



Impact of Tigernuts on Blood Glucose and Insulin Levels in Normal Weight Male Humans

Igbinovia Edokpolor N^{1*}, Ohiwerei Wisdom O², Blackie Okosun H³, Edebiri Ogbemudia E⁴, Otaye Micheal O⁵, Ohiwerei Faith O⁶

^{1,4}Ambrose Alli University, Ekpoma, Edo State

^{2,5,6}Ohilux Global, Ekpoma, Edo State

³Ambrose Alli University, Ekpoma, Edo State

Corresponding Author: Igbinovia Edokpolor N

Ohiwereiwisdom@gmail.com

ARTICLE INFO

Keywords: Blood Glucose, Sterols, Insulin, Male Humans, Vitamins

Received : 5 September

Revised : 23 October

Accepted: 23 November

©2024 Edokpolor, Wisdom, Okosun, Ogbemudia, Micheal, Faith: This is an open-access article distributed under the terms of the [Creative Commons Attribution 4.0 International](https://creativecommons.org/licenses/by/4.0/).



ABSTRACT

Tigernuts contain bioactive compounds such as sterols, alkaloids, tannins, saponins, resins, and vitamins E and C. This study examined their effects on blood glucose and insulin levels in normal-weight male subjects under resting conditions. **Methods:** Forty non-habitual tigernut chewers, aged 18–28 years, participated. After recording anthropometric data, subjects rested for 90 minutes. Blood glucose levels were measured using the enzymatic method of Barham and Trinder with a glucometer. Insulin levels were assessed using the ELISA Teco kit following Tiez and Andresen's method. On a separate day, the same subjects consumed 5g of tigernuts as a bolus, followed by 50ml of water. After another 90-minute rest, blood glucose and insulin levels were reassessed. Statistical analysis was conducted using GraphPad Prism Version 8.1. **Results:** Tigernut consumption led to a slight reduction in blood glucose levels (92.66 ± 2.156 to 89.61 ± 1.907 mg/dl), though not statistically significant. However, insulin levels showed a significant decrease ($P < 0.05$, 4.220 ± 0.297 to 1.705 ± 0.061 $\mu\text{g/ml}$). **Conclusion:** Tigernuts demonstrated both blood glucose and insulin-lowering effects in normal-weight male subjects

INTRODUCTION

Cyperus esculentus L., commonly known as earthnut (chufa or earth almond), is a perennial tuberous plant from the sedge family (*Cyperaceae*). It is cultivated in Brazil, Spain, East Africa, several West African countries, including Nigeria and Portugal [1], and in Ukraine, where it is grown in experimental and home gardens [2,3]. The plant is valued for its small, sweet, almond-shaped tubers, which serve as a source of edible oil. These tubers, formed at the roots, have a hard shell, crispy texture, and sweet taste. Historically, chufa tubers have been consumed for their high nutritional value, containing 20–25% lipids, 20–35% starch, 12–28% sugars, and 5–9% proteins. The extracted oil has applications in food, industrial processing, and medicine [4]. Due to its biologically active compounds, earthnut tubers are considered promising for dietary, children's, and specialty foods.

LITERATURE REVIEW

Widely cultivated in the Arabian Peninsula and other regions, *Cyperus esculentus* is an erect, fibrous-rooted perennial plant that grows between 1 and 3 feet tall, reproducing via seeds and rhizomes [5]. The edible tubers have a distinct sweet, nutty flavor and are consumed in Nigeria in various forms, including roasted, baked, dried, raw, or as a drink called *kunnu* [6]. The fat composition of these tubers is similar to olive oil, with 72% unsaturated fatty acids (oleic and linoleic acids) and 28% saturated fatty acids (palmitic and stearic acids) [7]. Extracts from *C. esculentus* have been reported to possess anti-cancer, anti-microbial, anti-diarrheal, and anti-flatulent properties and have been used in treating anemia, urinary tract infections, and hypercholesterolemia [8,9,10,11,12].

Beyond its nutritional value, *C. esculentus* tubers have other applications. In Spain, they are used to prepare a milk-like beverage called *horchata* [13]. Tigernuts are highly nutritious, cholesterol- and gluten-free [15], and are among the richest known sources of flavonoids [16]. They are abundant in water, fiber, alkaloids, digestible carbohydrates, saponins, and fatty oils (glycerides), and contain essential elements such as phosphorus, potassium, calcium, iron, zinc, magnesium, and manganese [17,18].

