

Original Article

DEVELOPMENT OF NUTRIENT ENRICHED FLOUR BLEND FROM OATS, CHIA SEEDS AND SPINACH

Aqsa Nadeem¹, Anosh², Anusha Sajjad³, Syeda Sani e Zahra⁴, Anoosha Ramzan⁵, Farwa Rani⁶

ABSTRACT:

Background: Diet and nutrition play an important role in general health, highlighting the importance for incorporating nutrient dense foods in diet. Particularly those made from plant-based ingredients; offer a promising approach to improving public health. Oats, chia seeds, and spinach powder are rich in essential nutrients such as fibre, protein, healthy fats, vitamins, and minerals, which can contribute to better overall health.

Materials and Methods: In this interventional study flour blend from oats, chia seeds, and spinach powder was developed along with its nutritional profile and sensory attributes evaluation. Two formulations were prepared utilizing locally sourced ingredients, Group 0 utilized (4:1:1) and experimental Group 1 utilized (5:2:2) of oats, chia seeds and spinach powder respectively. Proximate analysis and Sensory evaluation of both flours in the form of tortilla wraps was conducted and data was analysed in SPSS using independent sample t test at 95% level of confidence.

Results: Group 1 has higher crude protein, crude fiber, fat, ash, contains lower amount of carbohydrates and moisture compared to Group 0 flour. Mineral analysis revealed that Group 1 flour is enriched in iron, potassium, contains moderate amount of magnesium and phosphorus but least amount of calcium whereas statistical analysis shows that there is no significant difference in sensory attributes such as colour, texture, taste, appearance and general acceptability ($p > 0.05$) between both flours. Group 1 flour exhibited enhanced nutritional properties, making it suitable for individuals with specific dietary needs such as high protein or Fiber intake, and lower carbohydrate requirements.

Conclusion: Group 1 has higher crude protein, crude fiber, fat, ash, but contains lower amount of carbohydrates and moisture compared to Group 0.

Key words: Crude protein, Oats, Dietary Fibers

doi: <https://doi.org/10.51127/JAMDCV06I04OA01>

How to cite this:

Nadeem A, Anosh, Sajjad A, Zahra SS, Ramzan A, Rani F. Development of Nutrient Enriched Flour Blend from Oats, Chia Seeds and Spinach. JAMDC, 2024; 6(4): 130-137
doi: <https://doi.org/10.51127/JAMDCV06I04OA01>

INTRODUCTION

Diet and nutrition are important for maintaining optimal body function and general health of populations. Total quantity of foods consumed by individuals is referred as diet whereas the process of utilizing food for the growth, metabolism, repair and maintenance of tissue is called nutrition. The association between diet,

nutrition and health is bilateral, nutrient deficiency can affect overall health status and vice versa.¹ According to data by Institute for Health Metrics and Evaluation presented that poor diet contributed to 10.6% of all deaths in 2021.² highlighting the urgent need for incorporating nutrient dense foods in our diet. The quality of the energy we obtain is directly influenced by the nutritional value of our diet, which should ideally include a variety of wholesome and nutrient rich foods. Among the healthy dietary options available, a particularly nutritious choice is a flour that has been

¹ Assistant professor at UMT, Lahore

²⁻⁶ UMT Students

Date of Submission: 10-10-2024

Date of Review: 21-10-2024

Date of Acceptance: 11-11-2024

enriched through the blending of oats, chia seeds, and spinach. This nutrient enriched flour represents a sophisticated approach to health-conscious eating, combining the benefits of three powerful ingredients. By incorporating this blended flour into one's diet, this offers versatile and nutrient-dense ingredient that supports a balanced and healthful lifestyle. Whether used in baking, cooking or as a base for various dishes, this flour not only adds nutritional value but also aligns with contemporary dietary trends that emphasize whole plant-based foods including fresh fruits and vegetables, legumes, seeds, nuts are healthier alternatives to fulfil nutritional demand in comparison to animal-based ingredients such as fatty and processed meats³. Oats have unique proteins called globulins, unlike other cereals that have prolamins. They contain the most fat among cereals being lower in quantity of saturated fats and higher in essential unsaturated fats, which can lessen the risk of heart diseases. Oats are abundant in soluble fiber mainly B glucan which is very favourable for health. B-glucan helps lowering blood cholesterol and glucose absorption, thus favourable for prevention of cardiovascular diseases, dyslipidaemia, hypertension, inflammation, and type 2 diabetes. Moreover, antioxidants are present in abundant quantity in oats.⁴ Oats food with B-glucan have been also affirmed by the European Food and Safety Authority and the US FDA for helping to lower cholesterol and lessen the risk of cardiovascular diseases. Besides B-glucan oats also contain favourable compounds one of these are, avenanthramides (AVAs), is an antioxidant that intercepts impairment to LDL cholesterol. AVA-enriched oats extracts, chiefly when combined with vitamin C, can also lessen LDL oxidation. AVAs have distinct health advantages including reducing inflammation, preventing cell growth and protecting from cancer.⁵ Chia seeds carry many nutrients and used more often because they have many health advantages and are enriched in protein, fiber and omega 3 fatty acids. In contrast to other cereals, chia seeds are enriched with protein

