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Section 1. Biology

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PHYTOCHEMICAL STUDY AND EVALUATION OF THE IN VITRO ANTIOXIDANT ACTIVITY OF THE MEDICINAL PLANT BRUGMANSIA CANDIDA PERS. USED IN THE TREATMENT OF MADNESS IN THE SANKURU PROVINCE (DR CONGO)

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Abstract

The species Brugmansia candida Pers. was introduced in the Sankuru province of the Democratic Republic of Congo (DRC) by Catholic or Protestant missionaries as an ornamental plant. They were mainly interested in its decorative appearance and beautiful multi-colored flowers, which give off a pleasant scent in the evening and at night. B. candida is known for its psychotropic and hallucinogenic properties. In the Sankuru province, it is known as a strong drug that is easier to obtain than local drugs. The objective of this work was therefore to highlight the phytochemical compounds of this plant and to evaluate their antioxidant activity. This phytochemical analysis was carried out following the method described by Harbone (1998). The polyphenolic compounds were assayed by the spectrometric method and the antioxidant activity was determined using the DPPH and ABTS trapping tests. These analyses showed that aqueous

extracts of B. candida leaves contain polyphenols, anthocyanins, tannins, leucoanthocyanidins, alkaloids, bound quinones, and saponins, but no flavonoids. On the other hand, in organic extracts of the leaves of this species, steroids, terpenoids, and free quinones were detected. As for the antioxidant activity, the ABTS radical showed interesting IC50 values, namely 38.95 ± 0.15 µg/mL for aqueous extracts and 21.15 ± 0.08 µg/mL for organic extracts. In conclusion, B. candida leaves are a source of active compounds and have a significant antiradical profile. It can therefore be suggested that this species be integrated into alternative medicine for the management of certain psychosomatic diseases. However, its excessive use should be discouraged by government authorities in the same way as tobacco.
Keywords: *Phytochemistry, antioxidant, psychotropic, Brugmansia candida, DR Congo*

1. Introduction

The species *Brugmansia candida* was introduced to the Sankuru province in the Democratic Republic of Congo (DRC) by Catholic or Protestant missionaries who were probably interested in its appearance since it is a very beautiful decorative plant with magnificent flowers of various colors, which give off a lovely scent in the evening and at night. Initially, this species was introduced and cultivated as an ornamental plant. It has subsequently adapted to local environmental conditions and currently grows spontaneously and naturally throughout the Sankuru province in DR Congo.

Best known for its psychotropic and hallucinogenic properties, *B. candida* is considered and widely used in the Sankuru province by local people as medicinal as a strong drug, that is easier to obtain than local drugs. Its resemblance to tobacco and its violent and unpleasant effects have earned it the nickname “Ofokafoka”. Indeed, the word “Ofokafoka” comes from “Foka”, which means tobacco in Tetela (the language spoken in the Sankuru province), and “Ofokafoka” means something that looks like tobacco (something that acts like tobacco). In certain circumstances, Ofokafoka means stronger, producing more effects than local tobacco. In addition to its psychotropic properties, the B. candida plant has many medicinal virtues. In Sankuru province, all parts of the plant are used in traditional medicine: leaves, flowers, seeds, stems and roots.

The genus *Brugmansia* comprises 7 species, many cultivars, as well as spontaneous or artificial hybrids, in a variety of colors and shapes. Depending on their size at maturity, small and medium-sized species such as *B. versicolore* and *B. sanguinea* are distinguished, and large species such as *B. candida,* which produces magnificent decorative flowers. B. candida Pers. is a vigorous shrub 2 to 5 m high, belonging to the Kingdom Plantae, the Embranchment Spermatophytes, the Sous Embranchment Angiospermae, the class Dicotyledones, the order Solanales, the family Solanaceae, and the genus *Brugmensia* (Stevens (2012). It is a very decorative tropical plant whose flowers are in the form of huge colorful and fragrant trumpets (Bongbeme, 2015). It is also called Angel’s Trumpet, White Brugmensia, Jimson Weed, Angel’s Trumpet, etc.

The species *B. candida* has simple, alternate, dark, or variegated yellow leaves, semi-evergreen or deciduous, depending on the climate. Many varieties have been developed for ornamental gardens. In temperate climates, flowering occurs from June to October. It can be early in greenhouses or winter gardens. The fruits are not prickly and keep for a long time (several decades). Its large flowers (up to 30 cm) are hanging trumpets of various colors, directed towards the ground at an angle of about 40°. In the evening and at night, they give off a strong and pleasant scent, particularly attractive to nocturnal insects. This scent has earned them the nickname “angel’s trumpet” (Ibrahim et al., (2017).

Plants of the species *B. candida* have psychotropic and hallucinogenic properties. Several authors report that *Brugmansia* hallucinogens cause violent and unpleasant effects. They are widely used in several Latin American communities: during initiation or shamanic rituals, for seduction, rape, even murder, to correct unruly children, to hypnotize people who are robbed without realizing it or remembering it when they wake up, mixed with corn beer or tobacco, they were administered to wives and slaves as a drug before being buried with their lords

(Bongbeme, 2015). Many nicknames attributed to the plant testify to its toxicity: "devil's herb", "sorcerer's herb", "magician's herb", "rapist's herb", "thorny apple", etc. The plant *B. candida* has many therapeutic properties. In Sankuru province, the leaves, flowers, seeds, roots, and stems of B. candida are widely used in various ways to treat a wide range of skin, stomach, and muscle diseases, as an anti-inflammatory to treat pain, rheumatism, etc., and sometimes as a poison (Niedz et al., 2012).

According to Alvarez (2008) and Gonzalo et al. (2015) all parts of the plant are toxic The seeds, for example, contain high concentrations of poisons and ingestion can cause muscle paralysis, confusion, dry mouth, diarrhea, hallucinations, and death. Although very attractive for their flowers, all varieties of B. candida are toxic if ingested (Athony et al., 2009). They mainly contain two alkaloids: hyoscyamine and scopolamine, which are responsible for an atropinoid syndrome if ingested after prolonged contact with the sap, stems, leaves, flowers, or fruits. It is advisable to wash your hands after prolonged contact with the plant and to keep it out of the reach of children. In the past, drugs in general and strong drugs, in particular, were the preserve of adults, especially the elderly, as a stimulant (Odavia, 2015). Today, it is increasingly young people who are attracted to drugs. This is explained by the current context: youth unemployment and the loss of purchasing power of the population, leading to an increase in crime and the number of people developing mental disorders. This explains the craze among young people for the leaves of *B. candida*, which are a powerful and easy-to-obtain medicine, as the plant grows in all habitats in the DRC.

The fact that *B. candida* is commonly used in Sankuru Province for medicinal purposes prompted us to undertake this study. The main objective pursued was to determine the chemical compounds present in the leaves of this species through phytochemical analyses and to evaluate their antioxidant activity. To detect the phytochemical compounds present in this plant, the Harbone (1998) method was used. The polyphenolic compounds were evaluated by the spectrometric method and the antioxidant activity using the DPPH and ABTS trapping tests.

2. Material and methods

2.1. Material

The plant material used in this study consists of *Brugmansia candida* leaves that was collected in the experimental botanical garden of the Department of Biology of the Faculty of Science and Technology of the University of Kinshasa and dried at Laboratory room temperature. Qualitative phytochemical analyses were carried out at the Laboratory of Phytochemistry of Natural Substances and Medicinal Chemistry of the Faculty of Sciences of the University of Kinshasa. On the other hand, quantitative phytochemical and biological analyses were carried out at the Laboratory of Analysis and Research on Food and Nutrition (LARAN) of the Department of Biology of the Faculty of Sciences and Technology of the University of Kinshasa.

2.2. Methods

2.2.1 Preparation and packaging of samples

After harvesting, the leaves of *B. candida* were sent to the laboratory and then dried in an oven (Fisher Scientific model 665 fc), at a temperature of 40 °C for three days. After drying, the samples were ground using an electric grinder (IKA MF10 basic) and sieved to obtain a fine and homogeneous powder. The powders obtained were stored in glass containers in the laboratory until the time of analysis.

2.2.2 Phytochemical analysis

1. Chemical screening (qualitative analysis

The use of this test provides a general idea of the secondary metabolites, with potential biological or therapeutic properties, present in the leaves of B. candida. The characterization reactions were carried out in tubes (solution tests) (Harbone 1998). Indeed, this is a qualitative analysis based on coloring and/or precipitation reactions.

2. Preparation of aqueous and organic extracts

The **aqueous and organic extracts** were prepared as follows: 10 g of the powder of the species leaves was placed in 100 ml of distilled water and boiled at 100 °C for 15 minutes in a water bath. The decoc-

tion obtained was filtered hot through cotton and collected in an Erlenmeyer flask. For the organic extracts, we weighed 10 g of the powder and added 100 ml of ethyl acetate for at least 1 hour, filtered the solution on filter paper using a funnel, and collected the filtrate in an Erlenmeyer flask.

3. Aqueous phase test

a. Polyphenol detection

To detect polyphenols, 1 mL of aqueous extract of B. candida leaves was placed in a test tube. Then a few drops of Burton's reagent ($FeCl_3$) 2% and K3Fe(CN)6 1% (1:1/v/v) were added using a Pasteur pipette. This reagent can be used to highlight the presence of polyphenols when the solution becomes intense blue (sometimes accompanied by a precipitate). In case of a positive test, we systematically looked for the following different polyphenolic compounds: flavonoids, quinones, anthocyanins, tannins, leucoanthocyanidins.

b. Flavonoid detection

Shinoda's reagent was used to detect flavonoids. This reagent consists of a mixture of various reagents, namely: 95% ethyl alcohol, concentrated HCl, distilled water (1:1:1 v/v/v), and Mg or Zn shavings. For this purpose, 1 ml of aqueous extract was taken with a Pasteur pipette and placed in a test tube. Then, Shinoda's reagent, a few Mg shavings, and a few drops of stirred isoamyl alcohol were added and this mixture was left to stand. The formation of a thin film of orange (flavones), cherry red (flavonols), or purplish coloring indicates the presence of flavonoids.

c. Search for Anthocyanins

To highlight anthocyanins, hydrochloric acid (HCl 20%) concentrated at 20% was used. For this purpose, 1 mL of aqueous extract was placed in a test tube, to which a few drops of HCl 20% were added. This mixture was then heated in a water bath. A purplish coloration of the anthocyanin chloride develops and can crystallize.

d. Leucoanthocyanidin detection

The Shinoda's reagent was used to detect leucoanthocyanidins. One mL of aqueous extract was placed in a test tube. A few drops of Shinoda reagent, and isoamyl alcohol were then added and the whole mixture was then heated in a water bath. The presence of a red or purplish color in the supernatant layer indicates a positive test.

e. Detection of tannins

Tannins are water-soluble phenolic compounds that, in addition to the classic reactions of phenols, have the properties of precipitating proteins and alkaloids. To detect them, we used Stiansny's reagent $FeCl_3$ 2% (formaldehyde 30% + concentrated HCl, 2:1), CH3COONa. First, 1 mL of aqueous extract is placed in a test tube to which a few drops of FeCl3 1% are added. The appearance of a green color with or without precipitate generally indicates the presence of tannins. In case of a positive test, the catechic tannins and gallic tannins can be differentiated as follows: 1 mL of the aqueous extract is placed in a test tube to which a few drops of Stiansny's reagent are added. The mixture obtained is then heated in a water bath at 90 °C for 30 minutes. The appearance of a brown precipitate indicates the presence of catechic tannins. In this case, it is necessary to filter this mixture and then saturate the filtrate with CH_3COONa crystals. Finally, 1 mL of 2% $FeCl_3$ must be added. When the blackish color appears, this indicates the presence of gallic tannins.

f. Search for alkaloids

The search for alkaloids was carried out using Dragendorff reagents ($Bi(NO_3)_3$ 0.85 g; glacial CH3COOH 10 ml; KI 8 g and distilled water 80 ml) and 0.1 N HCl. We proceeded as follows: 1 ml of slightly acidified aqueous extract with a few drops of 0.1 N HCl, added a few drops of Dragendorff reagent. A red-orange precipitate forms and indicates the presence of alkaloids.

g. Search for saponins

Saponins are genuine steroidal or terpenic glycosides characterized by their surfactant properties. Their dissolution in water forms a foaming solution. To detect them, we placed 1mL of aqueous extract in a test tube to which we added a few drops of distilled water which was then shaken vigorously. The formation of a foam of at least 1 cm in height for 15 minutes indicates the presence of saponins, which corresponds to a positive test.

h. Search for bound quinones

This was done using the Borntrager reagent (NaOH 10% or NH4OH 10%). For this purpose, 1mL of the aqueous extract was placed in a test tube, to which the Borntrager's reagent was added and the mixture was

shaken vigorously. The color ranging from orange to bright red characterized that the test is positive, which indicates the presence of bounds quinones.

