ARTICLE | OPEN ACCESS

International journal of
adulteration

The 'draw effect' (viscosity) of okra by different cooking additives

Juliana Amoah[1]*, Jonathan Ntow[1], Prosper Kodwo Nwi[1], John Kwabena Otchere[1], Emmanuel Tetteh Sampeney[2], Geoffrey Saah Botchway[2]

To Cite:
Amoah J, Ntow J, Nwi PK, Otchere JK, Sampeney ET, Botchway GS. The 'draw effect' (viscosity) of okra by different cooking additives. *International journal of adulteration*, 2025; 9: e5ijad3063
doi: https://doi.org/10.54905/disssi.v9i11.e5ijad3063

Author Affiliation:
[1]University of Cape Coast, School of Physical Sciences, Department of Laboratory Technology, University Avenue Road, PMB, Cape Coast, Ghana.
[2]University of Cape Coast School of Biological Sciences, Department of Environmental Science, University Avenue Road, PMB, Cape Coast, Ghana.

***Corresponding author:**
Juliana Amoah,
University of Cape Coast, School of Physical Sciences, Department of Laboratory Technology, Cape Coast, Ghana.
E-mail address: juliana.amoah@ucc.edu.gh

Peer-Review History
Received: 18 April 2025
Reviewed & Revised: 29/April/2025 to 09/August/2025
Accepted: 18 August 2025
Published: 25 August 2025

Peer-Review Model
External peer-review was done through double-blind method.

International journal of adulteration
eISSN (Online) 2456 – 0294

DISCOVERY
SCIENTIFIC SOCIETY

ABSTRACT

Okra, scientifically known as *Abelmoschus esculentus L.*, is a member of the family Malvaceae, which also includes marshmallows. Research reveals that okra is in nearly every market in Africa and is Ghana's fourth most popular vegetable. To improve the mucilaginous quality, okra is mostly cooked with crude trona. Okra can also be cooked with other food ingredients such as onions and pebbles, while monitoring the temperature of the boiling water to improve the viscosity of the okra, which is the aim of this study. Crude trona, onions, pebbles, and Clemson spineless okra (fresh, green, and tender) were bought from the University of Cape Coast market. A digital rotating viscometer with several rotational viscometer rotors (spindles) with spindle numbers (3, 4) and rotational speeds of 6 rpm, 12 rpm, 30 rpm, and 60 rpm was used to measure the viscosity. The measured viscosities were recorded and repeated throughout the various spindles and rotational speeds. In measuring the initial and final temperatures of the boiled okra (control) and treated samples, a digital thermometer was used. The study revealed that okra cooked with different food additives differed significantly from the control. It was established that using crude trona to cook okra produced a higher viscosity, whereas using pebbles produced the lowest viscosity in this study. This outcome demonstrates how different food additives, as mentioned, affect the okra mucilage's resistance to shear stress and structural integrity.

Keywords: Okra, draw effect, cooking additives, adulterant, viscosity, rotor speed

1. INTRODUCTION

Okra, also known as Abelmoschus esculentus L., is a popular and commonly used species. Worldwide production of okra is estimated at over 7 million MT, whereas that of Ghana is over 60,000 MT (Benjamin et al., 2023). Okra is primarily found in its fresh state in almost all markets in Ghana during the rainy season and in a dehydrated form during the dry season, particularly in Northern Ghana, due to its substantial commercial value for farmers and women marketers (Temam et al., 2021). Farmers grow okra as an economically important vegetable crop in tropical and subtropical regions. Primarily, it is grown for its green leaves and pods, which are consumed as a green vegetable. (Thakur, 2022). Many people across the world use various local names for okra. In West and Central Africa (WCA), okra is known as 'gombo' (French), 'nkruma' (Akan), and 'fetri' (Ewe). It is among the most frequently and popularly consumed traditional vegetables (Kumar et al., 2017).

Viscosity is an essential characteristic of fluids that indicates their resistance to deformation when shear stress is applied. It represents the internal friction present within a fluid, which results from the molecular interactions as fluid layers move about one another (de Alvarenga et al., 2016). Understanding the connection between viscosity and shear rate is vital for analyzing the behavior of okra mucilage. Typically, as the shear rate rises, the apparent viscosity decreases, a trend referred to as shear thinning (Minh, 2023). This behaviour is commonly observed in non-Newtonian fluids like okra mucilage, where the molecular structure aligns under stress, thereby decreasing flow resistance. Temperature also plays a crucial role, as higher temperatures increase molecular motion, reducing viscosity (Noorlaila et al., 2015).