and are gluten free, making them applicable for people with celiac disease. They also carry essential amino acids and provide a substantial quantity of dietary fiber, contributing to daily fiber needs. Chia seeds have variety of health benefits, including supporting heart health, aiding brain development during pregnancy, and helping manage diabetes.⁶ Furthermore, by lowering triglycerides and blood pressure, the addition of omega 3 fatty acids from chia seeds promotes cardiovascular health.⁷

Spinach is a readily available green leafy vegetable being familiar for its enhanced nutritional benefits. It is enriched with many essential vitamins and minerals, including iron, manganese, zinc and magnesium. Spinach contains low quantity of calories, but higher quantity of fat, comes antioxidants and anti-inflammatory properties. Consuming spinach may lessen risk of certain cancers and improve health outcomes, for its extended shelf-life spinach offers dehydrated and processed powder for easier storage and use.⁸ Chia seeds and spinach powder have antioxidant qualities.^{9,10} that can help fight oxidative stress and lower the chance of developing chronic illnesses including cancer and heart disease. Numerous studies focused on individual applications of these ingredients like use of spinach powder in ultra-filtered soft cheese cake,¹¹ gluten free bread with chia seeds,¹² biscuits were prepared using oats,¹³ durum wheat bread was fortified with spinach powder,¹⁴ despite the combined use of these ingredients has not been explored in existing literature.

The objective of this study is to analyze the chemical and sensory properties of a flour developed from oats, chia seeds and spinach. The rationale behind this research is to explore the potential of this flour as a functional food, by analyzing its nutritional composition including fiber, protein, fat, carbs, moisture and minerals, as well as sensory characteristics of taste, texture, appearance, general acceptability and color. The study seeks to contribute valuable insights into the development of plant-

based, health promoting foods. The findings will provide a better understanding on how the combination of these ingredients can improve the nutritional composition and sensory attributes of plant-based food products, contributing to healthier alternatives in food industry.

MATERIALS AND METHODS

Its interventional study design focused on the development of flour blends and comparison of their nutritional composition and sensory performed under ethical approval from the IRB (RE= 087-2023) of University of Management and Technology. The study duration was of 5 months (13-11-2023 to 30-03-2024), during which the experiment was performed. The eligibility criteria for ingredient selection in study included buying fresh oats, chia seed and spinach from local market of Lahore. Spinach was sun dried for three days to conserve its nutrients and then we grinded oats, chia seeds and dried spinach separately from each other in electrical spice grinder to prepare flour of these ingredients.

A previous study, utilized an oat- chia composite in a proportion of (4:1) as a filler, and were added at concentrations of 3 and 5% in yogurt (200 ml total volume). Thus, instead of yogurt spinach powder was used in (4:1) oats-chia seeds composite making two new samples. Group 0 (4:1:1) of oats, chia seeds, spinach powder which is standardized and referred as control, and Group 1 (5:2:2) referred as experimental group.