4. Tests on the organic phase

a. Detection of steroids and triterpenoids

To detect steroids and triterpenoids, 1 mL of organic extract was added to the Liebermann-Buchardat reagent. A purple coloration of this mixture indicates the presence of triterpenoids and steroids. Separately, triterpenoids form a purple complex while steroids develop a green coloration.

b. Detection of free quinones

Free quinones are highlighted by treating the organic extract with Borntrager reagent. The appearance of a coloration ranging from orange to bright red indicates the presence of free quinones.

2.2.3 Polyphenolic compound assays (quantitative analyses)

Polyphenolic compounds were detected through cold extraction. For this purpose, 40 mg of B. candida leaf powder was weighed and placed in glass flasks. Then, 40 mL of distilled water was added. Afterward, the flasks were then placed in the ultrasonic bath for 45 minutes. The macerates obtained were filtered using Whatman paper n°1. The filtrates were used for the analysis of the determination of the content of polyphenolic compounds (total polyphenols, flavonoids, and tannins).

a. Total polyphenols determination

The determination of the total polyphenol content was carried out using the Folin-Ciocalteu reagent (Mbadiko et al., 2019; Mbemba et al., 2023; Nyamangombe et al., 2023). For this purpose, we prepared a reaction mixture comprising: 0.2 mL of extract, 2 mL of distilled water, and 0.2 mL of Folin reagent. We added 0.4 mL of sodium carbonate (20%) after 3 minutes of incubation. The mixture obtained was shaken well and then incubated for one hour at laboratory temperature and protected from light. We also carried out the same operation for the blank, except that instead of the extract, we added 0.2 mL of 80% methanol. The absorbances were read on a spectrophotometer at 725 nm. Each assay was repeated in triplicate. A standard concentration range with gallic acid (0.016 mg/ml to 0.125 mg/ml) was prepared to calculate the concentration of total polyphenols contained in the analyzed sample. The amount of total polyphenols obtained is expressed in mg of gallic acid equivalent (GAE)/g of dry matter using the following equation from the calibration line.

$$Y = 7.2852x + 0.0581$$

Where y = the absorbance of the extract, and x = gallic acid equivalent (mg/g).

b. Determination of Total flavonoids

Aluminum trichloride $AlCl_3$ forms a yellow complex with flavonoids that absorbs at 415 nm (Heimler et al., 2006; Mbadiko et al., 2019). For this purpose, we prepared a reaction mixture composed of 1 mL of the extract to be analyzed and 1 mL of 2% $AlCl_3$ (dissolved in methanol). The mixture obtained was shaken well, then incubated at laboratory temperature, and protected from light for one hour. The same operation was carried out for the blank, except that instead of the extract, 1 mL of methanol was added. We also prepared a standard range with quercetin (0.03125 to 0.125 µg/ml) to calculate the flavonoid concentration contained in the analyzed sample. The absorbances were measured using a spectrophotometer at 415 nm. Note that the mixtures were prepared in triplicate for each analysis and the average value was retained. Finally, the flavonoid content was expressed as mg quercetin equivalent (EQ)/g dry matter using the calibration line equation:

$$y = 22.382x - 0.15$$

Where: y = the absorbance of the extract, and x = the equivalent of quercetin (mg/g).

c. Tannin determination

The principle of this determination is based on the fixation of the aldehyde group of vanillin on carbon 6 of the A cycle of catechin to form a red chromophore complex that absorbs at 510 nm (Anthony S. J., Zuchowski W., Setzer, W. N., 2009). The reaction mixture containing 0.5 mL of organic extract, 1.5 mL of a vanillin solution (4% in methanol), and 1.5 mL of concentrated hydrochloric acid was prepared and all this was well shaken. After 30 minutes of incubation at laboratory temperature, and protected from light, we measured the absorbances with a spectrophotometer at 510 nm. The mixtures were prepared in triplicate for each analysis and the average value was retained. The tannin concentration was deduced from a calibration range established

with catechin (0 to 1 mg/mL). The total tannin content of the extracts is expressed in mg catechin equivalent per gram of dry matter using the calibration line equation:

$$y = 34.358x - 0.0132$$
$$R_2 = 0.9994,$$

Where: x = the absorbance, and y = the equivalent of catechin (mg/g).

2.2.4. Evaluation of biological activity

a. Preparation of total dry extracts

The evaluation of the biological activity was done as follows: 10 g of the powder of the analyzed sample was macerated in 100 mL of distilled water for 24 hours. The macerate was filtered using Wathman paper No. 1 and the filtrate was placed in a Petri dish which was then placed in an oven (Memmer) at 40 °C for 24 hours. The total dry methanolic extracts were prepared as follows: 10 g of the powder of the analyzed sample was macerated in 100 mL of an 80% methanol solution for 24 hours. The macerate was then filtered using Wathman paper No. 1 and the filtrate was placed in a Petri dish. This was placed in an oven (Memmer) at 40 °C for 24 hours.

b. Evaluation of antioxidant activity

1. DPPH (2,2 DiPhenyl-1- Picrylhydrazyl) radical test

The method reported by (Heimler et al., 2006; Mayele et al., 2024) was used to evaluate the antioxidant power by the DPPH test. The chemical compound 2, 2-diphenyl-1-picrylhydrazyl (DPPH) is a purplish free radical that absorbs at the wavelength of 517 nm. The reduction of the free radical DPPH to DPPH-H (2,2-diphenyl-1-picrylhydrazine) produced when single electron pairs cause representative decolorization reflects the ability of an extract to scavenge free radicals. This discoloration of the radical measured by the spectrophotometer at 517 nm is proportional to the concentration of antioxidants (Mbadiko et al., 2019; Mbemba et al., 2023). To prepare the DPPH radical, 3.2 mg of DPPH was dissolved in 100 mL of 80% methanol. The solution thus obtained was kept away from light for at least one hour. After incubation, the absorbance of the DPPH solution was adjusted to 0.7 ± 0.05 using 80% methanol.

To prepare the different concentrations of the analyzed extracts, 40 mg of total dry extracts were weighed and diluted in 4 mL of distilled water. From this mother solution (10 mg/mL), we made successive dilutions to have a concentration range from 10 to 6 mg/mL Then, 20 µL of each concentration level of extract to be analyzed was taken and placed in test tubes to put the sample in contact with the DPPH. We then added 1980 µL of the DPPH · radical analysis solution. The same operation was carried out for the control solution (DPPH · radical solution), except that instead of the extract, we added 20 µL of 80% methanol. The different solutions prepared were incubated away from light for 30 minutes.

We used quercetin, gallic acid, and catechin as reference antioxidants (positive control). They were prepared under the same conditions as the analyzed extracts. The reaction solutions were prepared in triplicate. The absorbance reading and the determination of the DPPH · inhibition power were done via the absorbances at 517 nm using a spectrophotometer (Jenway 7615). In addition, the percentage of inhibition of the radical by the sample was determined using the following formula:

$$\%\ inhibition = \frac{1 - A_x}{A_c} \times 100$$

Where: A_x = absorbance of the DPPH radical in the presence of the extract, and A_c =: absorbance of the DPPH radical (control solution or blank).

Finally, the IC50 values of the different samples were determined using the Grap Pad Prism 10.4 software.

c. ABTS (2,2'-azino-bis-3ethylbenzthiazoline-6-sulfonic acid) test

By reacting with potassium or sodium persulfate, ABTS (2,2'-azino-bis-3ethylbenzthiazoline-6-sulfonic acid) forms the cationic radical ABTS · + of blue to green color. The addition of an extract containing antioxidant compounds reduces this radical and causes a discoloration which is measured by spectrophotometer at 734 nm. The discoloration of the ABTS · + radical is proportional to the antioxidant concentration (Mbadiko et al., 2019).

The preparation of ABTS · + was carried out by diluting 32.49 mg of the ABTS radical in 1500 µL of distilled water (solution A). Then, 8 mg of potassium persulfate ($K_2S_2O_8$) was weighed and dissolved in 1142 µL of distilled water (solution B). The two solutions were then mixed in equal volume

(1:1). The resulting mixture was stored away from light for 12 to 16 hours to obtain the ABTS · + stock solution which was then diluted with methanol to obtain an analysis solution with an absorbance of 0.800 to 1.000.

The different concentrations of the analyzed extracts were prepared from a stock solution of 10 mg/mL of the analyzed basic extracts. Subsequently, a range of concentrations ranging from 10 to 6 mg/mL was prepared by performing successive dilutions. To bring the sample into contact with ABTS ·+, 20 µL of each concentration level of extracts to be analyzed were taken and placed in the test tubes. We then added 1980 µL of the ABTS · radical analysis solution. The same operation was carried out for the control solution (ABTS ·+ solution), except that instead of the extract, 20 µL of 80% methanol was added. The different solutions obtained were finally incubated away from light for 30 minutes. Gallic acid was used as a reference antioxidant (positive control). The different solutions concerned were prepared under the same conditions as the extracts analyzed. Note that each mixture was prepared in three repetitions.

The absorbance reading and the determination of the ABTS · + inhibitory power were carried out at 734 nm using a Jenway 7615 spectrophotometer, for the blank (methanol), the control solution, and the solutions of the samples analyzed. The determination of the ABTS ·+ radical inhibitory power of the analyzed extracts was calculated according to the following formula:

$$\%\ inhibition = \frac{1 - A_x}{A_c} \times 100$$

Where: Ax = the absorbance of the ABTS ·+ radical in the presence of the extract.

Ac = the absorbance of the ABTS ·+ radical (control solution or blank)

The IC50 values of the samples studied were determined using the Graph Pad Prism 10.4 software.

III. Results

3.1. Phytochemical analyses

3.1.1 Data from Phytochemical screening in solution

Phytochemical screening was carried out following the precipitation coloring reactions for the search for secondary metabolites and the results are recorded in Table 1 below. This table shows the results of the qualitative analysis of aqueous and organic extracts of B. candida leaves.

Table 1. *Results of chemical screening of B. candida leaf extracts*

Substances sought	Reagents used	Results
	Aqueous phase	
Total Polyphenols	Burton	+
Flavonoïds	Shinoda	–
Anthocyanins	Hydrochloric Concentrated acid 20%	+
Tannins	$FeCl_3$ 2%.	+
Leucoanthocyanins	Shinoda	+
Alkaloids	Dragendorff	+
Saponins	Agitation	+
Related Quinones	Borntrager	+
	Organic Phase	
Steroids	Liebermann	+
Triterpenes	Liebermann	+
Free quinones	Borntrager	+

Legend: +: Presence of the substance sought; -: Absence of the substance sought

It appears that aqueous extracts of B. candida leaves contain polyphenols, anthocyanins, tannins, leucoanthocyanidins, alkaloids, bound quinones, and saponins, but

they do not contain flavonoids. On the other hand, organic extracts of leaves of this same plant species contain steroids, terpenoids, and free quinones

This table presents the results of the qualitative analysis of aqueous and organic extracts of *B. candida* leaves. It can be seen that aqueous extracts of B. candida leaves contain polyphenols, anthocyanins, tannins, leucoanthocyanidins, alkaloids, bound quinones, and saponins. On the other hand, they do not contain flavonoids. On the other hand, organic extracts of leaves of this same plant species contain steroids, terpenoids, and free quinones.

3.1.2 Determination of total polyphenol, flavonoid, and tannin contents.

Table 2 below presents the results of the analysis concerning the contents of polyphenols, flavonoids, and total tannins.