Okra is widely known as a viscous, mucilaginous plant that results in a slimy or gooey mouthfeel when cooked. It has been utilized in the production of plasma expanders as a suspending and emulsifying agent (Dantas et al., 2021). This mucilage contains soluble fibers that can be broken down and digested. Some consumers enjoy this slimy texture, while some attempt to conceal the slick quality of the pods.

The sliminess of okra comes from the mucilage found in the vegetable. Okra mucilage is an acidic polysaccharide composed of galacturonic acid, rhamnose, and glucose in a ratio of 1.3:1.0:0.1, which attains maximum viscosity at neutral pH and tends to degrade under intense heat (Sengkhamparn et al., 2009). Cooking methods can influence the "draw effect" of okra. Cooking okra with crude trona to improve its "draw effect" has been a common practice. The "draw effect" may also be enhanced by boiling with specific food ingredients, such as onions and pebbles, necessitating this study.

Crude trona, a naturally occurring alkaline substance, likely interacts with the acidic polysaccharides in okra mucilage, enhancing its gel-like structure. According to Kolawole et al. (2024), this interaction enhances the mucilage structure, improving its durability against shear stress and leading to greater. A study conducted by Fujii et al. (2008) advised that onions play a role in viscosity by providing natural sugars and soluble fibers (Fujii et al., 2008). These components may mildly interact with the mucilage but do not reinforce the network as effectively as crude trona (Zhu et al., 2017). Pebbles act as heat conductors during cooking, elevating the boiling temperature and potentially breaking down the polysaccharide structure more rapidly. This breakdown reduces the viscosity of mucilage (Vorobyov et al., 2023).

One common way of preparing an okra meal is by boiling grated or diced fresh okra. Okra is a vegetable rich in nutrients, which contains vitamins A and C, along with antioxidants that id in lowering the risk of health conditions such as heart disease, stroke, and cancer, particularly colorectal cancer (Osawaru et al., 2014). Due to these health benefits, okra is widely consumed. Consumers have varying preferences concerning its sliminess, with some preferring a higher "draw effect" and others preferring less. Traditionally, most okra preparation involves using crude trona to enhance the "draw effect." Nevertheless, because crude trona is not suitable as a food additive (may consider as adulterant) for certain consumers, alternative cooking methods, other cooking techniques such as using grated onions and pebbles, have been investigated to produce the "draw effect." It is important to assess these alternative cooking techniques to understand their effect on the viscosity of okra.

The objective of this study was to determine the viscous consistency of okra prepared with different cooking additives (crude trona, onions, and pebbles) using two different rotors with varying speeds, as well as to measure the initial and final temperature for each cooking method when boiled within ten (10) min.

2. METHODOLOGY

Study Area and Design

The research was carried out in Cape Coast. Cape Coast serves as the capital of the Central Region in Ghana. It is bounded on the south by the Gulf of Guinea, and its geographical coordinates are 5° 6' 0" North, 1° 15' 0" West. Fresh, green, and tender Clemson spineless okra was purchased from the University of Cape Coast market (science market). All laboratory analyses were conducted at the Department of Laboratory Technology's research laboratory, Cape Coast, Ghana. The University is located at Cape Coast in the central region of Ghana along the Gulf of Guinea. Cape Coast is a city, fishing port, and capital city of the Cape Coast Metropolitan District and the Central Region. It is one of Ghana's most historic cities. The main livelihood of the residents is fishing. The study utilized the combination of qualitative and quantitative approaches, and sampling took place over a year.

Sample Method and Pretreatment

Purposive sampling method was used to obtain fresh, green, and tender Clemson spineless okra from among the various okra varieties available at the University of Cape Coast Science Market. The freshly bought (green and tender Clemson spineless) okra was meticulously sorted to eliminate infected pods and unwanted debris. The okra was rinsed with distilled water, and the ends were trimmed with a sterile, sharp knife. After that, the fruits were grated using a clean grater and transferred into a clean, dry container for subsequent analysis.

Cooking Okra by Boiling without Food Additives

A 150 g portion of grated okra was weighed using an electronic balance (LE623P, Sartorius AG, Germany). A beaker was used to transfer the measured sample. A 150 ml of distilled water was added, and the initial temperature was measured using a thermometer. The mixture was cooked and brought to a boil for 10 minutes without any additives. The final temperature was subsequently measured and noted. This process was carried out again, and the temperature difference was noted.