Standardized measurement of 1 teaspoon equivalent to 5 grams was used for calculating amount of each ingredient in both flours. For Group 0 (4:1:1), formulation consisted of 20 g of oat flour, 5g chia flour and 5 g spinach powder and for Group 1 formulation consisted of 25g of oat flour, 10g chia flour and 10 g spinach powder. Additionally, scaling factor was used to calculate the proportion of 100g for both flours. For Group 0, the flour consisted of

66g of oat flour, 17 g of chia flour and spinach powder. Similarly, for Group 1, the flour comprised 56g of oat flour, 22 g of chia flour and 22 g of spinach powder.¹⁵

Scaling factor= (Desired weight)/ (Total weight of ingredient)

The study was conducted at University of Management and Technology with standardized methods. The variables in the study included proximate composition which as determined in laboratory using (hot air oven for moisture, Kjeldahl for crude protein, fiber analyser for crude fiber, muffle furnace for ash, Soxhlet system for fat) and mineral analysis (atomic absorption spectrophotometer for iron, calcium, flame photometry for potassium and magnesium and spectrophotometer for phosphorus) as well as sensory attributes for appearance, color, texture, taste and general acceptability of both flours was determined using a questionnaire. For investigating the organoleptic properties, tortilla wraps were prepared from both flour samples. Sensory evaluation panel from the Department of Nutrition and Dietetics of the University of Management and Technology evaluated the wraps using standard questionnaire. The questionnaire was based on a 9-point hedonic scale with scores ranging from 1 to 9, designating 1 (least undesirable), 2 (dislike very much), 3 (dislike moderately), 4 (dislike slightly), 5 (neither like nor dislike), 6 (like slightly), 7 (like moderately), 8 (like very much), 9 (most desirable). Panellist evaluated both the samples based on these scores for sensory attributes of color, texture, taste, appearance and general acceptability of both samples. The sensory evaluation data for each was analysed in SPSS version 26 using independent sample t test to compare the sensory attributes of both samples at 95% level of confidence. Potential biases were limited by conducting blinded sensory assessment and assuring standardized preparation and serving of the samples.

RESULTS

Proximate analysis of both flours shows that

Group 1 flour has increased amount of dry matter 92.17%, crude protein 13.20%, crude fiber 11.85%, fat 8.0%, ash 6.63% but lower amount of moisture 7.83%, carbs 60.32% and energy 365 Kcal compared to Group 0 dry matter 63.63%, Crude protein 12.10%, Crude fiber 4.62%, ash 2.30%, fat 4.25%, moisture 36.37%, Carbs 76.73% and energy 393 Kcal. (Table-1).

Table 1: Proximate Analysis of Both Flours

Type of test in percentages %	Group 0 (4:1:1)	Group 1 (5:2:2)
Dry matter	63.63	92.17
Moisture	36.37	7.83
Crude Protein	12.10	13.20
Crude fiber	4.62	11.85
Fat	4.25	8.0
Ash	2.30	6.63
Carbs	76.73	60.32
Energy (Kcal/100g)	393	365

Group 1 (5:2:2) flour has increased K (112.0 mg/L), Fe (95.0 mg/L), moderate amount of P (25.6 mg/L), Mg (15.0 mg/L), and least amount of Ca (6.79 mg/L). (Table-2).

Table 2: Mineral Analysis of Group 1 Flour

Test	Fe (mg/L)	Mg (mg/L)	Ca (mg/L)	P (mg/L)	K (mg/L)
	95.0	15.0	6.79	25.6	112.0

Independent sample t test group statistics shows that the mean and standard deviation for appearance of flour for Group 0 is 6.87 ± 1.302

& for Group 1 is 7.40 ± 1.121 , color of product for Group 0 is 6.93 ± 1.163 & for Group 1 is 7.00 ± 1.254 , texture of product for Group 0 is 6.80 ± 1.373 & for Group 1 is 7.47 ± 0.990 , taste of product for Group 0 is 7.67 ± 0.976 & for Group 1 is 7.73 ± 1.223 , general acceptability of product for Group 0 is 7.80 ± 1.014 and for Group 1 is 8.00 ± 0.845 . Since all the features have ($p > 0.05$), it means that there is no significant difference between color, appearance, taste, texture and acceptability of both flours. (Table-3).