Tigernut oil is rich in monounsaturated fatty acids, resembling those found in olive, avocado, and hazelnut oils [19]. This oil contains high levels of unsaponifiable matter, phospholipids, and various bioactive compounds such as tocopherols, phytosterols, and polyphenols [20,19]. The small, round tubers, which grow along the roots, have a mild almond-like flavor and can be consumed raw, cooked, or prepared as *orxata*. Research indicates that these tubers contain phytosterols, ascorbic acid (*Vitamin C*), tocopherol (*Vitamin E*), and β -carotene [21]. These compounds, in conjunction with the tubers' unsaturated fatty acids, may contribute to their antioxidant activity.

Many plant-derived compounds have demonstrated various health benefits [22]. Medicinal plants, including *Cyperus esculentus*, have shown potential therapeutic effects [23,24,25]. Approximately 160 phytochemicals from 101 plant species have been reported to offer liver and kidney protection [26]. Medicinal plants continue to play a crucial role in treating liver and kidney diseases [27].

The World Health Organization (WHO) recognizes diabetes mellitus as a growing non-communicable epidemic that presents significant medical and social challenges due to its complications, such as angiopathies, which negatively impact patients' quality of life and life expectancy [28,29,30,31]. As a response, pharmacotherapy is increasingly incorporating traditional medicinal practices, particularly phytopreparations [32,33,34]. Herbal remedies are being explored as either monotherapy for type 2 diabetes mellitus prevention or as part of early-stage interventions [35,36,28,29]. Thus, the search for new plant-based treatments to regulate metabolic disorders in diabetes remains a critical focus in pharmacy and medicine [29,37]. This approach is justified, as phytotherapy offers several advantages over synthetic drugs, including lower toxicity, mild pharmacological effects, and long-term use with minimal side effects [38,39,40]. There is growing interest in identifying medicinal plants with extensive historical use and minimal adverse effects [41,28]. The primary goal of using plant-based treatments is to manage metabolic disorders since plant metabolites closely resemble those found in the human body [40,42,43,38,39].

Given this background, the present study investigated the effects of *Cyperus esculentus* (CE) on blood glucose and insulin levels in normal-weight male human subjects. Additionally, the study sought to explore the potential mechanisms through which CE influences these metabolic parameters.

METHODOLOGY

Subjects

Forty normal-weight male volunteers (18–28 years) from Ambrose Alli University participated. They were non-habitual tigernut chewers, and their health status was assessed via questionnaires and physical examination. Informed consent and ethical approval were obtained before the study.

Inclusion/Exclusion Criteria

Subjects with hypertension, kidney, heart conditions, ulcers, diabetes, or other health issues were excluded. Only normal-weight individuals (BMI 18.5–25.0 kg/m²) were studied. Before the study, age, weight, height, BMI, blood pressure, and heart rate were recorded.

Determination of Body mass index

Body mass index (BMI) was calculated as weight (kg) divided by height (m²). Subjects removed shoes and heavy clothing before measurements, with weight recorded using a Camry balance (Italy) and height measured using a Henglida stadiometer (China). Only individuals with BMI 18.5–24.9 were included.

Control subjects arrived fasting, relaxed for 1 hour 30 minutes, and had their blood glucose and insulin levels measured. Blood glucose was assessed enzymatically using a glucometer, while insulin levels were determined with an ELISA Teco kit.

On a separate day, the same subjects consumed 5g of tigernut, followed by 50ml of water. After resting for 1 hour 30 minutes, blood samples were collected again to measure glucose and insulin levels.

Collection of Blood Sample

A 3ml blood sample was drawn from the medial cubital vein using a vacutainer syringe on the same day as serum collection. The sample was placed in an anticoagulant-free tube and allowed to clot for 60 minutes. Serum was then separated by centrifugation at 3,000 rpm for 10 minutes at room temperature..

Statistical Analysis

Statistical analyses were carried out using Graph Pad Prism Statistical Software version 8.1. The results were presented as Mean \pm SEM. A P-value of less than 0.05 was considered to be statistically significant.