Boiling of Grated Okra with Crude Trona

A 150 g portion of grated okra was weighed and transferred into a beaker containing 150 ml of distilled water. 2.0 g of crude trona was added, and the temperature (initial) was measured using a thermometer and recorded. The okra and the crude trona were brought to a boil for 10 min using a hot plate. The temperature after boiling (final) was measured and recorded. The temperature differences were calculated and recorded. The procedure was carried out again, and mean values were noted.

Boiling of Grated Okra with Grated Onion

A 150 g portion of grated okra was weighed and transferred into a beaker containing 150 ml of distilled water, 2.0 g of grated onion was added, and the temperature (initial) was measured and recorded. The okra and grated onion were allowed to boil for 10 minutes. The temperature after boiling (final) was measured and recorded. The procedure was done again, and the temperature differences and mean values were documented.

Boiling of Grated Okra with Pebbles

A 150 g portion of grated okra was weighed. The okra was transferred into a beaker containing 150 ml of distilled water with four pebbles weighing 2.0 g, and the temperature (initial) was measured and recorded. The okra, together with the pebbles, were boiled for 10 minutes. The temperature after boiling (final) was taken and recorded. The procedure was carried out again, and the temperature differences and mean values were noted.

Determination of the Viscosity of Boiled Okra Using a Digital Rotational Viscometer Approximately 250 ml of okra-water mixture was poured into a beaker from each boiled sample, including the control (boiled okra and water), and those cooked with different additives: crude trona, grated onions, and pebbles. The viscosity for each sample was measured with a viscometer (NDJ-8S Digital rotary viscometer, Mainland China). Different rotational viscometer spindles (numbers 1, 2, 3, 4) were used at rotational speeds 6, 12, 30, and 60 rpm to determine the viscosities. This procedure was carried out again, and the viscosities were measured and recorded.

Data Analysis

The data were carefully entered into Microsoft Excel and subsequently analyzed using Minitab Statistical Software Version 20.1 (Minitab, LLC, USA). A one-way analysis of variance (one-way ANOVA) was employed to determine differences among viscosities of the control and treated samples (boiled okra with food additives); a $p < 0.05$ was considered statistically significant.

3. RESULTS AND DISCUSSIONS

The viscosities of treated samples and the control were precisely determined using a digital rotational viscometer at various rotor speeds (shear rate) with different spindles (R3 and R4).

Table 1 presents the viscosities of boiled okra prepared with different cooking additives, measured at various rotor speeds using spindle R3. All samples exhibited varied viscosities at 6, 12, 30, and 60 rpm. Significant differences ($p<0.05$) were noted across all samples at 6, 12, 30, and 60 rpm. At 12 rpm, however, no significant difference was found between crude trona and pebbles treatments, while the onion additive showed no significant difference compared to the control. The highest viscosity values across all speeds were recorded for the sample treated with pebbles, in descending order: 17060±1442.000 cP(6 rpm), 6845±120.200 cP (12 rpm), 2726±93.300 cP (30 rpm), 1281±72.10 cP (60 rpm). Following the pebble-treated sample, the crude trona-treated sample recorded the next highest viscosities: 12590±495.000 cP (6 rpm), 7560±56.600 cP (12 rpm), 3735±15.600 cP (30 rpm), 1937±1.410 cP (60 rpm). The lowest viscosities were observed in the onion-treated sample: 8820±790.000 cP (6 rpm), 4585±559.000 cP (12 rpm), 1814±42.400 cP (30 rpm), and 785±1.410 cP (60 rpm).

Table 1: Viscosities (cP) of control and treated samples at different speeds using Rotor 3.

	Viscosity			
Sample Additive	**6 rpm**	**12 rpm**	**30 rpm**	**60 rpm**
Crude trona	$12590±495.000^{C}$	$7560±56.600^{A}$	$3735±15.600^{A}$	$1937±1.410^{A}$
Onion	$8820±790.000^{D}$	$4585±559.000^{B}$	$1814±42.400^{C}$	$785±1.410^{C}$
Pebble	$17060±1442.000^{B}$	$6845±120.200^{A}$	$2726±93.300^{B}$	$1281±72.10^{B}$
Control	$62050±707.000^{A}$	$3430±14.100^{B}$	$1180±56.600^{D}$	$581±12.730^{D}$
P value	0.000	0.000	0.000	0.000

Legend: rpm - revolution per minute, cP – centipoise, values are means ± standard deviation of duplicate determination of viscosity, values in the same column with different superscript letters are significantly different ($P<0.05$).