Table 3: Comparison of Sensory Attributes

Sensory Attributes	Group 0 (4:1:1)	Group 1 (5:2:2)	P value
Appearance	6.87 ± 1.302	7.40 ± 1.121	0.239
Colour	6.93 ± 1.163	7.00 ± 1.254	0.881
Texture	6.80 ± 1.373	7.47 ± 0.990	0.138
Taste	7.67 ± 0.976	7.73 ± 1.223	0.870
General acceptability	7.80 ± 1.014	8.00 ± 0.845	0.562

DISCUSSION

The results of the current study presented notable variations in both the nutritional and sensory analysis of flour blends, Group 0 (4:1:1) and Group 1 (5:2:2)

A key finding from the sensory evaluation of tortilla wraps made from both flour mixtures was the impact of spinach powder on the color of product. Inclusion of spinach powder in both Group 0 and Group 1 flour produced green color, where Group 1 presented a darker green color than Group 0 which aligns with the findings of the study that prepared dried noodles using different proportions of spinach powder demonstrated that increasing the amount of spinach powder in dough results in a darker green color.¹⁶ Furthermore, the

ingredient ratio in both flours noticeably affected water holding and retention capacity of the doughs. Group 0 dough with lower chia seeds content, exhibited better water retention and absorption capacity, resulting in dough that was easy to knead, shape and roll out and doesn't become excessively sticky. In comparison, the Group 1 dough with higher chia seeds content contributed to improved water retention but became more vulnerable to sticking, needing more efforts and adjustments during the kneading process to reach the intended consistency. The findings align with the study that prepared chicken meat sausages using different proportion of chia seeds presented that increasing chia seeds content resulted in increased water holding capacity of chicken meat sausages.¹⁷

Proximate analysis manifests that Group 1 flour has increased amount of crude protein, fiber, fat, ash, but lower amount of moisture and carbohydrates compared to Group 0 flour. Increased protein content in Group 1 flour may increase its demand among individuals seeking to improve their protein intake for exercising regularly,¹⁸ whereas the increased fiber content can contribute to improved bowel movements and digestion whereas higher amount of chia seeds contributed to lower moisture content of Group 1 flour,¹⁹ the lower carbohydrate content of Group 1 flour is suitable for individuals with diabetes,²⁰ as it provides a source of complex carbohydrates and higher fat content of Group 1 which contains polyunsaturated and monounsaturated fatty acids is valuable for patient with heart disease as it help lowers cholesterol and is associated with reduced risk of developing type 2 diabetes mellitus and CVD.²¹ Furthermore, it is also beneficial for patients with iron deficiency and elevated blood pressure as it is enriched in iron and potassium. Statistical analysis shows that both flours are equally acceptable based on sensory attributes of color, general acceptability, texture, taste and appearance.

The current study strives to prepare a flour blend from plant-based local ingredients oats, chia seeds and spinach powder for promoting

the health of community. Chia seeds are known for higher amounts of protein and fiber²² and contains abundant quantity of fatty acids, vitamins, minerals and dietary fiber²³ contributing valuable addition to any food. Spinach carries lower amount of carbohydrate.²⁴ but abundant quantity of many minerals comprising calcium, potassium, zinc, iron, sodium.²⁵ Oats contain abundant quantity of fiber, iron and zinc.²⁶

While many studies have looked at the nutritional benefits of oats, chia seeds and spinach powder individually while modifying traditional foods, but the outcomes of this study highlight the importance of combining all three ingredients to create a nutrient enriched flour. For instance, one study found that fortifying traditional wheat flour biscuits with oats flour enhanced protein, fat, fiber and mineral content of the biscuits.²⁷ Whereas, spinach powder was utilized in preparing cookies compared to wheat flour cookies enhances its nutritional profile.²⁸ Similarly, chia seeds were used with corn flour for enhancing nutritional profile of gluten free products for celiac patients. and incorporation of chia seeds resulted an increase in fat, fiber and mineral content compared to corn flour gluten free product without chia seeds.²⁹

The limitation of the study is that all ingredients were purchased from local markets of Lahore. The nutritional content and quality of ingredients from different regions or seasons could affect the consistency of the results. While the sensory evaluation was conducted blind, probable biases could have been introduced due to panellists preferences, familiarity with ingredients used and subjective nature of sensory assessments whereas the evaluation was performed by 15 trained panellist which could not be a representative of broader population.

CONCLUSION

The study highlights that the flour created from the incorporation of oats, chia seeds and spinach powder can improve nutritional value

while retaining favourable sensory attributes. The findings manifest that Group 1 flour offers more protein, fiber, fat and mineral content in contrast to Group 0 flour making it highly beneficial for individuals who wants to improve dietary status. The combination of these three ingredients not only amplify nutritional profile but also promote nutritional benefits for individuals with diabetes, cardiovascular diseases, bowel problems and nutrient deficiencies. Furthermore, the outcomes manifest that these ingredients can be advantageously combined for promoting the health of community through locally available plant-based ingredients to develop healthier food alternatives.