Table 2. *Total polyphenol, flavonoid, and tannin contents (mean, n = 4)*

Extracts	Total Polyphenols (mg EAG/g MS)	Total Flavonoids (mg EQ/g)	Tannins (mg EC/g)
B. candida	163.8 ± 6.5	46.1 ± 0.2	17.7 ± 0.7

Legend: GAE/g DM: Equivalent of gallic acid per gram of dry matter; – EQ/g DM: Equivalent of quercetin per gram of dry matter; – EC/g DM: Equivalent to catechin per gram of dry matter

The results in Table 2 show that among these chemical compounds, total polyphenols are the highest, followed by flavonoids and tannins, the lowest. Such high content of polyphenolic compounds in B. candida leaf extracts makes them responsible for antioxidant activity.

3.2. Evaluation of antioxidant activity in vitro

Table 3 below summarizes the results of the antioxidant properties from the different leaf extracts of B. candida. It appears from this Table that the different leaf extracts of B. candida have low antioxidant properties since the IC50 values are greater than 10 µg/mL This indicates a low antioxidant activity of different extracts analyzed.

Table 3. *Screening of antioxidant activity by the ABTS and DPPH test, expressed in terms of IC50 and µg/mL (mean ± SD, n=4)*

	IC_{50} (µg/mL)			
Plants used	DPH		ABTS	
	Aqueous extract	Organic extract	Aqueous extract	Organic extract
B. candida	2491.25 ± 1.06	Nd	38.95 ± 0.15	38.95 ± 0.15
Gallic Acid	0.42±0.10		22.32±3.4	

Legend: Nd: not determined

IV. Discussion and conclusion

Phytochemical screening revealed on the one hand that the aqueous extracts of *B. candida* leaves contain polyphenols, anthocyanins, tannins, leucoanthocyanidins, alkaloids, bound quinones, and saponins and on the other hand do not contain flavonoids. In addition, the organic extracts revealed the presence of steroids, terpenoids, and free quinones in the leaves of *B. candida* Pers. These results are consistent with those of Bongbeme (2015) on aqueous and organic extracts of B. candida leaves. Gonzalo (2015) and Ibrahim et al. (2017), also brought to light the presence of alkaloids in *B. candida* leaf extracts. This confirms the toxicity of *B. candida* leaf extracts. Moreover, quantitative analysis of polyphenolic compounds

showed that B. candida leaf extracts have a high content of total polyphenols (163.8 ± + 6.5 mg EAG/g DM), followed by a medium content of flavonoids (46.1 ± 0.2 mg EQ/g) and a low content of tannins (17.7 ± 0.7 mg EC/g).

Furthermore, the results of antioxidant activity revealed that the different extracts of *B. candida* leaves analyzed in this work have a low antioxidant power for the DPPH test (aqueous extracts) (2491.25 ± 1.06 µg/mL), since the IC50 values are greater than 10 µg/m, far from that of quercetin used as a control. According to Mbemba et al. (2023), a low IC50 value corresponds to a higher antioxidant activity of the extract, while a high IC50 value means that the antioxidant activity is high, which is not the case for the values obtained in this study. As for the ABTS test, the organic extracts showed a high antioxidant power compared to the aqueous extracts. The values obtained in this case (38.95 ± 0.15 µg/m) are significantly lower compared to the control. The difference between the two tests lies in their reaction mechanism. Indeed, the ABTS radical reacts at the same time with hydrophilic and lipophilic compounds while DPPH only reacts with hydrophilic compounds (Floegel et al., 2011).

In conclusion, this work further shows that aqueous extracts of *Brugmansia candida* leaves contain polyphenols, anthocyanins, tannins, leucoanthocyanidins, alkaloids, bound quinones, and saponins, but no flavonoids. On the other hand, organic extracts of B. candida leaves contain free steroids, terpenoids, and quinones.

Indeed, Petricevich et al. (2020), Algradi et al. (2021), and Pundira et al. (2022) pointed out that the species of the family Solanaceae in general, and those of the *Brugmansia* genus in particular, are very rich in phytochemical compounds. These are particularly alkaloids, steroids, polyphenols, terpenes, tannins, etc. All these chemical compounds are of obvious interest for the different pharmacological and therapeutic activities. Among these different compounds, tropane alkaloids predominate. The latter are among those that present toxic effects. Alvarez (2008) also highlights the fact that all parts of B. candida are toxic. Therefore, their use for therapeutic purposes requires great caution because of the potential risks.

In conclusion, this study showed that *B. candida* is rich in chemical compounds like most other species of the Solanaceae family. Among these compounds, total polyphenols appear to be dominant. These are followed by flavonoids and tannins whose contents appear to be the lowest. As for the screening of antioxidant activity, the analysis of different extracts of Brugmansia candida leaves by the ABTS test showed a higher antioxidant power compared to DPPH. This study has therefore made it possible to highlight the phytochemical compounds, biological activities, and toxicity of *B. candida*. Such results demonstrate the therapeutic potential of this species. This species can therefore play a major role in pharmacological and therapeutic activities. However, its use requires great caution due to their toxicity.

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Declaration of available data

The sharing of available data does not apply to this article, as no new data was created as part of this study. However, we are willing to answer any question regarding this article.

Author contributions

Project conception, lead author, and funding (on own funds): N. L. G. Writing – original project execution: N. L. G.; M. M. B., MAI., D. A. Writing – revision: N. L. G., MMD., M. M. B., M. A. I., D. A. Editing – English translation: M. M. D. All authors have read and accepted the final version of the manuscript.

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Conflict of interest

The authors declare that there is no conflict of interest.

Declaration of available data

The sharing of available data does not apply to this article, as no new data was created as part of this study. However, we are willing to answer any question regarding this article.

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FERTILITY PRESERVATION AND QUALITY OF LIFE: A COMPARATIVE STUDY OF YOUNG WOMEN FACING CANCER TREATMENT

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Abstract

In light of significant advancements in the diagnosis and treatment of oncological diseases that have increased patient survival rates, the issue of quality of life has become increasingly relevant. Particularly important are aspects of reproductive health in younger women, as aggressive treatment methods, such as chemotherapy and radiation therapy, can lead to fertility loss and subsequently lower life satisfaction. Fertility preservation programs emerge as crucial components of treatment, providing women with the opportunity to preserve their reproductive functions.

This study assessed the quality of life of oncology patients participating in fertility preservation programs as compared to a control group that did not receive such support. A total of 140 patients were included, divided into the main group (n=75) and the control group (n=65). Quality of life was evaluated using the FACT-G questionnaire, which encompasses physical well-being, emotional and social wellness, as well as everyday life satisfaction.

The results indicated that patients with lymphoma exhibited the highest quality of life scores, while women with gynecological cancer showed the lowest results. The findings highlight the necessity of fertility preservation programs as a means to enhance the psychological and emotional well-being of women facing the threat of fertility loss during oncological treatment. The study emphasizes the importance of an individualized approach to the treatment and support of oncology patients, which can significantly improve their quality of life and level of satisfaction.

Keywords:

Relevance of the study:

In recent decades, significant advances in the diagnosis and treatment of cancer have led to increased patient survival. However, with increasing life expectancy after cancer diagnosis, the issue of quality of life is becoming more relevant. Quality of life (QOL) assessment is a key aspect of an integrated

approach to the treatment of cancer patients, as it reflects the impact of the disease and its therapy on the physical, emotional and social well-being of patients.

Special attention should be paid to young cancer patients who are in the reproductive period. Problems associated with loss of fertility due to aggressive treatments such as chemotherapy and radiation therapy can significantly affect overall life satisfaction. Fertility preservation programs are becoming a vital component of treatment, providing women with the opportunity to preserve their reproductive functions and thus improve their quality of life and emotional well-being after completing therapy.

The study of factors affecting the quality of life of cancer patients is particularly important in the context of fertility preservation programs. The location of the tumor can significantly affect patients' perception of their life after treatment. For example, the difference in quality of life between breast cancer patients and patients suffering from gastrointestinal tumors may depend on access to fertility programs and the personal circumstances of women.

The present study is aimed at an in-depth analysis of the impact of these factors on the quality of life of cancer patients participating in fertility preservation programs.

Materials and methods:

The study was comparative and descriptive in nature. It was aimed at assessing the quality of life of cancer patients participating in fertility preservation programs, in comparison with patients who do not participate in these programs.

The study included 140 patients from two groups: the main group (n = 75), which included women who had gone through fertility preservation programs, and the control group (n = 65), consisting of patients who did not participate in such programs. All participants provided informed consent to participate in the study.

Inclusion and exclusion criteria:

The group included women aged 18 to 40 years, diagnosed with a malignant tumor, who had no contraindications to fertility preservation. Patients with severe concomitant diseases that could affect the overall quality of life and fertility preservation were excluded.

The FACT-G (Functional Assessment of Cancer Therapy – General) questionnaire, which is adapted for cancer patients, was used to assess the quality of life. It covers four main domains: physical well-being, social/family relationships, emotional well-being, and well-being in daily life.

Statistical analysis of the data was carried out using the Statistica v program. 4.7.1. First, the data were checked for compliance with the normal distribution using the Shapiro-Wilk criterion (if the group size was less than 50) or the Kolmogorov-Smirnov criterion (if the group size exceeded 50). In the case of an abnormal distribution, the data were described by the median (Me) and the interquartile range (Q1 – Q3).

The Mann-Whitney U-test was used to compare the two groups with an abnormal data distribution. In the case of multigroup analysis, the Kruskal-Wallis criterion was applied, and post-hoc analysis was performed using the Dunn criterion with the Holm correction. The level of statistical significance was set at $p < 0.05$.

The study was conducted in accordance with ethical standards approved by the local Ethics committee and in full compliance with the Helsinki Declaration. Informed consent was obtained from all participating patients.

Table 1 shows descriptive statistics on the quality of life of cancer patients, depending on the location of the tumor. The main focus is on the following localizations: breast cancer, lymphoma, gastrointestinal tumors, and cancer of the female genital area. Patients with lymphoma had a median of 14.00 (IQR [12.00; 20.00]), which indicates a relatively high physical condition compared to other locations. For breast cancer, the data was 13.00 (IQR [12.00; 19.00]), for gastrointestinal tumors it was 14.00 (IQR [11.00; 18.75]), and cancer of the female genital area – 12.00 (IQR [11.00; 14.00]). This may be due to the fact that lymphoma patients may be less aware of the severity of their condition, which may affect their perception of physical well-being. In this category, lymphoma also shows the highest score – 15.00 (IQR [11.50; 20.50]), while breast cancer – 12.50 (IQR

Table 1. *Descriptive statistics of quantitative variables depending on the location of the tumor*

Indicators	Localization of the tumor				p
	Breast cancer	Lymphoma	Gastrointestinal tumors	Cancer of the female genital area	
physical condition, Me [IQR]	13.00 [12.00; 19.00]	14.00 [12.00; 20.00]	14.00 [11.00; 18.75]	12.00 [11.00; 14.00]	0.152
Social/family relationships, Me [IQR]	12.50 [10.25; 18.75]	15.00 [11.50; 20.50]	12.00 [10.00; 15.75]	12.00 [10.00; 14.00]	0.074
Emotional well-being, Me [IQR]	12.00 [10.25; 17.75]	14.00 [10.00; 20.00]	12.00 [10.25; 18.00]	10.00 [9.00; 14.00]	0.091
Well-being in everyday life, Me [IQR]	18.00 [15.00; 20.75]	18.00 [16.00; 24.00]	18.00 [16.00; 21.75]	15.00 [15.00; 19.00]	0.125
Total score, Me [IQR]	58.50 [50.00; 73.00]	64.00 [51.00; 83.50]	60.50 [50.00; 73.75]	49.00 [47.00; 62.00]	0.027* $p_{\text{Cancer of the female genital area – Lymphoma}} = 0.016$

[10.25; 18.75]), gastrointestinal tumors – 12.00 (IQR [10.00; 15.75]), and cancer of the female genital area – 12.00 (IQR [10.00; 14.00]). Higher rates in patients with lymphoma may indicate better social support or less attention to personal problems. On the contrary, female genital cancer patients may face psychological pressure due to the threat of fertility loss, which negatively affects their perception of social relationships. In this measurement, it is also noted that patients with lymphoma have a median of 14.00 (IQR [10.00; 20.00]), which is higher compared to other groups.: breast cancer – 12.00 (IQR [10.25; 17.75]), gastrointestinal tumors – 12.00 (IQR [10.25; 18.00]), cancer of the female genital area – 10.00 (IQR [9.00; 14.00]).

