*. *17*(4). 741–743.

[3]. Alexander OC, Anne D, Howard RM, Stuart MH, Roy AM, Alexander SS, Nikolay EN, Elena AK, Anatolii IU. (1999). A study of fucoidan from the brown seaweed *Chorda filum*. *Carbohydrate Research*. *320*. 108–119.

[4]. Bilan MI, Grachev AA, Ustuzhanina NE, Shashkov AS, Nifantiev NE, Usov AI. (2004). A highly regular fraction of a fucoidan from the brown seaweed *Fucus distichus* L. *Carbohydrate Research*. *339*. 511–517.

[5]. Daniel R, Berteau O, Chevolot L, Varenne A, Gareil P, Goasdoue N. (2001). Regioselective desulfation of sulfated L-fucopyranoside by a new sulfoesterase from the marine mollusk Pecten maximus: application

to the structural study of algal fucoidan (*Ascophyllum nodosum*). *European Journal of Biochemistry*. *268*(21). 5617-5626.

[6]. Ellya S, Endar M. (2012). Fucoidan from brown seaweed and its bioactivity. *Squalen*. *7*(3). 131-138.

[7]. Lionel C, Alain F, Frederic C, Nelly K, Corinne S, Anne-Marie F, Catherine B-V. (1999). Further data on the structure of brown seaweed fucans: relationships with anticoagulant activity. *Carbohydrate Research*. *319*. 154–165.

[8]. Manish SP, Sergio OQ, Townsend B, Roy LW, Gary FC. (1993). A revised structure for fucoidan may explain some of its biological activities. *Biological Chemistry*. *268*(29). 21770-21776.

[9]. Maria IB, Alexey AG, Nadezhda EU, Alexander SS, ikolay EN, Anatolii IU. (2002). Structure of a fucoidan from the brown seaweed Fucus evanescens C.Ag. *Carbohydrate Research*. *337*(8). 719-730.

[10]. Maria IB, Alexey AG, Alexander SS, Nikolay EN, Anatolii IU. (2006). Structure of a fucoidan from the brown seaweed Fucus serratus L. *Carbohydrate Research*. 341. 238-245.

[11]. Mian AJ, Percival E. (1973). Carbohydrates of the brown seaweeds *Himanthalia lorea*, *Bifurcaria bifurcata*, and *Padina pavonia*. *Carbohydrate Research*. 26(1). 133-146.