According to Table 2, as the rotor speeds increased, the viscosities of the samples decreased. Crude trona recorded the highest viscosities under the four-rotor speeds (6, 12, 30, and 60 rpm). The sample with crude trona at a speed of 6 rpm had the highest viscosity. At 6 rpm, the crude trona-treated sample showed no significant difference compared to the other, unlike at the remaining rotor speeds (12, 30, 60 rpm), where significant differences were observed.

Table 2: Viscosities (cP) of control and treated samples at different speeds using Rotor 4

	Viscosity			
Sample Additive	**6 rpm**	**12 rpm**	**30 rpm**	**60 rpm**
Crude trona	$6350±354.000^{A}$	$4075±247.000^{A}$	$2270±127.300^{A}$	$1195±49.500^{A}$
Onion	$5700±141.000^{A}$	$3700±141.000^{A}$	$2130±14.100^{A}$	$1155±63.600^{A}$
Pebble	$4675±2369.000^{A}$	$2575±35.400^{B}$	$1520±56.600^{B}$	$630±14.100^{B}$
Control	$3680±42.400^{A}$	$3680±42.400^{A}$	$1740±28.300^{B}$	$782.5±10.610^{B}$
P-value	0.543	0.002	0.001	0.000

As shown in Table 3, the initial temperatures of all samples were the same, whereas the final temperatures varied among the treatments. The sample treated with pebbles recorded the highest final temperature among all the treatments.

Table 3: Initial and final boiling temperatures (°C) of control and treated samples.

Sample	Initial temperature	Final temperature
Crude trona	29.000	71.000
Onion	29.000	80.000
Pebble	29.000	91.000
Control	29.000	83.000

Viscosity, which is the desired parameter, is one of the fundamental qualities that characterize flow behavior. It measures a fluid's resistance to motion when shearing stress is applied. In practical terms, a fluid's viscosity indicates its thickness (Juutinen, 2001). A liquid's viscosity changes when its density and molecular weight change, which also affects how the liquid flows. It mostly fluctuates depending on the shear rate (Yuan et al., 2018).

Viscosities of boiled okra with various food additives (crude trona, onion, and pebbles) and without any additives were measured using a digital rotational viscometer at different shear rates with various rotors (spindles). The results indicated that all viscosities decreased with increasing rotor speed because apparent viscosity lowers as shear strain rate increases. This shear-thinning behavior has been previously documented (Kontogiorgos et al., 2012).

From Table 1, using Rotor 3, maximum viscosities were recorded at 6 rpm. Pebbles produced the highest viscosity (17060±1442.000 cP) and onion the lowest (8820±792.000 cP). The p-value generated was 0.000 ($p < 0.05$), indicating a significant difference among the viscosities of all the samples. The control had a viscosity of 62050±70.700 cP, exceeding the viscosity of okra boiled with food additives (crude trona, onion, and pebbles). This value decreased as speed increased, with 60 rpm recording the least viscosity of 581 cP, aligning with the manufacturer's operational instructions for measurement.

Crude trona recorded the highest viscosities at all four rotor speeds (6 rpm, 12 rpm, 30 rpm, and 60 rpm), according to Table 2, using Rotor 4. The boiled okra with crude trona at 6 rpm had the highest viscosity, with no significant difference (p-value = 0.543) among the samples. As rotor speeds increased from 12 rpm to 60 rpm, p-values decreased accordingly, with the lowest recorded at 60 rpm, where all sample differences were statistically significant. For the food additives used (crude trona, onion, and pebbles), pebbles recorded the lowest viscosities. The cause of this effect can be ascribed to higher temperatures during boiling since pebbles are good conductors of heat (Bromberg, Sidorov, and Titus, 1996). Studies confirm that measured viscosity decreases with increasing temperature, validating the properties of a liquid. Temperature significantly impacts viscosity, with viscosity decreasing as temperature rises. As temperature increases, molecules in the liquid move more freely, reducing internal friction (Abbasi et al., 2019).