Decreased emotional well-being in female genital cancer patients may be associated with high levels of stress and concern about their ability to motherhood, which creates additional psychological barriers to feeling emotionally calm. The overall quality of life score for patients with lymphoma was 64.00 (IQR [51.00; 83.50]), which is the highest indicator among these localizations. On the contrary, cancer of the female genital area showed the lowest score – 49.00 (IQR [47.00; 62.00]). This difference supports the hypothesis that the perception of health status and its psychological aspects can affect the overall quality of life. Patients with lymphoma may be more prone to underestimating their situation and, as a result, show higher scores on all criteria of quality of life.

Conclusion

Thus, this study confirms that tumor localization plays a significant role in the perception of the quality of life of cancer patients. The best indicators in patients with lymphoma can be explained by the psychological aspects of an imperfect understanding of their disease, whereas patients with cancer of the female genital area demonstrate lower levels of quality of life, which may be directly related to the threat to their reproductive health and fertility. This once again highlights the importance of fertility preservation programs for women with cancer, which can help reduce stress levels and improve their overall quality of life.

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ENHANCING LIFE SATISFACTION: THE IMPORTANCE OF FERTILITY PRESERVATION IN YOUNG WOMEN WITH CANCER

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Abstract

Recent advances in oncology have significantly increased the survival rates of patients with cancer; however, issues regarding their quality of life remain a pressing concern. Particularly important are the aspects of reproductive health in women of childbearing age, as aggressive treatments such as chemotherapy and radiation therapy can lead to fertility loss. This study aimed to evaluate the quality of life of oncology patients participating in fertility preservation programs using the FACT-G questionnaire.

The study included 140 patients divided into two groups: the main group (n=75), who underwent fertility preservation programs, and the control group (n=65), who did not participate in such programs. Statistical methods were employed to analyze differences in quality of life between the groups.

The results revealed that all measured parameters, including physical well-being, social and family relationships, emotional well-being, and overall quality of life scores, were significantly higher in the main group compared to the control group. This confirms the positive impact of fertility preservation programs on improving the quality of life for oncology patients.

This research underscores the need to integrate fertility preservation programs into standard treatment protocols for oncology patients, ultimately improving not only their physical health but also their psychoemotional state, thereby providing a more comprehensive approach to their care.

Keywords:

Relevance of the study:

Modern advances in the field of oncology, such as new diagnostic and treatment methods, have significantly increased the survival rate of patients with cancer, which, in turn, makes the issue of the quality of life of these women especially important. Since many of them are in their reproductive years, the loss of fertility due to aggressive treatments such as chemotherapy and radiation therapy is becoming a serious problem affecting not only physical health, but also emotional and social well-being.

Fertility-related issues are indirectly related to women's sense of identity and self-realization, which highlights the need to integrate fertility preservation programs into patient care standards. These programs offer

women the opportunity to preserve their reproductive functions and plan a family in the future, which directly improves their quality of life and emotional state.

However, despite the growing number of women who are offered such programs, there remains insufficient data to fully highlight the impact of these interventions on various aspects of quality of life. There is a lack of systematic research in the scientific literature analyzing how fertility preservation programs affect the physical, emotional, and social aspects of patients' lives.

There is also a need to understand individual factors such as age, type of cancer, and mental and emotional state that can influence perceptions of quality of life and outcomes of participation in fertility preservation programs. This is especially important for women's health, because not all patients respond to the same treatment in the same way. Our research aims not only to identify the positive and negative results of fertility preservation programs, but also to analyze their impact on the overall quality of life, which will allow us to develop individualized approaches to patient support.

At a time when issues of reproductive health and fertility are becoming increasingly important, this study plays a key role in shaping the scientific basis for optimizing care for cancer patients, which ultimately can lead to an improvement in their quality of life at all levels. The results of the study can directly influence clinical practice, contributing to a more comprehensive and humane approach to the treatment of cancer in women, which also corresponds to current trends in the field of patient-centered care (patient-centered medical approach).

Materials and methods:

The study was comparative and descriptive in nature. It was aimed at assessing the quality of life of cancer patients participating in fertility preservation programs, in comparison with patients who do not participate in these programs.

The study included 140 patients from two groups: the main group (n=75), which included women who had gone through fertility preservation programs, and the control group (n=65), consisting of patients who did not participate in such programs. All participants provided informed consent to participate in the study.

Inclusion and exclusion criteria:

The group included women aged 18 to 40 years, diagnosed with a malignant tumor, who had no contraindications to fertility preservation. Patients with severe concomitant diseases that could affect the overall quality of life and fertility preservation were excluded.

The FACT-G (Functional Assessment of Cancer Therapy – General) questionnaire, which is adapted for cancer patients, was used to assess the quality of life. It covers four main domains: physical well-being, social/family relationships, emotional well-being, and well-being in daily life.

Statistical analysis of the data was carried out using the Statistica v program. 4.7.1. First, the data were checked for compliance with the normal distribution using the Shapiro-Wilk criterion (if the group size was less than 50) or the Kolmogorov-Smirnov criterion (if the group size exceeded 50). In the case of an abnormal distribution, the data were described by the median (Me) and the interquartile range (Q1 – Q3).

The Mann-Whitney U-test was used to compare the two groups with an abnormal data distribution. In the case of multigroup analysis, the Kruskal-Wallis criterion was applied, and post-hoc analysis was performed using the Dunn criterion with the Holm correction. The level of statistical significance was set at $p < 0.05$.

The study was conducted in accordance with ethical standards approved by the local Ethics committee and in full compliance with the Helsinki Declaration. Informed consent was obtained from all participating patients.

Results

Table 1 provides descriptive statistics of quantitative variables illustrating differences in the quality of life of cancer patients depending on their participation in fertility preservation programs. Data were collected from 140 patients divided into two groups: the main group, consisting of 75 women participating in the program, and a control group, including 65 patients who had not gone through such activities.

Table 1. *Descriptive statistics of quantitative variables depending on the group*

Indicators	Groups		p
	Main group	Control group	
physical condition, Me [IQR]	18.00 [14.00; 22.00]	12.00 [11.00; 13.00]	< 0.001*
Social/family relationships, Me [IQR]	19.00 [14.50; 21.50]	10.00 [10.00; 12.00]	< 0.001*
Emotional well-being, Me [IQR]	18.00 [14.50; 20.00]	10.00 [9.00; 11.00]	< 0.001*
Well-being in everyday life, Me [IQR]	21.00 [18.00; 24.00]	16.00 [15.00; 18.00]	< 0.001*
Total score, Me [IQR]	73.00 [65.50; 83.50]	49.00 [46.00; 51.00]	< 0.001*

For the main group, the median was 18.00 with an interquartile range (IQR) [14.00; 22.00], which indicates a relatively high physical condition of the patients who actively participated in fertility preservation programs. In the control group, the median was significantly lower, amounting to 12.00 (IQR [11.00; 13.00]). This difference is significant ($p < 0.001$), which indicates that the programs have an obvious positive effect on the physical condition of women undergoing cancer treatment.

The assessment of this aspect also showed convincing differences: in the main group, the median was 19.00 (IQR [14.50; 21.50]), while in the control group, this figure dropped to 10.00 (IQR [10.00; 12.00]). This result ($p < 0.001$) highlights not only the emotional support women receive through participation in programs, but also the importance of social interactions that contribute to improving their quality of life.

The main group showed a median of 18.00 (IQR [14.50; 20.00]) in assessing emotional state, while the control group showed a significantly lower value of 10.00 (IQR [9.00; 11.00]). This difference ($p < 0.001$) indicates the need to take into account the emotional support provided by fertility preservation programs, which is important for the psychoemotional state of patients.

The median for the main group was 21.00 (IQR [18.00; 24.00]), while for the control group it was significantly lower, 16.00 (IQR [15.00; 18.00]). This difference ($p < 0.001$) highlights that participation in fertility preservation programs not only helps preserve reproductive health, but also positively affects the general aspects of daily life and functional well-being of women.

Finally, the overall quality of life score for the main group was 73.00 (IQR [65.50; 83.50]), which significantly exceeds the similar value in the control group of 49.00 (IQR [46.00; 51.00]). This sharp contrast ($p < 0.001$) clearly shows that participation in fertility preservation programs significantly improves the overall quality of life of cancer patients.

Conclusion:

The results summarize the significant differences in quality of life between cancer patients who went through fertility preservation programs and those who did not use these opportunities. All measured parameters, such as physical condition, social and family relationships, emotional well-being, and an overall assessment of quality of life, confirm the positive impact of these programs. This highlights the importance of integrating fertility preservation programs into the overall treatment of cancer patients to improve their quality of life on both physical and psychoemotional levels.

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THE PREVALENCE OF DEPRESSION AMONG CHRONIC HEALTH CONDITIONS: RESULTS FROM NHANES DATA 2005 TO 2018

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Abstract

Background: Depression as a multifaceted psychological disorder has grown in prevalence in recent years. This study investigates the trends and prevalence of depression symptoms in the United States from 2005 to 2018, with a particular focus on its relationship with chronic physical conditions including diabetes, asthma, hypertension, and high cholesterol levels.

Method: Using data from NHANES, the responses of 70,190 participants in self-reported surveys are analyzed in terms of depression severity, demographic factors, and chronic conditions from 2005 to 2018. Depression prevalence was categorized into four groups of severities based on PHQ-9 scores, while chronicle conditions were determined with yes and no responses. R was used to carry out statistical analysis for an evaluation of trends and associations.

Results: Depressive symptom prevalence showed increases over time, with females constantly showing a higher percentage compared to males. On average, the depressive prevalence in chronic condition patients fluctuated around 30% while the average prevalence was around 20%. Participants of all four chronic physical conditions show a higher prevalence of depression, suggesting an association.

Conclusion: The results of this study support the associations between chronic health conditions with the development of depressive symptoms. The indicated association highlights the importance of healthcare which integrates physical treatments with mental healthcare interventions.

Keywords: *Depression prevalence, NHANES, chronic conditions, mental health*

Introduction

Depression is a prevalent psychological disorder often associated with lasting feelings of sadness, loss of interest, and low or irritable moods (Chand S. P., Arif H., 2024). Depressive symptoms can often lead to changes with somatic and cognitive, limiting and impacting one's behaviors and ability to function. Depression however is a multifaceted disorder with varying causes, biological, neurological, or environmental, depending on different cases. It can severely hinder the everyday lives of those affected, from fatigue to mood swings to developing thoughts of self-harm and death. Alarmingly, depression has grown significantly in prevalence over

the past few decades. The number of people diagnosed with depressive symptoms nearly doubled from 1990 to 2017 and is still forecasted to continue rising (Liu Q., He H., Yang J., et al. 202), affecting an ever-growing number of individuals worldwide. Given the profound implications of depression on both individual and public health, it is crucial to investigate the trends in depression prevalence to determine the causes of its rising pervasiveness over the years.

Inevitable environmental stressors and genetic factors could easily impact an individual's susceptibility to developing depression, but depression could also put many at risk of developing physical chronic conditions. The prevalence of depression is thus interdependent and intricately linked with various other factors. Several studies have examined the prevalence and trends of depression across different populations, many of which have shown increases in depression rapidly, especially in young adults in America (Weinberger A. H., Gbedemah M., Martinez A. M., et al. 2018; Goodwin R. D., Dierker L. C., Wu M., et al. 2015). Cases of depression have also often been associated with physical chronic illnesses. Patients with chronic physical conditions, such as cancer and coronary heart disease, tend to have up to three times greater chances of obtaining depression (Ma Y., Xiang Q., Yan C., et al. 2021). Unlike conditions such as cancer or tumors, which typically have more complex etiologies and may develop later in life, chronic illnesses like asthma, diabetes, hypertension, and high cholesterol have a more predictable pattern where their early onset can contribute to the development of depression. However, there remains a gap in research that comprehensively evaluates depression prevalence trends in conjunction with less severe chronic medical conditions such as asthma, diabetes, hypertension, and high cholesterol levels. Questions remain about the contributions of each condition to the increasing prevalence of depression.