CONFLICT OF INTEREST

No conflict of interest is declared by authors.

FUNDING

None

AUTHOR'S CONTRIBUTIONS

AN: Manuscript writing

A: Interpretation of data

AS: Study design

SSZ: Data collection

AR: Data analysing

FR: Study concept

REFERENCES

- Zohoori FV. Nutrition and diet. The Impact of Nutrition and Diet on Oral Health. 2020;28:1-3.3. <https://doi.org/10.1159/000455365>
- World Health Organization. Malnutrition [Internet]. Geneva: World Health Organization; [cited 2025 Jan 23]. Available from: <https://www.who.int/news-room/fact-sheets/detail/malnutrition>
- Cena H, Calder PC. Defining a healthy diet: evidence for the role of contemporary dietary patterns in health and disease. *Nutrients*. 2020 Jan 27;12(2):334. <https://doi.org/10.3390/nu12020334>.
- Alemayehu GF, Forsido SF, Tola YB, Amare E. Nutritional and Phytochemical Composition and Associated Health Benefits of Oat (*Avena sativa*) Grains and Oat-Based Fermented Food Products. *TSWJ*.2023;2023(1):2730175. doi: <https://doi.org/10.1155/2023/2730175>
- Rafique H, Dong R, Wang X, Alim A, Aadil RM, Li L, Zou L, Hu X. Dietary-nutraceutical properties of oat protein and peptides. *Front Nutr*. 2022 Jul 5;9:950400. doi:<https://doi.org/10.3389/fnut.2022.950400>
- Agarwal A, Rizwana, Tripathi AD, Kumar T, Sharma KP, Patel SK. Nutritional and functional new perspectives and potential health benefits of quinoa and chia seeds. *Antioxidants (Basel)*. 2023;12(7):1413. doi: [10.3390/antiox12071413](https://doi.org/10.3390/antiox12071413).
- Khalid W, Arshad MS, Aziz A, Rahim MA, Qaisrani TB, Afzal F et.al.Chia seeds (*Salvia hispanica* L.): A therapeutic weapon in metabolic disorders. *Food sci nutr*. 2023 Jan;11(1):3-16. doi: <https://doi.org/10.1002/fsn3.3035>.
- Waseem M, Akhtar S, Manzoor MF, Mirani AA, Ali Z, Ismail T, et.al. Nutritional characterization and food value addition properties of dehydrated spinach powder. *Food sci nutr*. 2021 Feb;9(2):1213-21. doi: <https://doi.org/10.1002/fsn3.2110>.
- Chaudhary N, Dangi P, Kumar R, Bishnoi S. Chia Seeds—A renewable source as a functional food. In: *Handbook of Cereals, Pulses, Roots, and Tubers*. CRC Press; 2021. p. 235-252.
- Susanti S, Dwiloka B, Bintoro VP, Hintono A, Nurwantoro N, Setiani BE. Antioxidant status, nutrition facts, and sensory of spinach extract fortified wet noodles. *Food Res*. 2021 Dec;5(6):266-73. doi:[https://doi.org/10.26656/fr.2017.5\(6\).027](https://doi.org/10.26656/fr.2017.5(6).027)
- El-Sayed SM. Use of spinach powder as functional ingredient in the manufacture of