RESULT

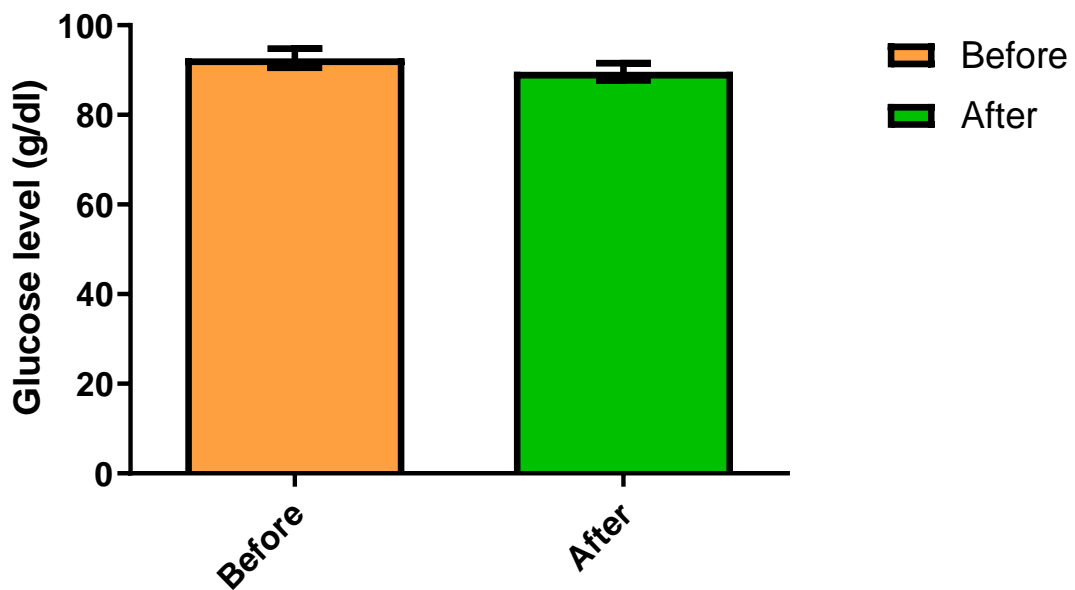


Fig: I Showing the Effect of Tigernut Consumption on Glucose Level in Young Adult Individuals

There was no significant difference after consumption of Tiger nut compared with before consumption