This rationale underscores the need for more nuanced studies that account for how these moderate chronic illnesses intersect with mental health outcomes. The purpose of this study is therefore to investigate the trends in depression prevalence among people of different genders and those affected by chronic physical conditions. The goal is to provide valuable insights that can guide healthcare providers and policymakers in understanding the relationship between chronic health conditions and mental health, ultimately contributing to more targeted and effective psychological health improvement strategies.

Methods

The National Health and Nutrition Examination Survey (NHANES) is a program from the United States that conducts studies and surveys to examine national health status. The program is run by the National Center for Health Statistics, the Centers for Disease Control and Prevention (CDC) (NHANES 2024).

Data throughout are from 2005–2018. During the time period from 2005 to 2018, there were a total of 70,190 subjects who took part in the surveys. However, not all are used. Those with insufficient data in the sections: are removed from the study sample, leaving the study with 26260 participants being analyzed. No consent from individual participants was taken given that data from NHANES are publicly available and are anonymized.

We assessed depression symptom levels using two definitions. The binary depression status was determined by the total PHQ9 scores and categorized into two groups: yes (Yes) and no (No). The depression severity status variable was determined by categorizing total PHQ9 scores into four groups: no depression (NoDpr), mild (Mild), moderate (Moderate), and severe (Severe). The independent variables were included in the analysis using self-reported questionnaires such as gender (male, female), diabetes (yes, no), asthma (yes, no), hypertension (yes, no), and high cholesterol levels (yes, no).

The demographic data for gender came from the variable (RIAGENDR) where the gender of the sample person was categorized into female, male, and missing. Diabetes was calculated using the variable DIQ010 where participants answered yes or no to "Doctor told you have diabetes". Participants for those with asthma (MCQ010) were asked "Has a doctor or other health professional ever told you that you have

asthma?" where their answers are categorized into yes and no. The variable BPQ080 assesses if the participant has hypertension by asking if they have "ever been told by a doctor or other health professional that you had hypertension, also called high blood pressure?" The results are similarly divided into yes and no. BPQ020 on the other hand is when participants are asked if they have "ever been told by a doctor or other health professional that your blood cholesterol level was high?" participants were subsequently divided into two groups: yes and no. Sample persons with missing values for any of the above variables were excluded from the models and statistical evaluations.

Statistical analyses

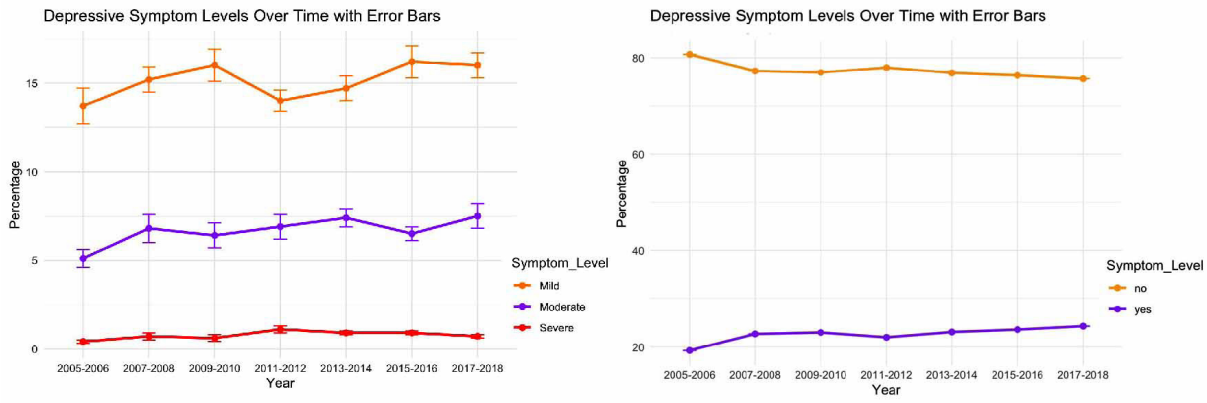
The prevalence of depressive symptoms within participants of the study samples was assessed according to the number of participants with depression and the corresponding percentage. The 95% confidence intervals were also obtained by using the percentage ± 1.96 times of standard error. All percentages were accounted for by the survey weights to represent the whole population in the US. To visualize the statistics and trends of depression prevalence across multiple years, we plotted multiple line charts with error bars. All analyses were conducted in R software (Olive D. J., 2010).

Results

Table 1 presents the frequency and prevalence (95% confidence interval) trends of four depression severity levels, including no, mild, moderate, and severe depression. Generally speaking, people with mild depression had an increasing trend of prevalence from 2005 to 2018, with prevalence growing from 13.7% to 16%. The prevalence of people with moderate depression also showed an increase from 5.1% in 2005 to 7.5% in 2018. People with severe depression show a different pattern with it peaking in 2012 with 1.1%. The general trend however for those with severe depression still shows a slight increase from 2005 to 2018, from 0.4% to 0.7%. On the contrary, people without any depression symptoms had a continuously decreasing trend in the prevalence, which decreased from 80.7% to 75.7%.

Table 2 shows the depression prevalence grouped by a variety of conditions such as gender, diabetes, etc. For gender, males had a continuously increasing trend in depression prevalence from 14.6 (2005–2006) to 20.6 (2017–2018), while females' depression prevalence increased to about 27% in 2007–2008, and then leveled off. However, for each survey cycle, the depression prevalence in female participants was significantly higher than that of males, with a difference between 7% and 11.6%.

Figure 1.



The trend for people who have depression while having the chronic illness diabetes fluctuates at around 30%. It started from 23.7% in 2005–2006 (the lowest) to 30.8 in 2017–2018. Within the same group of people, those without diabetes have a lower average rate of depression at around 20%, starting from 18.8% in 2005–2006 to 23.4% in 2017–2018 (Figure 1).

This trend is similar to the prevalence of depression in asthma patients as it also fluctuates around 30%, growing slightly from

26.2% to 32% from 2005 to 2018. The prevalence of depression in people without asthma fluctuates around 20%, going from 18.1% to 22.9% over the time period from 2005 to 2018 (Figure 4).

Figure 2. *Gender and Depression*

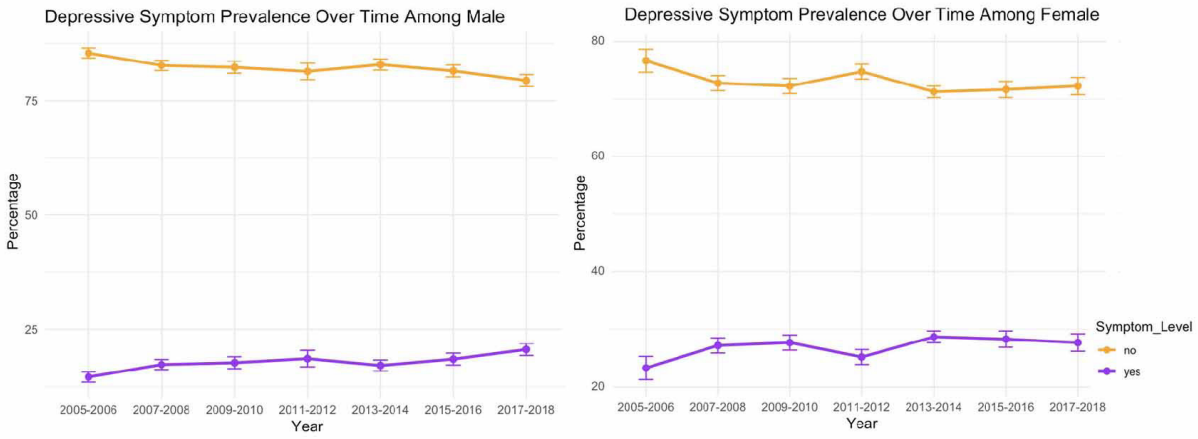


Figure 3. *Diabetes and Depression*

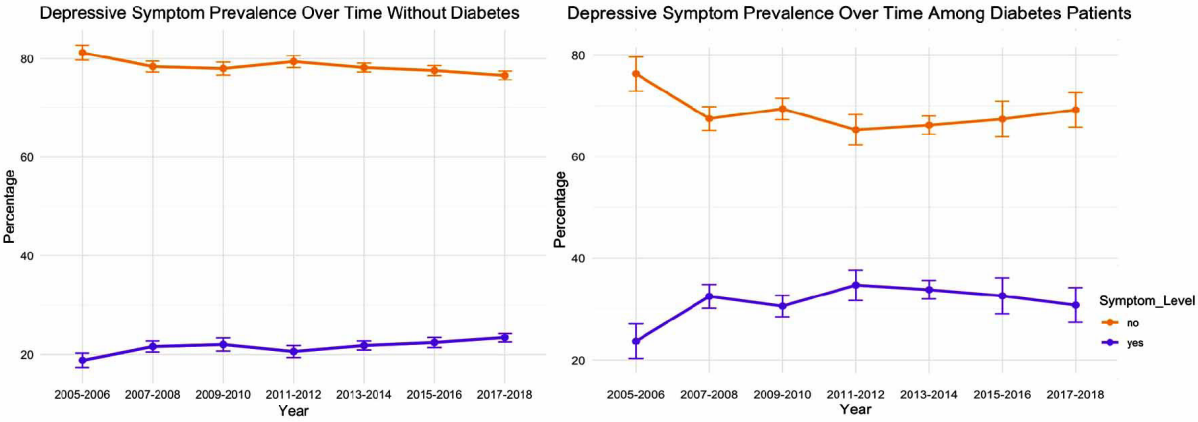
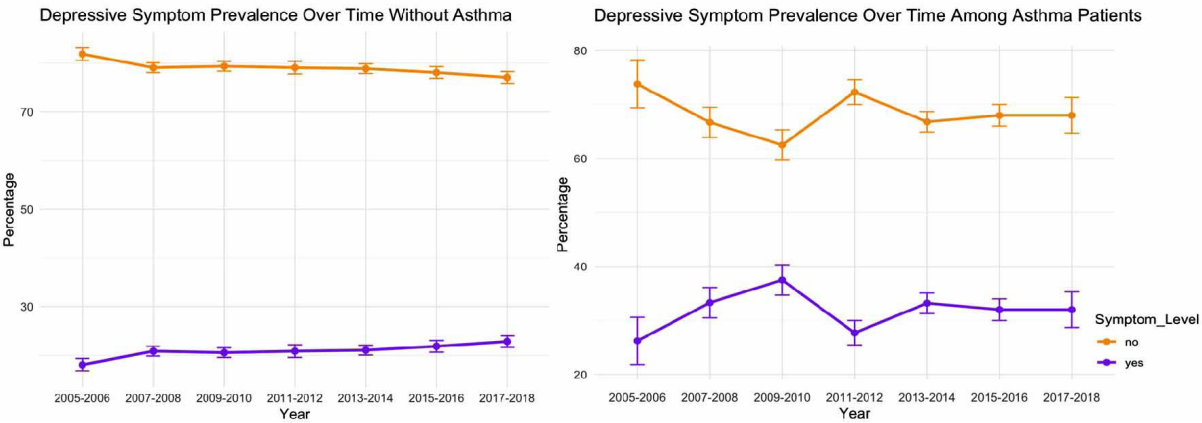


Figure 4. *Asthma and Depression*



The rate of depression in people with hypertension and high cholesterol also sees a similar trend, the prevalence however is slightly lower, oscillating around 25%. Over

2005 to 2018, depression in hypertension patients grew from 22.7% to 30.8%, while high cholesterol patients with depressive symptoms grew from 20.5% to 26.4%.