12. UF-Soft cheese. *Heliyon*. 2020 Jan 1;6(1):e03278.
doi: 10.1016/j.heliyon.2020.e03278
13. da Costa Borges V, Fernandes SS, da Rosa Zavareze E, Haros CM, Hernandez CP, Dias AR, de las Mercedes Salas-Mellado M. Production of gluten-free bread with flour and chia seeds (*Salvia Hispanica L*). *Food Biosci*. 2021 Oct 1; 43:101294.
doi: 10.1016/j.fbio.2021.101294
14. Swapna KS, Vijaya Geeta V, Anupama M, Mishra D, Kulkarni J. Effect of oat incorporation on textural parameters of dough and sensory quality of biscuits. *J Food Drug Res (JFDR)*. 2023 Mar 10;3(1):15-23.
doi: 10.48165/jfdr.2023.3.1.4
15. Junejo SA, Rashid A, Yang L, Xu Y, Kraithong S, Zhou Y. Effects of spinach powder on the physicochemical and antioxidant properties of durum wheat bread. *LWT - Food Sci Technol*. 2021 Oct 1; 150:112058.
doi: 10.1016/j.lwt.2021.112058
16. Nadtochii LA, Baranenko DA, Lu W, Safronova AV, Lepeshkin AI, Ivanova VA. Rheological and physical–chemical properties of yogurt with oat–chia seeds composites. 2020.
doi: 10.1515/AR.20.142
17. Hamid MA, Yip QQ, Yeap CH, Martony O, Ayub MS, Boestamam N, Sugianto S. The Effect of Spinach Leaves Powder (*Spinacia oleracea*) on the Quality of Dried Noodle. *Proceeding International Conference on Religion, Science and Education*. 2024 Mar 13;3:131-139.
18. Arifin N, Hanifah NF, Yahya HN. Physicochemical Properties, Nutritional Composition and Sensory Acceptance of Chicken Meat Sausages with Chia Seed Powder Substitution. *Malays J Sci Health Technol (MJSH)*. 2021 Mar 30;7(1):34-42.
19. Kerksick CM, Jarim A, Hagele A, Jäger R. Plant proteins and exercise: what role can plant proteins have in promoting adaptations to exercise? *Nutrients*. 2021 Jun 7;13(6):1962.
doi: 10.3390/nu13061962
20. McRorie JW, McKeown NM. Understanding the physics of functional fibers in the gastrointestinal tract: an evidence-based approach to resolving enduring misconceptions about insoluble and soluble fiber. *J Acad Nutr Diet (JAND)*. 2017 Feb 1;117(2):251-64.
doi: 10.1016/j.jand.2016.09.021
21. Kelly T, Unwin D, Finucane F. Low-Carbohydrate diets in the management of obesity and type 2 diabetes: a review from clinicians using the approach in practice. *Int J Environ Res Public Health (IJERPH)*. 2020 Apr;17(7):2557.
doi:10.3390/ijerph17072557.
21. Petersen KS, Maki KC, Calder PC, Belury MA, Messina M, Kirkpatrick CF, Harris WS. Perspective on the health effects of unsaturated fatty acids and commonly consumed plant oils high in unsaturated fat. *Br J Nutr (BJN)*. 2024 Sep 24;1-2.
doi: 10.1017/S0007114524002459
22. Kluczynski B, Kobus-Cysewski J, Taczanowski M, Kmiecik D, Gramza-Michałowska A. The chemical composition and nutritional value of chia seeds—Current state of knowledge. *Nutrients*. 2019 May 31;11(6):1242.
doi: 10.3390/nu11061242
23. Mehta J, Saeed MS, Saeed A. Health aspects of Chia seeds (*Salvia hispanica L.*)-an overview. *Curr Agric Res J*. 2020;1(3):9-12.
doi: 10.18782/2582-7146.115
24. Jaiswal AK, editor. *Nutritional composition and antioxidant properties of fruits and vegetables*. Academic Press; 2020 Aug 17.
25. Rashid M, Yousaf Z, Din A, Munawar M, Aftab A, Riaz N, et al. Assessment of mineral nutrient efficiency in genetically diverse spinach accessions by biochemical and functional marker strategies. *Front Plant Sci*. 2022 May 30; 13:889604.
doi: 10.3389/fpls.2022.889604
26. Sangwan S, Singh R, Tomar SK. Nutritional and functional properties of oats: An update. *J Innov Biol*. 2014 Mar;1(1):3-14.

- 27.** Morsy MK. Physicochemical and Sensory Properties of Functional Biscuits Fortified With Oat Flour. *Ann Agric Sci.* 2022 Mar 1;60(1):63-72.
doi: 10.21608/assjm.2022.227247
- 28.** Shatat NA, Khalil M, El-Gammal R. Effect of Adding Veggies Powdered on Physico-Chemical and Sensory Properties of Cookies. *J Food Technol Res.* 2023 Sep 1;2(1):50-63.
doi: 10.21608/ftj.2023.316704
- 29.** Aly A, Abd El-Sabor R, Sadeek RA. The use of corn flour, chia and quinoa powders in preparing gluten-free products for celiac patients. *J Res Spec Educ Needs.* 2021 Jan 1;7(32):1855-76.
doi: 2022.163406.1753jedu1