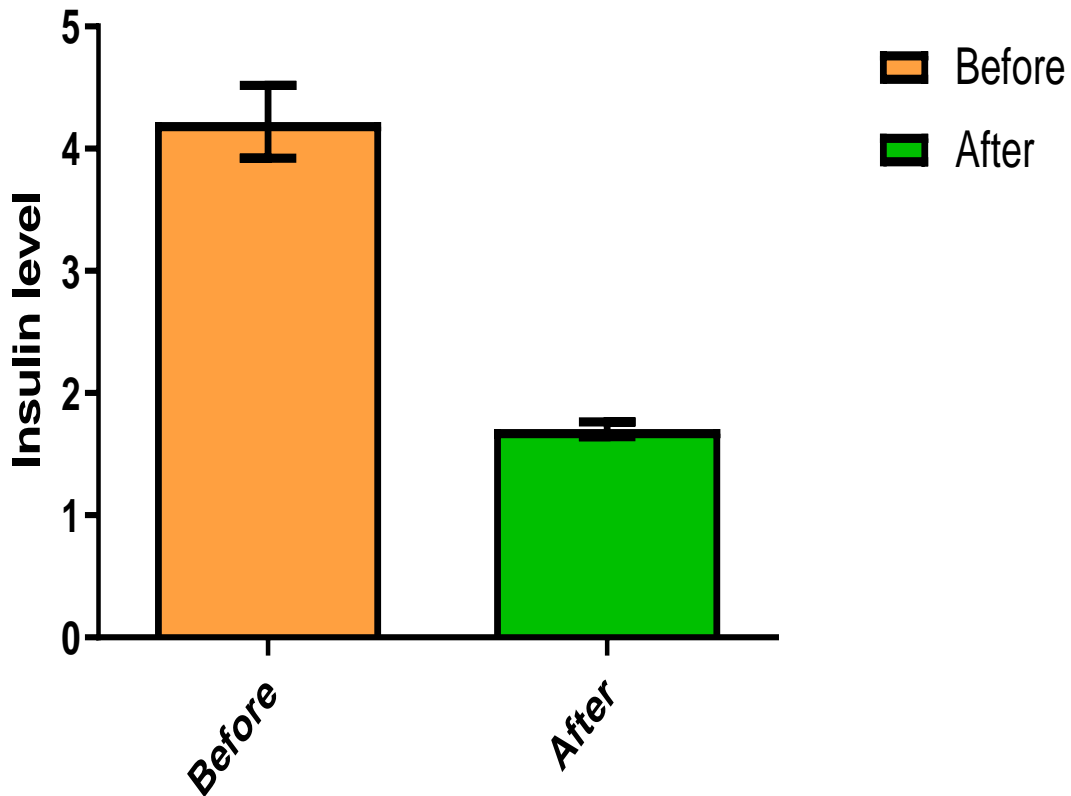


Fig II: Shows the Effect of Tiger Nut Consumption on Insulin Level in Young Adult Individuals

There was a significant decrease after consumption of Tiger nut compared with before consumption.

DISCUSSION

The study examined the potential impact of tigernuts on blood glucose and insulin levels in normal-weight male subjects under resting conditions, as well as the possible mechanisms involved. Results indicated that tigernuts reduced blood glucose levels post-consumption (from 92.66 ± 2.156 to 89.61 ± 1.907 mg/dl), though this reduction was not statistically significant. However, a significant decrease ($P < 0.05$) in insulin levels was observed (from 4.220 ± 0.297 to 1.705 ± 0.061 µg/ml).

Tigernuts contain bioactive compounds such as sterols, alkaloids, tannins, saponins, resins, and vitamins E and C.[44] They are nutrient-rich, comprising 22.14–44.92% lipids, 3.28–8.45% proteins, 23.21–48.12% starch, 8.26–15.47% fiber, and 1.60–2.60% ash.[45] The tubers are a valuable source of edible oils, predominantly monounsaturated fatty acids, with a nutritional profile similar to olive oil.[46] Given their high lipid content (22.14–44.92%), tigernut oil is considered highly suitable for human consumption, with a composition akin to olive oil, which is widely regarded as the healthiest dietary fat.[47] Additionally, tigernuts contain essential minerals such as sodium, potassium, calcium, iron,

magnesium, zinc, copper, and phosphorus.[48,49] The oil's antioxidant properties enhance its oxidative stability compared to other vegetable oils.[50] Furthermore, alkaloids, saponins, tannins, and phenols in tigernuts exhibit antibacterial and anti-inflammatory effects.[51]

Tigernuts are composed of 77.49–80.01% essential fatty acids and 31.32–34.03 mg/100 g essential amino acids.[52] The tubers are rich in disaccharide *D-saccharose*, which hydrolyzes into *D-glucose*, *D-galactose*, *D-xylose*, and *D-arabinose*. [44] Notably, most studies investigating the effects of tigernuts on blood glucose have been conducted on animals. This study is among the few human-based investigations, potentially pioneering in its field. Comparisons with previous animal studies indicate that tigernuts consistently lowered blood glucose levels upon administration, aligning with the present study's findings, despite the non-statistical significance of the reduction.

Further supporting evidence from [53] demonstrated that *C. esculentus* oil significantly contributed to weight reduction and blood sugar control. Additionally, [33] reported that a concentrated earthnut extract exhibited a dose-dependent hypoglycemic effect, with an effective dose estimated at 200 mg/kg in animal experiments. Research by [54] found that streptozotocin-induced diabetic rats fed with tigernut tubers exhibited considerable hypoglycemia and hypolipidemia. Moreover, [55] suggested that tigernut milk could be beneficial for diabetic individuals and aid in weight management due to its high fiber content. The presence of digestive enzymes such as catalase, lipase, and amylase in tigernuts also supports their role in treating indigestion, constipation, flatulence, and diarrhea.