Figure 5. *Hypertension and Depression*

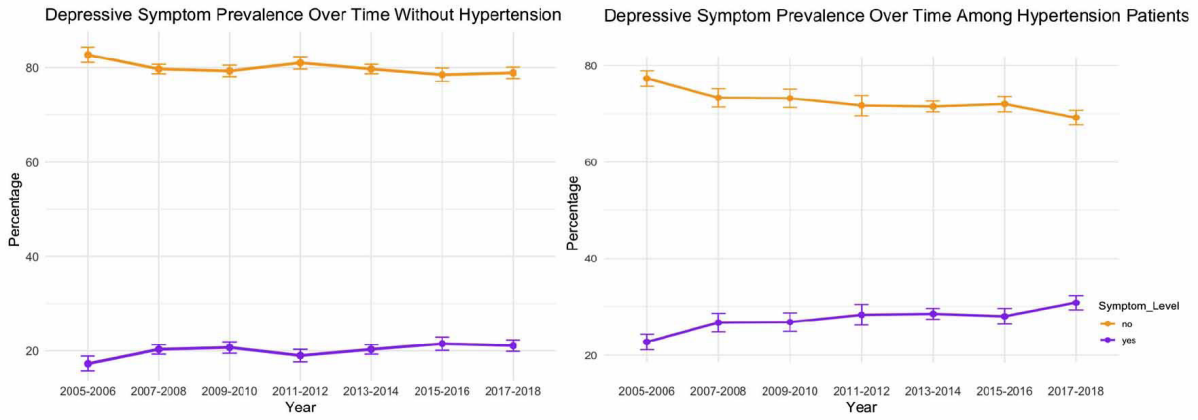


Figure 6. *High Cholesterol and Depression*

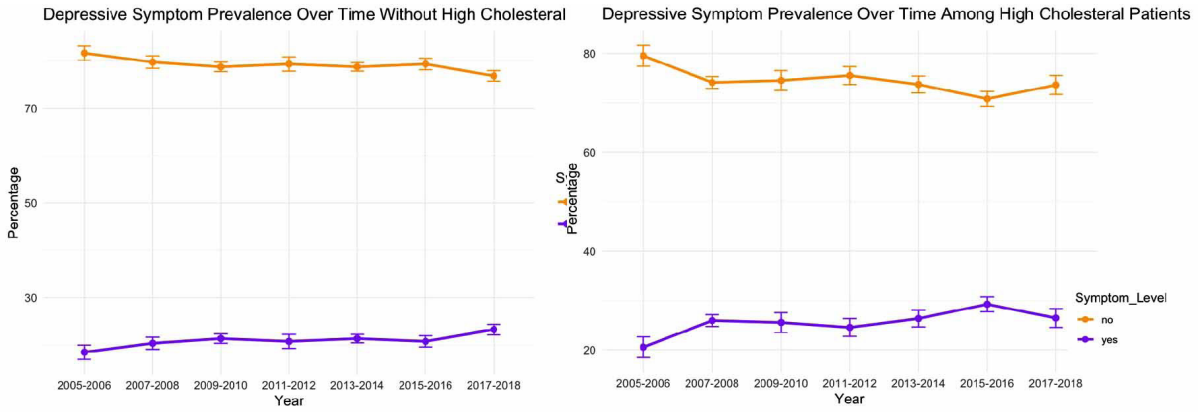


Table 1. *Prevalence of different depression severities over time*

Year	No (n, %, 95% CI)	Mild	Mod	Sev
2005–2006	2181 (80.7 [77.956, 77.956])	370 (13.7 [11.74, 15.66])	160 (5.1 [4.12, 6.08])	14 (0.4 [0.204, 0.596])
2007–2008	2457 (77.3 [75.144, 79.456])	509 (15.2 [13.828, 16.572])	262 (6.8 [5.232, 8.368])	30 (0.7 [0.308, 1.092])
2009–2010	2495 (77 [74.844, 79.156])	528 (16 [14.236, 17.764])	267 (6.4 [5.028, 7.772])	30 (0.6 [0.208, 0.992])
2011–2012	3146 (78 [75.452, 80.548])	617 (14 [12.824, 15.176])	325 (6.9 [5.528, 8.272])	51 (1.1 [0.708, 1.492])
2013–2014	3375 (76.9 [75.136, 78.664])	711 (14.7 [13.328, 16.072])	374 (7.4 [6.42, 8.38])	45 (0.9 [0.704, 1.096])
2015–2016	3182 (76.4 [74.244, 78.556])	734 (16.2 [14.436, 17.964])	297 (6.5 [5.716, 7.284])	49 (0.9 [0.704, 1.096])
2017–2018	3032 (75.7 [73.74, 77.66])	668 (16 [14.628, 17.372])	319 (7.5 [6.128, 8.872])	32 (0.7 [0.504, 0.896])

Table 2. *Depression prevalence in different variable groups*

Variable	2005–2006	2007–2008	2009–2010	2011–2012	2013–2014	2015–2016	2017–2018
Gender							
Male	198 (14.6 [12.4, 16.8])	286 (17.3 [15.1, 19.5])	304 (17.7 [15.2, 20.2])	408 (18.6 [15.1, 22.1])	416 (17.1 [14.7, 19.5])	441 (18.5 [16, 21])	409 (20.6 [18.1, 23.1])
Female	346 (23.3 [19.4, 27.2])	515 (27.2 [24.7, 29.7])	521 (27.7 [25.2, 30.2])	585 (25.2 [22.7, 27.7])	714 (28.7 [26.7, 30.7])	639 (28.3 [25.6, 31])	610 (27.7 [24.8, 30.6])
Diabetes							
No	456 (18.8 [15.9, 21.7])	643 (21.6 [19.4, 23.8])	648 (22 [19.5, 24.5])	799 (20.6 [18.2, 23])	905 (21.8 [20, 23.6])	862 (22.4 [20.4, 24.4])	822 (23.4 [21.6, 25.2])
Yes	88 (23.7 [17, 30.4])	158 (32.5 [28, 37])	177 (30.6 [26.5, 34.7])	194 (34.7 [28.8, 40.6])	225 (33.8 [30.3, 37.3])	218 (32.6 [25.7, 39.5])	197 (30.8 [24.1, 37.5])
Asthma							
No	440 (18.1 [15.6, 20.6])	620 (20.9 [18.9, 22.9])	638 (20.6 [18.6, 22.6])	776 (20.9 [18.4, 23.4])	876 (21.1 [19.1, 23.1])	860 (21.9 [19.5, 24.3])	793 (22.9 [20.5, 25.3])
Yes	104 (26.2 [17.6, 34.8])	181 (33.3 [27.8, 38.8])	187 (37.5 [32, 43])	217 (27.7 [23.2, 32.2])	254 (33.2 [29.5, 36.9])	220 (32 [28.1, 35.9])	226 (32 [25.5, 38.5])
Hyper-tension							
No	294 (17.3 [14.2, 20.4])	405 (20.3 [18.3, 22.3])	423 (20.7 [18.3, 23.1])	540 (19 [16.5, 21.5])	591 (20.3 [18.3, 22.3])	625 (21.5 [18.8, 24.2])	563 (21.1 [18.7, 23.5])
Yes	250 (22.7 [19.6, 25.8])	396 (26.7 [23, 30.4])	402 (26.8 [23.1, 30.5])	453 (28.3 [24.2, 32.4])	539 (28.5 [26.3, 30.7])	455 (28 [24.9, 31.1])	456 (30.8 [27.9, 33.7])
Choles-terol							
No	311 (18.4 [15.5, 21.3])	395 (20.3 [17.8, 22.8])	432 (21.3 [19.3, 23.3])	587 (20.7 [17.8, 23.6])	665 (21.3 [19.5, 23.1])	635 (20.7 [18.3, 23.1])	618 (23.2 [21, 25.4])
Yes	233 (20.5 [16.4, 24.6])	406 (25.9 [23.5, 28.3])	393 (25.5 [21.6, 29.4])	406 (24.5 [21, 28])	465 (26.3 [23, 29.6])	445 (29.2 [26.3, 32.1])	401 (26.4 [22.7, 30.1])

Discussion

This research investigates the increasing prevalence of depression in different severity levels and in relation to chronic physical conditions in the U.S. from 2005 to 2018. Depression rates showed a general increase

in all severities, with women showing a higher prevalence than men on the whole. The prevalence of depression in the sample from NHANES tends to fluctuate around 30% on average. Participants with chronic illnesses including diabetes, asthma, hypertension, and high cholesterol demonstrated higher percentages of depression generally in comparison to the average level of the sample group. Those without chronic conditions exhibited lower but still rising depression rates, averaging around 20%. The findings of this study underscore the potential interrelation between chronic physical conditions and depression, emphasizing the importance of addressing mental health in individuals with chronic physical conditions.

Many studies align with the findings of this research. A study that reported the depression prevalence trend between 2005 and 2016 showed that severe depression has an increasing trend (Yu B., Zhang X., Wang C., et al. 2020). Our study showed a consistent trend before 2017, but during 2017–2018, the prevalence increased significantly. Another study showed that depression prevalence increased dramatically between 2005/2006 and 2007/2008, and then levels off (Iranpour S., Sabour S., Koohi F., et al. 2022). Another trend was also that females generally show more prevalence with depression in comparison to men. Both these trends were consistent with our results, though our criteria for determining depression were different. The prevalence the study shows fluctuates around 7% while our results are around 20%. In terms of the relationship between depression prevalence and chronic medical conditions, a study on their epidemiology has shown that patients with coronary heart diseases and myocardial infarction show a greater prevalence of depression (Spijkerman T., de Jonge P., van den Brink R. H., et al. 2005), and those with chronic medical conditions tend to have greater risks of developing psychiatric disorders, not just depression. The study suggests a bidirectional causation relationship which gives reasons why depressive symptoms are higher in prevalence in those with chronic health conditions. This aligns with our research findings as patients with the chronic physical conditions examined in this study also have a higher prevalence of depression, a type of psychiatric disorder. Our finding is also supported by another research that focused on the epidemiology of depression and specifically diabetes, which suggested that the prevalence rate of depression triples in people with type 1 diabetes and is twice as high in those with type 2 diabetes in comparison to people without (Bobo W. V., Grossardt B. R., Virani S., et al. 2022). This result shows a much more significant difference but has a similar correlation to our findings. Research studies conducted in other countries like China in 2015 have also indicated the close relationship between chronic illnesses in elderlies and the likelihood of developing depression.

This research study possesses both strengths and limitations. One significant strength is the use of a representative and reliable source of sample data. Seven cycles of samples were used from NHANES, a large database. The PHQ scores provide sufficient inference in determining the prevalence of depression. Another advantage is that this study extends previous ones with a multitude of variables like asthma, diabetes, hypertension, and high cholesterol levels, along with an extended time frame from 2005 to 2018. A series of complex data analyses in examining depression prevalence over time were done to enhance precision of results. Nevertheless, there exist some disadvantages in the research process. First, given that no analysis or calculations were done for ages, it is unknown how people of different ages may have had an impact on the results. Other demographics should also be evaluated. Second, the relationship between sociodemographic factors and the prevalence of different depression severities was not evaluated. Third, no data was available regarding pharmacotherapy or access to mental health treatments. Finally, and importantly, all data used for the different variables are self-reported which could lack authenticity.

Conclusion

In conclusion, this study was able to highlight the increasing and fluctuating prevalence of depression in the United States from 2005 to 2018, with particular emphasis on its potential interrelation with chronic physical conditions. Women consistently showed higher depression rates than men, and individuals with chronic illnesses such

as diabetes, asthma, hypertension, and high cholesterol generally demonstrated higher depression prevalence compared to those without. Similar findings were identified in other related research studies. Further research is needed to explore the causal pathways and mechanisms underlying these associations. These findings which address the interrelation between chronic physical conditions and depression underscore the need for integrated healthcare strategies that address both mental health and chronic physical conditions.

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Declaration Conflict of Interest

None.

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FEATURES OF MULTIPARAMETRIC MRI STUDY IN PROSTATE CANCER

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Abstract

This study investigates the magnetic resonance (MR) imaging features associated with prostate cancer (PCa) using multiparametric MRI (mpMRI). Data from 114 patients undergoing mpMRI of the prostate were analyzed to identify correlations between MR signs, apparent diffusion coefficient (ADC) values, and the presence of organ deformation. The study reveals statistically significant differences in DWI b-values and the presence of organ deformation between patients with and without MR signs of prostate tumor. These findings contribute to a better understanding of MR imaging characteristics in PCa diagnosis and management.