From Table 3, the initial boiling temperature of grated okra was consistent (29 °C) across all food additives, including the control (no additive). However, the final boiling temperatures varied. Okra boiled with pebbles had the highest final temperature (91 °C), while crude trona recorded the lowest (71 °C). Pebbles, being good conductors of heat (Bromberg et al., 1996), heat up quickly, absorb heat, and efficiently transfer it to the food. In contrast, crude trona reduced the boiling temperature of okra, resulting in the least temperature value recorded.

Understanding the effects of cooking additives on the viscosity of okra has practical implications for culinary practices and consumer preferences. Some customers prefer higher viscosity (slimy texture), while others prefer a lower viscosity. Crude trona is effective in traditional dishes that require a significant "draw effect" because of its capacity to enhance viscosity (Kolawole et al., 2024). Nonetheless, its potential unacceptability for certain consumers means alternatives, such as onions, should be considered. Onions offer a moderate viscosity without the pronounced alkalinity that crude trona has.

The research indicates that okra mucilage is sensitive to heat. A significant reduction in viscosity at elevated temperatures and shear rates highlights the importance of managing cooking conditions to achieve the desired texture (Rao, 2013). This knowledge can assist both food scientists and culinary professionals in modifying recipes to suit different taste and texture preferences.

4. CONCLUSION

The results of this research demonstrated notable differences in the viscosities of okra prepared with various additives (crude trona, onion, and pebbles) compared to the control. The use of crude trona during cooking resulted in a higher viscosity, or "draw effect" for the okra, whereas the use of pebbles resulted in the lowest viscosity. This highlights the influence of these additives on the structural integrity of okra mucilage and its resistance to shear stress.

The observed viscosity fluctuations highlight how complexly chemical and physical factors interact during food preparation. Onion's inherent sugars and soluble fibers helped to lower viscosity, whereas crude trona's alkaline nature increased the viscosity by strengthening the polysaccharide network. As efficient heat conductors, pebbles increased the cooking temperature, which led to the breakdown of the mucilage structure to break down and a reduction in viscosity. Gaining insights into this process provides valuable advice for improving cooking methods to align with consumer tastes. The findings can assist people in adjusting the thickness of okra-based recipes to achieve their preferred texture. Additionally, this research lays the groundwork for future investigations into other natural recipes that can enhance or modify the viscosity of plant-based foods. Future studies should examine these nutritional and sensory implications to ensure both functional and health benefits in food preparation.

Acknowledgments

The authors acknowledge the technical support of the Department of Laboratory Technology of the University of Cape Coast for this study.

Authors' contributions

Juliana Amoah: conceptualization, investigation, formal analysis, data curation, writing - original draft, review & editing.
Jonathan Ntow: investigation, formal analysis, data curation, review.
Prosper Kodwo Nwi: investigation, resources, project administration, formal analysis, data curation, and writing.
John Kwabena Otchere: conceptualization, supervision, review, and editing.
Emmanuel Tetteh Sampeney: formal analysis, writing - original draft.
Geoffrey Saah Botchway: formal analysis, writing - original draft.

Informed consent

Not applicable.

Funding

This study has not received any external funding.

Ethical approval

In this article, the product ethical regulations are followed as per the ethical committee guidelines of University of Cape Coast, School of Physical Sciences, Department of Laboratory Technology, University Avenue Road, PMB, Cape Coast, Ghana; the authors observed the 'draw effect' (viscosity) of okra by different cooking additives. The "brand name" of the product is not mentioned in content and also the "brand image" not displayed as figure in the article. The product ethical guidelines are followed in the study for observation, identification & experimentation.

Conflict of Interest

The author declares that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

REFERENCES

1. Abbasi FM, Shanakhat I, Shehzad S A. Entropy generation analysis for peristalsis of nanofluid with temperature-dependent viscosity and Hall effects. Journal of Magnetism and Magnetic Materials 2019; 474: 434-441. doi: 10.1016/j.jmmm.2018.10.132
2. Benjamin A, Alexander WK, Kwabena AB. Variability among West African okra (*Abelmoschus* spp. L.) accessions based on quantitative traits. Ecological Genetics and Genomics 2023; 26, 100156. doi: 10.1016/j.egg.2022.100156
3. Bromberg L, Sidorov M, Titus P. Pebble bed conductors. Fusion Technology 1996; 30(3P2B):1209-1211. doi: 10.13182/FST96-A11963112
4. Dantas TL, Alonso BFC, Florentino ER. Okra (*Abelmoschus esculentus* L.) as a potential functional food source of mucilage and bioactive compounds with technological applications and health benefits. Plants 2021; 10(8):1683. doi: 10.3390/plants10081683
5. de Alvarenga PC, Mottin AC, Ayres E. Preparation and characterization of okra mucilage (*Abelmoschus esculentus*)

edible films. In Macromolecular Symposia 2016; 367 (1):90-100. doi: 10.1002/masy.201600019