Regarding insulin levels, previous studies have largely focused on animal experiments. Some researchers previously reported that tigernuts contain high levels of *L-arginine*, which stimulates insulin secretion.[56] This study initially expected an increase in insulin levels; however, the findings revealed a significant reduction, possibly indicating that only the necessary amount of insulin for glucose regulation was produced, regardless of the observed decrease. Insulin is a crucial hormone for metabolism, and its secretion is tightly regulated by metabolic demands. Along with glucose, certain amino acids and fatty acids influence insulin release, and tigernuts are abundant in these compounds. The possibility exists that the bioactive components in tigernuts led to β -cell burnout or inhibition, ultimately contributing to the observed insulin reduction.

Comparisons with previous animal-based research suggest that insulin secretion could be associated with various biochemical mechanisms, supporting the current study's findings that tigernuts significantly lowered ($P < 0.05$) blood insulin levels after consumption. Potential mechanisms for tigernuts' effect on glucose levels include their high *L-arginine* content, which promotes insulin release.[10] Additionally, [57] reported that *C. esculentus* seed extract inhibits *α -glucosidase* and *α -amylase*, reducing or even preventing starch hydrolysis into free glucose. Their study suggested that the enzymes exhibit a higher affinity for *C. esculentus* than for their natural substrates, effectively modulating carbohydrate breakdown. Other potential mechanisms include (i) stabilized glycosylated hemoglobin, (ii) glucose-6-phosphate dehydrogenase regulation, (iii) inhibited *α -*

amylase activity, (iv) improved lipid profiles, and (v) enhanced antioxidant capacity. These findings suggest that *C. esculentus* oil may serve as a therapeutic agent or dietary supplement for managing type 2 diabetes.[53]

CONCLUSIONS AND RECOMMENDATIONS

In summary, tigernuts were found to reduce blood glucose and insulin levels in normal-weight human subjects. The mechanisms underlying these effects are likely multifactorial, and several potential explanations have been proposed above.

ACKNOWLEDGMENT

The authors acknowledge the entire staff of Ohilux Global Laboratory, Ekpoma, Edo State, Nigeria.

Conflict of Interest

The authors declare that we have no financial or personal relationship(s) which may have inappropriately influenced us in writing this paper.

Author Contributions

1. Igbinovia, Edokpolor N. conceptualized the research, was involved in data curation and supervision of the research
2. Ohiwerei, Wisdom O. was involved in the formal analysis, investigation, methodology and reviewing of the manuscript
3. Olugbenga, Mary A. was involved in funding acquisition, providing essential materials and reagents for the research
4. Otaye, Micheal O. was involved in validation of the research and writing of the initial manuscript
5. Festus, Oloruntoba O. was involved in funding acquisition and provision of essential materials and reagents for the research
6. Echekwube Marylyn E. was involved in the preparation of the initial manuscript and data visualization
7. Ibadode Adesuwa was involved in investigation and review of the manuscript

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to patient confidentiality.

REFERENCES

- Abuharfeil NM, Salim M, Von Kleist S. Augmentation of natural killer cell activity in vivo against tumour cells by some wild plants from J Salim EI, Fukushima S. Chemopreventive potential of volatile oil from black cumin (*Nigella sativa* L.) seeds against rat colon carcinogenesis. *Nutrition and cancer*. 2003 Mar 1;45(2):195-202.ordan. *Phytotherapy Research*. 2001 Mar;15(2):109-13.
- Addy EO, Eteshola E. Nutritive value of a mixture of tigernut tubers (*Cyperus esculentus* L.) and baobab seeds (*Adansonia digitata* L.). *Journal of the Science of Food and Agriculture*. 1984 Apr;35(4):437-40.