Keywords: *Prostate Cancer (PCa), Multiparametric MRI (mpMRI), Magnetic Resonance Imaging (MRI), Diffusion-Weighted Imaging (DWI), Apparent Diffusion Coefficient (ADC), Organ Deformation, Diagnosis, Screening, T2-weighted imaging (T2w)*

Relevance

Prostate cancer (PCa) is the most common cancer among the male population of the world, accounting for 22.7% of all diagnosed malignant diseases (excluding non-melanoma skin cancer), and is the second leading cause of death among cancer patients (Robert-Koch-Institut und die Gesellschaft der epidemiologischen Krebsregister in Deutschland e. V. Hrsg. 2019). MRI is included in the list of mandatory diagnostic studies of PCa (Wei J. T., Barocas D., Carlsson S., Coakley F., Eggener S., Etzioni R., Fine S. W., Han M., Kim S. K., Kirkby E., Konety B. R., Miner M., Moses K., Nissenberg M. G., Pinto P. A., Salami S. S., Souter L., Thompson I. M., Lin D. W. 2023). In recent years, a trend has been identified that demonstrates a certain value of traditional diffusion-weighted imaging (DWI) with T2 – weighted imaging (T2 w) in magnetic resonance imaging (MRI), which is a key component of multiparametric MRI (mpMRI) in screening for prostate diseases, including PCa (Abreu-Gomez J., Lim C., Haider M. A., 2024; Spilseth B., Margolis D. J.A., Gupta R. T., Chang S. D. 2024).

The aim of the study: To determine the features of MR signs of MRI in prostate cancer.

Relevance

Prostate cancer (PC) is the most common cancer among the male population of the world, accounting for 22.7% of all

diagnosed malignant diseases (excluding non-melanoma skin cancer), and is the second leading cause of death among cancer patients (Robert-Koch-Institut und die Gesellschaft der epidemiologischen Krebsregister in Deutschland e. V. Hrsg. 2019). MRI is included in the list of mandatory diagnostic studies of PC (Wei J. T., Barocas D., Carlsson S., Coakley F., Eggener S., Etzioni R., Fine S. W., Han M., Kim S. K., Kirkby E., Konety B. R., Miner M., Moses K., Nissenberg M. G., Pinto P. A., Salami S. S., Souter L., Thompson I. M., Lin D. W. 2023). In recent years, a trend has been identified that demonstrates a certain value of traditional diffusion-weighted imaging (DWI) with T2-weighted imaging (T2w) in magnetic resonance imaging (MRI), which is a key component of multiparametric MRI (mpMRI) in screening for prostate diseases, including PC (Abreu-Gomez J., Lim C., Haider M. A. 2023; Spilseth B., Margolis D. J.A., Gupta R. T., Chang S. D., 2024).

Purpose of the study: To determine the features of MR signs of MRI in PC.

Materials and methods of the study. The study was conducted at the Fedorovich Clinic and included 114 patients who underwent multiparametric MRI of the prostate gland. The age of the participants ranged from 40 to 87 years. The multiparametric MRI (mpMRI) procedure is a comprehensive study that includes several imaging modes that allow obtaining detailed information about the structure and function of the pelvic organs, including the prostate gland. The study data are divided into 2 groups depending on the presence/absence of a multiparametric feature (Table 1).

Table 1. *Descriptive statistics of quantitative variables depending on the multivariable MRI feature among study participants*

Indicators	MRI MP sign		p
	Availability	Absence	
Age of participants, M (SD)	66.88 (10.01)	68.63 (10.53)	0.364
MR dimensions of the PG (mm^2), Me [IQR]	43.5 [34.0; 60.0]	39.0 [32.0; 62.0]	0.486
Prostate tumor size (mm^2), Me [IQR]	13.1 [8.0; 23.0]	12.0 [8.5; 18.0]	0.775
DWI b (s/mm^2), Me [IQR]	2000.0 [2000.0; 2000.0]	1100.0 [1000.0; 1600.0]	< 0.001*
IDC values (mm^2/s), Me [IQR]	0.68 [0.59; 0.80]	0.63 [0.42; 0.81]	0.096

Results: An analysis of the presence of signs of organ deformation depending on the multiparametric MRI feature was performed among the study participants.

Table 2. *Analysis of the presence of signs of organ deformation depending on the multiparametric MRI sign among study participants*

Indicators	Categories	MRI MP sign		p
		Availability	Absence	
Deformation of the right ventricle	Availability	47 (82.5)	36 (63.2)	0.021*
	Absence	10 (17.5)	21 (36.8)	

** – differences in indicators are statistically significant (p < 0.05)*

According to the data obtained when comparing the presence of signs of organ deformation depending on the multiparametric MRI sign among the study participants, we established statistically significant differences (p = 0.021) *(method used: Pearson Chi-square)*.

The odds of absence of organ deformation in the group without MR signs of prostate tumor were 2.742 times higher than in the group with MR signs of prostate tumor; the differences in odds were statistically significant (95% CI: 1.150–6.539).

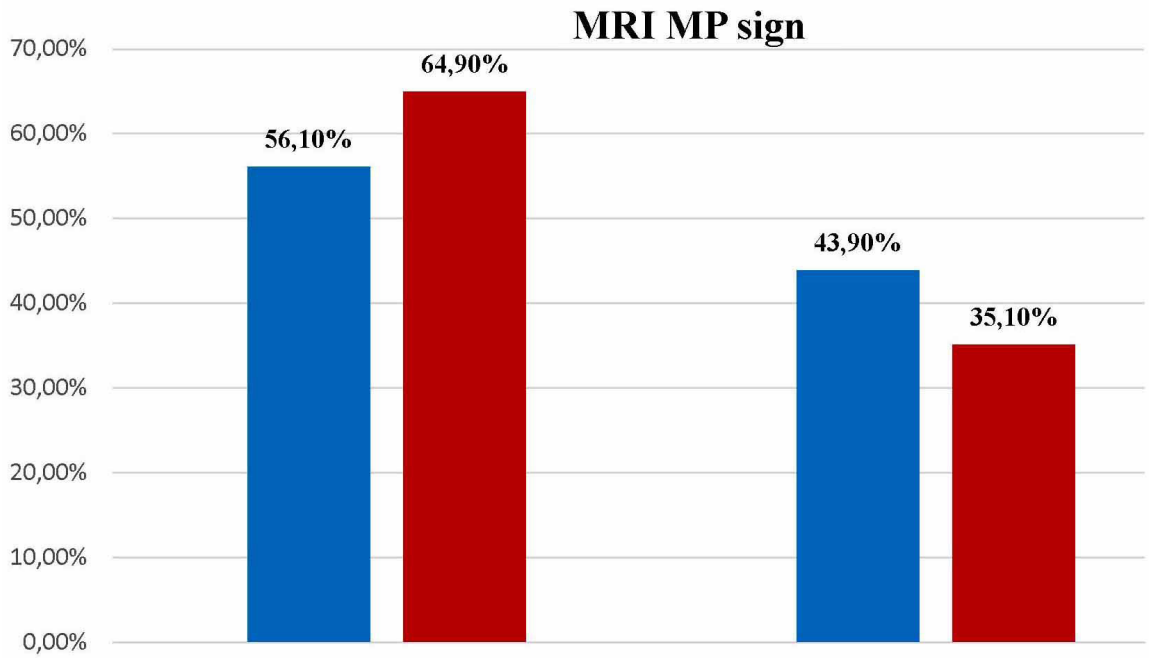
An analysis of the parameters of the MR signal of tumor localization was performed depending on the multiparametric MRI feature among the study participants.

When assessing the parameters of the MR signal of tumor localization depending on the multiparametric MRI feature among the study participants, it was not possible to identify statistically significant differences (p = 0.338) *(method used: Pearson Chi-square)*.

The odds of indicator 2 in the group without MR signs of prostate tumor were 1.445 times lower compared to the group with MR signs of prostate tumor; the differences in odds were not statistically significant (OR = =0.692; 95% CI: 0.325–1.472).

We performed an analysis of the values of the parameters of the apparent diffusion coefficient depending on the multiparametric MRI feature among the study participants.

Figure 1. *Analysis of MR signal parameters of tumor localization depending on the multiparametric MRI feature among study participants*



According to the presented table, when assessing the values of the parameters of the apparent diffusion coefficient depending on the multiparametric MRI feature among the study participants, we identified statistically significant differences (p < 0.001) (method used: Pearson Chi-square).

The odds of indicator 2 in the group without MR signs of prostate tumor were 4.886 times higher than in the group with MR signs of prostate tumor; the differences in odds were statistically significant (95% CI: 2.185–10.930).

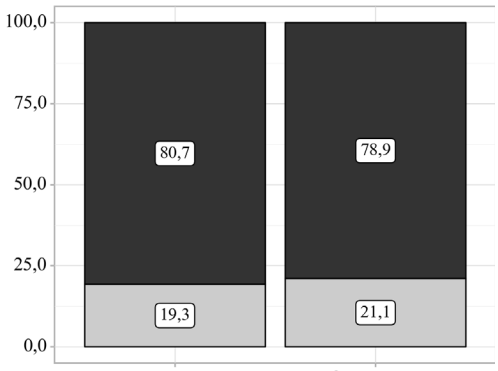
We conducted an analysis of MR differentiation of the pancreatic tumor focus depending on the multiparametric MRI feature among the study participants.

When comparing the MR differentiation of the pancreatic tumor focus depending on the multiparametric MRI feature among the study participants, we were unable to identify significant differences (p = 0.815) (method used: Pearson Chi-square).

The odds of indicator 2 in the group without MR signs of prostate tumor were 1.115 times higher than in the group with MR signs of prostate tumor; the differences in odds were not statistically significant (95% CI: 0.446–2.786).

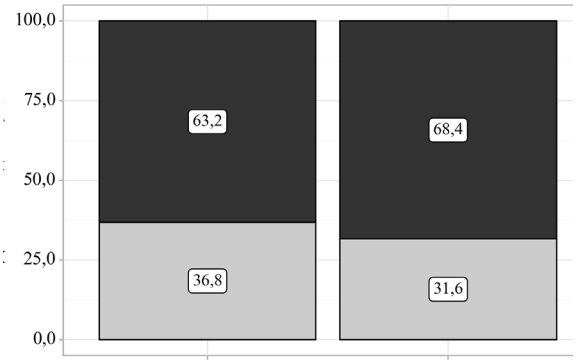
We conducted an analysis of the parameters of the measured diffusion coefficient depending on the multiparametric MRI feature among the study participants.

Figure 2. *Analysis of MR differentiation of pancreatic tumor focus depending on the multiparametric MRI feature among study participants*



When analyzing the parameter of the measured diffusion coefficient depending on the multiparametric MRI feature among the study participants, it was not possible to establish statistically significant differences (p = =0.554) (method used: Pearson Chi-square).

Figure 3. *Analysis of the parameters of the measured diffusion coefficient depending on the multiparametric MRI feature among study participants*

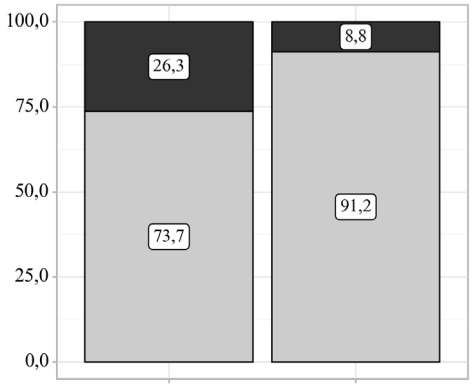


The odds of indicator 2 in the group without MR signs of prostate tumor were 1.264 times lower compared to the group with MR signs of prostate tumor; the differences in odds were not statistically significant (OR = 0.791; 95% CI: 0.364–1.718).

An analysis of possible signs of pancreatic tumor metastasis depending on the multiparametric MRI sign was performed among the study participants.

When comparing possible signs of pancreatic tumor metastasis depending on the multiparametric MRI sign among the study participants, statistically significant differences were found (p = 0.014) *(method used: Pearson Chi-square)*.