6. Fujii S, Konno M, Isono Y. Viscoelasticity of the onion phase composed of complex surfactant bilayers. Transactions of the Materials Research Society of Japan 2018; 33(2): 425-426. doi: 10.14723/tmrsj.33.425
7. Juutinen P. On the definition of viscosity solutions for parabolic equations. Proceedings of the American Mathematical Society 2001; 129(10):2907-2911. doi: 10.1090/S0002-9939-01-05889-0
8. Kolawole FL, Alonge TA, Akeem SA, Sanni-Olayiwola HO. Influence of trona (sodium sesquicarbonate) concentrations and storage period on the physicochemical properties, antinutrients, micronutrients and sensory qualities of dried okra (*Abelmoschus esculentus* L.) powder. Journal of Stored Products Research 2024; 106:102311. doi: 10.1016/j.jspr.2024.102311
9. Kontogiorgos V. Margelou I, Georgiadis N, Ritzoulis C. Rheological characterization of okra pectins. Food Hydrocolloids 2012; 29(2):356-362. doi: 10.1016/j.foodhyd.2012.04.003
10. Kumar S, Parekh M J, Fougat RS, Patel SK, Patel CB, Kumar M, Patel BR. Assessment of genetic diversity among okra genotypes using SSR markers. Journal of plant biochemistry and biotechnology 2017; 26(2):172-178. doi: 10.1007/s13562-016-0378-2
11. Minh NN. Investigation and prediction of the extensional viscosity of okra mucilage using the Giesekus model. Biorheology 2023; 59(1-2):29-42. doi: 10.3233/BIR-220006.
12. Noorlaila A, Siti AA, Asmeda R, Norizzah AR. Emulsifying properties of extracted Okra (*Abelmoschus esculentus* L.) mucilage of different maturity indices and its application in coconut milk emulsion. International Food Research Journal 2015; 22(2):82-787.
13. Osawaru E, Ogwu C M, Emokpare AA. Preliminary assessment of the microanatomy of okra (*Abelmoschus esculentus* L.). Egyptian Academic Journal of Biological Sciences 2014; 5(1):39-54. doi: 10.21608/eajbsh.2014.16827
14. Rao MA. Rheology of fluid, semisolid, and solid foods: principles and applications (3rd ed.). Springer Science & Business Media, 2014; 2.
15. Sengkhamparn N, Verhoef R, Schols HA, Sajjaanantakul T, Voragen AG. Characterisation of cell wall polysaccharides from okra (*Abelmoschus esculentus* (L.) Moench). Carbohydrate Research 2009; 344(14):1824-1832. doi: 10.1016/j.carres.2008.10.012
16. Temam N, Mohammed W, Aklilu S. Variability Assessment of Okra (*Belmoschus esculentus* (L.) Moench) genotypes based on their qualitative traits. International Journal of Agronomy 2021; 1-6. doi: 10.1155/2021/6678561.
17. Thakur O. Recent advances of plant growth regulators in vegetable production: A review. The Pharma Innovation Journal 2022; 11(3):1726-1731.
18. Vorobyov E I, Elbakyan VG, Johansen A, Lambrechts M, Skliarevskii AM, Stoyanovskaya OP. Formation of pebbles in (gravito-) viscous protoplanetary disks with various turbulent strengths. Astronomy & Astrophysics 2023; 670(A81):1-20. doi: 10.1051/0004-6361/202244500
19. Yuan B, Ritzoulis C, Chen J. Extensional and shear rheology of okra hydrocolloid–saliva mixtures. Food Research International 2018; 106:204-212. doi: 10.1016/j.foodres.2017.12.051
20. Zhu DY, Ma YL, Wang CH, Wang H, Ren YF, Zhang JG, Thakur K, Wei ZJ. Insights into physicochemical and functional properties of polysaccharides sequentially extracted from onion (*Allium cepa* L.). International journal of biological macromolecules 2017: 105(1):1192-1201. doi: 10.1016/j.ijbiomac.2017.07.164