- Adejuyitan JA, Otunola ET, Akande EA, Bolarinwa IF, Oladokun FM. Some physicochemical properties of flour obtained from fermentation of tigernut (*Cyperus esculentus*) sourced from a market in Ogbomoso, Nigeria. *African Journal of Food Science*. 2009 Feb;3(2):51-5.
- Adel AA, Awad AM, Mohamed HH, Iryna S. Chemical composition, physicochemical properties and fatty acid profile of Tiger Nut (*Cyperus esculentus* L) seed oil as affected by different preparation methods. *International Food Research Journal*. 2015 Aug 1;22(5).
- Airaodion AI, Ogbuagu U, Ekenjoku JA, Ogbuagu EO, Airaodion EO, Okoroukwu VN. Hepato-protective Efficiency of Ethanol Leaf Extract of *Moringa oleifera* Lam. against Hydrocarbon Exposure. 2019
- Bazhay-Zhezherun S, Antoniuk M, Smulska J. Biologically activated wheat grain as a functional component of glazed bars. *Ukrainian Food Journal*. 2015:310.
- Belewu MA, Abodunrin OA. Preparation of Kunnu from unexploited rich food source: Tiger nut (*Cyperus esculentus*). *World Journal of Dairy and Food Sciences*. 2006;1(1):19-21.
- Borges R, Carmona M, Costa B, Don WS. An improved weighted essentially non-oscillatory scheme for hyperbolic conservation laws. *Journal of computational physics*. 2008 Mar 1;227(6):3191-211.
- Budniak L, Slobodianiuk L, Darzuli N, Honcharuk Y. The antibacterial activity of the tablets with dry extract of round-leaved wintergreen leaves. *Pharmacologyonline*. 2021;2:672-9.
- Budniak L, Slobodianiuk L, Marchyshyn S, Basaraba R, Banadyga A. The antibacterial and antifungal activities of the extract of *Gentiana cruciata* L. herb. *PharmacologyOnLine*. 2021;2:188-97.
- Budniak L, Slobodianiuk L, Marchyshyn S, Demydiak O. Determination of *Arnica foliosa* Nutt. fatty acids content by GC/MS method. *Fatty Acids Content by GC/MS Method* (December 30, 2020). *ScienceRise: Pharmaceutical Science*. 2020 Dec 30;6(28):14-8.
- Budniak L, Vasenda M, Slobodianiuk L. Determination of flavonoids and hydroxycinnamic acids in tablets with thick extract of *Primula denticulata* SMITH. *PharmacologyOnLine*. 2021;2:1244-53.
- Chatterjee TK. Medicinal plants with hepatoprotective properties. *Herbal options*. 2000;3:135-7.
- Chevallier A. *The encyclopedia of medicinal plants*. 1996

- Coşkuner Y, Ercan R, Karababa E, Nazlıcan AN. Physical and chemical properties of chufa (*Cyperus esculentus* L) tubers grown in the Çukurova region of Turkey. *Journal of the Science of Food and Agriculture*. 2002 May 1;82(6):625-31.
- Darzuli N, Budniak L, Slobodianiuk L. Investigation of the antibacterial and antifungal activity of the *Pyrola rotundifolia* L. leaves dry extract. *PharmacologyOnLine*. 2021 Apr 30;1:395-403.
- Ejoh RA, Djomdi, Ndjouenkeu R. Characteristics of tigernut (*Cyperus esculentus*) tubers and their performance in the production of a milky drink. *Journal of Food Processing and Preservation*. 2006 Apr;30(2):145-63.
- El-Habashy IE. Taxonomical and Chemosystematic Studies on *Cyperus* (Cyperaceae) in Egypt (Doctoral dissertation, Ph. D. Thesis, Fac. Sci., Mansoura Univ). 1988
- Ezeh O, Gordon MH, Niranjana K. Tiger nut oil (*Cyperus esculentus* L.): A review of its composition and physico-chemical properties. *European journal of lipid science and technology*. 2014 Jul;116(7):783-94.
- Ezeh O, Gordon MH, Niranjana K. Tiger nut oil (*Cyperus esculentus* L.): A review of its composition and physico-chemical properties. *European journal of lipid science and technology*. 2014 Jul;116(7):783-94.
- Fischer S, Scheffler A, Kabelitz D. Stimulation of the specific immune system by mistletoe extracts. *Anti-Cancer Drugs*. 1997 Apr 1;8:S33-7.
- Hassan HA, Hassan HA. The potential effect of tigernut oil on some haemato-biochemical blood indices in male albino rats. *Egypt. J. Exp. Biol.(Zool.)*. 2007;3:49-54.
- Huzio N, Grytsyk A, Slobodianiuk L. Determination of carbohydrates in *Agrimonia eupatoria* L. herb. *Herb* (December 30, 2020). *ScienceRise: Pharmaceutical Science*. 2020 Dec 30;6(28):35-40.
- Ijarotimi OS, Yinusa MA, Adegbembo PA, Adeniyi MD. Chemical compositions, functional properties, antioxidative activities, and glycaemic indices of raw and fermented tigernut tubers (*Cyperus esculentus* L.) flour. *Journal of Food Biochemistry*. 2018 Oct;42(5):e12591.
- Jeong SJ, Miyamoto T, Inagaki M, Kim YC, Higuchi R. Rotundines A- C, three novel sesquiterpene alkaloids from *Cyperus rotundus*. *Journal of Natural Products*. 2000 May 26;63(5):673-5.

- Lechhab T, Lechhab W, Cacciola F, Salmoun F. Sets of internal and external factors influencing olive oil (*Olea europaea* L.) composition: A review. *European Food Research and Technology*. 2022 Apr;248(4):1069-88.
- Lemaure B, Touché A, Zbinden I, Moulin J, Courtois D, Macé K, Darimont C. Administration of *Cyperus rotundus* tubers extract prevents weight gain in obese Zucker rats. *Phytotherapy Research*. 2007 Aug;21(8):724-30.
- Marchyshyn S, Budniak L, Slobodianiuk L, Ivasiuk I. Determination of carbohydrates and fructans content in *Cyperus esculentus* L. *Pharmacia*. 2021 Feb 9;68:211-6.
- Marchyshyn S, Slobodianiuk L, Budniak L, Ivasiuk I. Hypoglycemic effect of *Cyperus esculentus* L. tubers extract. *Pharmacologyonline*. 2021;2:1383-92.
- Marchyshyn SM, Ivasiuk IM, Rakhmetov DB, Sira LM. Morfoloho-anatomichne vvychennia pidzemnykh orhaniv smykavtsia yistivnoho (chufy) *Cyperus esculentus* L. [Morphological and anatomical study of the underground organs of the edible (chufa) tumbler *Cyperus esculentus* L.]. *Farmatsevychnyi chasopys* [Pharmaceutical journal]. 2018;3:22-8.
- Martínez JL, Liu L, Petranovic D, Nielsen J. Pharmaceutical protein production by yeast: towards production of human blood proteins by microbial fermentation. *Current opinion in biotechnology*. 2012 Dec 1;23(6):965-71.
- Mohammed OF, Pines D, Dreyer J, Pines E, Nibbering ET. Sequential proton transfer through water bridges in acid-base reactions. *Science*. 2005 Oct 7;310(5745):83-6.
- Nina GC, Ukeyima M, Ogori AF, Hleba L, Hlebova M, Glinushkin A, Laishevtcev A, Derkanosova A, Pigorev I, Plygun S, Shariati MA. Investigation of physiochemical and storage conditions on the properties of extracted tiger nut oil from different cultivars. *Journal of microbiology, biotechnology and food sciences*. 2020;9(5):988-93.
- Oladele AK, Aina JO. Chemical composition and functional properties of flour produced from two varieties of tigernut (*Cyperus esculentus*). *African journal of biotechnology*. 2007;6(21).
- Onyenibe NS, Udogadi NS. *International Journal of Diabetes Research*. Int. J. Diabetes Res. 2019 May;2(1):33-9.
- Ozcan MM, Gumuscu A, Er F, Arslan D, Ozkalp B. Chemical and fatty acid composition of *Cyperus esculentus*. *Chemistry of Natural Compounds*. 2010 May;46:276-7.

- Pascual B, Maroto JV, López-Galarza S, Sanbautista A, Alagarda J. Chufa (*Cyperus esculentus* L. var. *sativus* Boeck.): an unconventional crop. Studies related to applications and cultivation. *Economic botany*. 2000 Oct 1;439-48.
- Patzelt C, Labrecque AD, Duguid JR, Carroll RJ, Keim PS, Heinrichson RL, Steiner DF. Detection and kinetic behavior of preproinsulin in pancreatic islets. *Proceedings of the National Academy of Sciences*. 1978 Mar;75(3):1260-4.
- Rakhmetov D, Rakhmetova S, Mykolaychuk V. Chufa-perspective culture of complex use. 2008:54-6
- Rohdewald P. A review of the French maritime pine bark extract (Pycnogenol), a herbal medication with a diverse clinical pharmacology. *International journal of clinical pharmacology and therapeutics*. 2002 Apr 1;40(4):158-68.
- Roselló-Soto E, Poojary MM, Barba FJ, Lorenzo JM, Mañes J, Moltó JC. Tiger nut and its by-products valorization: From extraction of oil and valuable compounds to development of new healthy products. *Innovative Food Science & Emerging Technologies*. 2018 Feb 1;45:306-12.
- Sabiu S, Ajani EO, Sunmonu TO, Ashafa AO. Kinetics of modulatory role of *Cyperus esculentus* L. on the specific activity of key carbohydrate metabolizing enzymes. *African Journal of Traditional, Complementary and Alternative Medicines*. 2017 Aug 3;14(4):46-53.
- Sánchez-Zapata E, Fernández-López J, Angel Pérez-Alvarez J. Tiger nut (*Cyperus esculentus*) commercialization: health aspects, composition, properties, and food applications. *Comprehensive Reviews in Food Science and Food Safety*. 2012 Jul;11(4):366-77.
- Savych A, Basaraba R, Muzyka N, Ilashchuk P. Analysis of fatty acid composition content in the plant components of antidiabetic herbal mixture by GC-MS. *Pharmacia*. 2021 May 20;68:433-9.
- Savych A, Basaraba R. Ascorbic acid content in the herbal mixture with antidiabetic activity. *PharmacologyOnLine*. 2021;2:76-83.
- Savych A, Bilyk O, Vaschuk V, Humeniuk I. Analysis of inulin and fructans in *Taraxacum officinale* L. roots as the main inulin-containing component of antidiabetic herbal mixture. *Pharmacia* (0428-0296). 2021 Jul 1;68(3).
- Savych A, Mazur O. Antioxidant activity in vitro of antidiabetic herbal mixtures. *PharmacologyOnLine*. 2021;2:17-24.
- Savych A, Milian I. Total flavonoid content in the herbal mixture with antidiabetic activity. *PharmacologyOnLine*. 2021;2:68-75.

- Savych A, Nakonechna S. Determination of amino acids content in two herbal mixtures with antidiabetic activity by GC-MS. *Pharmakeftiki*. 2021;33(2):116-23.
- Savych A, Polonets O. Study of hypoglycemic activity of antidiabetic herbal mixture on streptozotocin-nicotinamide-induced rat model of type 2 diabetes. *PharmacologyOnLine*. 2021;2:62-7.
- Slobodianiuk L, Budniak L, Marchyshyn S, Kostyshyn L, Ezhned M. Determination of amino acids content of the *Tagetes lucida* Cav. by GC/MS. *Pharmacia*. 2021 Nov 11;68(4):859-67.
- Slobodianiuk L, Budniak L, Marchyshyn S, Sinichenko A, Demydiak O. Determination of amino acids of cultivated species of the genus *Primula* L. *Biointerface Research in Applied Chemistry*. 2021;11(2):8969-77.
- Suleiman MS, Olajide JE, Omale JA, Abbah OC, Ejembi DO. Proximate composition, mineral and some vitamin contents of tigernut (*Cyperus esculentus*). *Clinical Investigation*. 2018;8(4):161-5.
- Temple VJ, Ojobe TO, Kapu MM. Chemical analysis of tiger nut (*Cyperus esculentus*). *Journal of the Science of Food and Agriculture*. 1990;50(2):261-3.
- Vega-Morales T, Mateos-Díaz C, Pérez-Machín R, Wiebe J, Gericke NP, Alarcón C, López-Romero JM. Chemical composition of industrially and laboratory processed *Cyperus esculentus* rhizomes. *Food chemistry*. 2019 Nov 1;297:124896.
- Wills GD, Hoagland RE, Paul RN. Anatomy of yellow nutsedge (*Cyperus esculentus*). *Weed Science*. 1980 Jul;28(4):432-7.
- Zhang HY, Hanna MA, Ali Y, Nan L. Yellow nut-sedge (*Cyperus esculentus* L.) tuber oil as a fuel. *Industrial crops and products*. 1996 Sep 1;5(3):177-81.