Figure 4. *Analysis of possible signs of pancreatic tumor metastasis depending on the multiparametric MRI sign among study participants*



The odds of indicator 2 in the group without MR signs of prostate tumor were 3.714 times higher than in the group with MR signs of prostate tumor; the differences in odds were statistically significant (95% CI: 1.248–11.056).

Conclusion

Comparative analysis of our study depending on the multiparametric MRI feature shows significant differences and presents MRI examination as a determining factor in the diagnosis of prostate cancer. In addition, multiparametric MRI examination has a great advantage over other clinical and radiation diagnostic methods in determining the localization, deformation of the prostate gland and the degree of its diffusion coefficient.

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CONCENTRATION OF EXTRACTIVE PHOSPHORIC ACID WITH HOT AIR

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Abstract

This article substantiates methods for concentrating extraction phosphoric acid (EPA) with a concentration of 22÷28% P_2O_5, obtained on the basis of phosphorites of the Central Kyzylkum to 55% P_2O_5. As a result of evaporation using heated air under laboratory conditions, the amount of fluorine in it is much less than during evaporation under normal conditions. Initially, EPA was obtained from local Kyzylkum phosphorites under normal laboratory conditions by the dihydrate method. For this, a simple glass reactor was used, with a moving stirrer with an electric motor and vacuum filtering devices. The initial composition of the resulting EPA was analyzed by chemical and physicochemical methods and evaporated in three ways to a concentration of 55% P_2O_5. Laboratory work carried out by these methods was carried out under strict temperature control. The experiment was repeated several times and the results were compared. Experiments have shown that when EPA is evaporated to a concentration of 39÷46% P_2O_5, a precipitate is formed, which is convenient to separate. After separating the precipitates, it turned out that the resulting highly concentrated EPA does not lose its fluidity.

Keywords: *Local phosphorite, reactor, extractive phosphoric acid (EPA), concentration, evaporation, vacuum, heated air, thermal phosphoric acid (TPA)*

1. Introduction

Increasing the amount of agricultural products is important for the survival of people on the globe. Because the most important part of food security is the amount of food products. In agriculture, increasing crop yields due to salinization of crop areas and the spread of drought is one of the main and most important issues.

To do this, it is necessary to increase the amount of substances and elements in the soil that are absorbed by the plant. In practice, there is a deficit of natural organic fertilizers, so to compensate for this, it is necessary to develop the mineral fertilizer industry. That is why these issues are included in the main plan of our country.

The problem of fertilizers is in the first place in the development of agriculture. To solve these problems, the development of their main types and the development of new technologies are among the main tasks facing the scientists-chemists of our republic. In our country, the industry for the production of mineral fertilizers is widely developed. However, it is necessary to continue scientific work in order to increase the level of absorption by plants, use raw materials economically and ensure the quality of fertilizer.

Currently, organic, mineral and organomineral types of fertilizers are used in agriculture, among which the leading place is occupied by complex fertilizers containing assimilable phosphorus. The necessary raw material for this is the phosphorite of the Central Kyzylkum, which is considered the poorest among phosphorus-containing phosphorites. There are many scientific works on their processing and concentration of phosphorus acids obtained from them in order to obtain high-quality phosphorus fertilizers (Awwad N. S., El-Nadi Y. A., Hamed M. M. 2013; Jiahui Men, Yiming Li, Peifeng Cheng, Zhanming Zhang. 2022; Khurramov N. I., Nurmurodov T. I., Erkaev A. U. 2021; Melikulova G. E. [and others]. 2019). Most importantly, in addition, due to the simplicity of production, the production of ammophos, simple and double superphosphate has been widely established (Bakhriddinov, N. S., & Turgunov, A. A., 2022). Their quality, firstly, it is necessary to increase the amount of phosphorus in the composition, and secondly, to increase the level of assimilation of the available phosphorus by plants.

Central Kyzylkum phosphorites used for the production of phosphorus fertilizers are local, which is convenient for production. However, the phosphorus content in it is 14–16% P_2O_5, the amount of phosphorus is increased in relation to the total mass of this phosphorite, using the enrichment method by reducing the content of excess substances through additional processing. Due to the use of this method, it is possible to obtain from them a concentration of extraction phosphoric acid (EPA) up to 22–28% P_2O_5 already at the primary stage.

In the process of producing phosphorus fertilizers, along with the enrichment of phosphorites, EFA is also obtained in low concentration during the production process. As a result, the evaporation process is widely used to reduce the water content of this acid in order to obtain high-quality, i.e. high-phosphorus EPA. The amount of energy consumed is also high, which leads to an increase in the cost of the produced mineral phosphorus fertilizer. Taking this into account, it is necessary to use an economical method of concentration. Another property of mineral fertilizers is that the level of absorption by plants is very low after their introduction into the soil and after watering. In particular, the rate of application of nitrogen fertilizers is based on the ease of evaporation and solubility of nitrogen in water. To eliminate these shortcomings, it is necessary to use gradually dissolving types of fertilizers, i.e. types in the form of polyforms.

To form phosphorus in the form of polyphosphate in phosphorus fertilizer, its concentration is increased by evaporating the EPA intended for mineral fertilizer. It is known that the use of thermal phosphoric acid (TPA) is convenient for obtaining highly concentrated phosphoric acid, easily absorbed in mineral fertilizers. However, due to the high cost in Uzbekistan, such TPA is not produced for the purpose of obtaining phosphorus mineral fertilizers, and EPA is used instead. To obtain high-quality ammonium phosphates from EPA, it is necessary to carry out a process of their purification from heavy metals, arsenic, calcium, magnesium and fluorine. This must be done in an economical way. Such methods are divided into evaporation, precipitation, the use of organic solvents, ion exchange, crystallization (Najmiddinov, R., Shamshidinov, I., Qodirova, G., Nishonov, A., & Sayfiddinov, O. 2022; Bakhriddinov, N.S., 2022; Bakhriddinov, N.S., 2021). One of the convenient methods currently being implemented is evaporation, which reduces the amount of water contained

in the original EPA. Laboratory chemical and physicochemical analyses have shown that the original EPA is completely composed of orthophosphoric acid P_2O_5. To increase the amount of phosphorus pentoxide in phosphorus P_2O_5 fertilizer, it is necessary to evaporate the primary EPA obtained from phosphorites (Kodirova, G. K., Shamshidinov, I. T., Turaev, Z., & Najmiddinov, R. Yu. U., 2020).

2. Main body

Laboratory work was carried out in a laboratory setup with a simple glass and also a metal reactor made of stainless steel, a water cooler from the evaporation of water as a result of the reaction and a stirrer driven by an electric motor, by gradually adding sulfuric acid to the phosphorite of the specified sample. Thermal concentrate of phosphorite from Central Kyzylkum (composition: P_2O_5–25.68%; CaO – –53.28%; CO_2–2.68%; MgO – 0.52%; F – 2.76, R_2O_3–3.58%; SO_3–5.01%) and 93% sulfuric acid H_2SO_4 were used for laboratory work. The stoichiometric rate of sulfuric acid was set equal to 100% of the amount required for the decomposition of calcium in phosphorite, and was brought to an aqueous solution of the corresponding concentration. When it interacts with the sulfuric acid H_2SO_4 – phosphorite $Ca_5F(PO_4)_3$ taken for the reaction, the following process is observed:

$$Ca_5F(PO_4)_3+5H_2SO_4=3H_3PO_4+5CaSO_4+HF$$

It is known that in addition to the basic phosphoric acid H_3PO_4 formed during the acidic decomposition of phosphorites, calcium dihydro- and hydrophosphates are formed:

$$2Ca_5F(PO_4)_3+7H_2SO_4=3Ca(H_2PO_4)_2+7CaSO_4+2HF,$$

$$2Ca_5F(PO_4)_3+4H_2SO_4=6CaHPO_4+4CaSO_4+2HF.$$

The process lasted 4 hours, and the EPC was isolated by filtration. The chemical composition of the EPA was obtained by repeating this process 3 times, the EPA was first taken separately, then three EPAs were put together and mixed until one mass was formed, and the total mass composition was determined analytically using the established method (Table 1).

It is known that extracted EPA is used in the production of double superphosphate or ammonium phosphates. If we take into account the requirements of the present time, then the abundance of additional substances and elements in its composition, especially excess fluorine, negatively affects the quality of the resulting fertilizer. Taking this into account, the process of concentrating EPA is carried out at high temperature, which gives a positive result. For this purpose, it has been experimentally established that when the original EPA is evaporated by heated air, the rate of volatilization of the fluorine contained in it increases.

Table 1. *Chemical composition of EPA obtained from phosphorite*

№	P_2O_5	H_2SO_4	CaO	MgO	Al_2O_3	Fe_2O_3	F
Composition of separately received EPA							
1	27.76	0.20	0.48	1.25	1.90	1.46	2.21
2	27.61	0.24	0.51	1.22	1.95	1.39	2.27
3	27.92	0.27	0.47	1.18	1.89	1.43	2.23
With mixed EPAs							
4	27.76	0.25	0.49	1.22	1.91	1.43	2.24

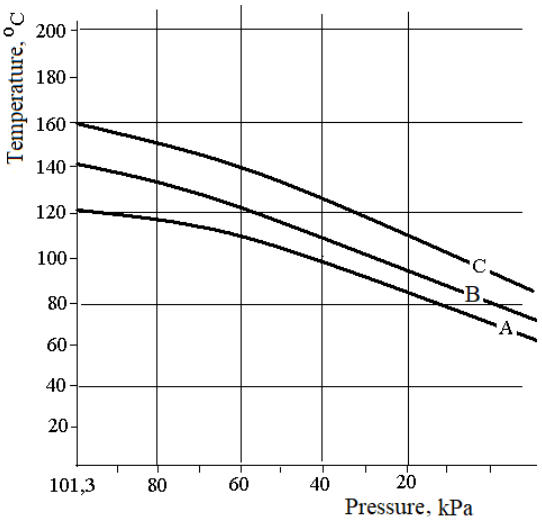
During the evaporation process of the EPA, as its concentration increases, the boiling point also increases accordingly. When the obtained concentration of the EPA reaches 45–46% P_2O_5, the boiling point reaches 120 °C, 140 °C at 50% and 160 °C at 55% (Fig. 1).

Modern industrial production requires the use of energy-efficient technologies. Accordingly, as shown in Figure 1, boiling temperatures are reduced under reduced pressure conditions and energy savings are observed.

It is known that the presence of substances and elements in the EPA and its quantity depend on the content of the phosphorite

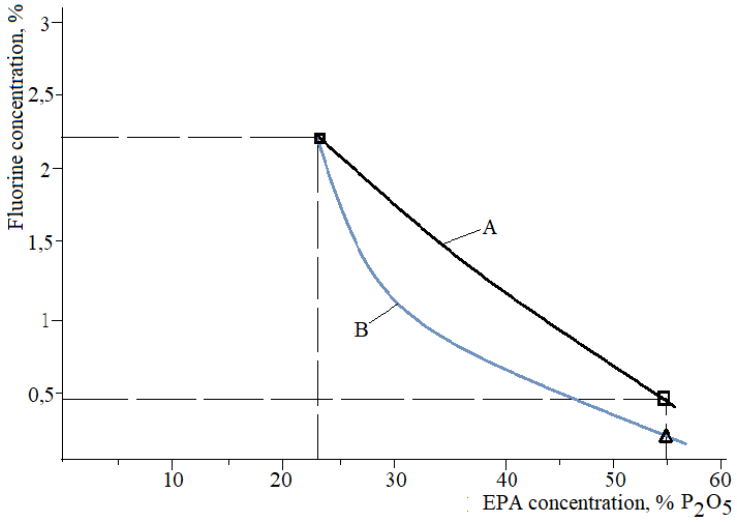
used. Phosphorite contains fluorine, magnesium and similar additives that pass into the EPA during the extraction process. One of the properties of magnesium is that it causes its condensation when the concentration of evaporating EPA reaches 40–45% P_2O_5. Therefore, the first stage of the evaporation process is up to 40–45% P_2O_5, after reaching this concentration, the EPA is purified from magnesium sediment and other by-products (Sadriddinovich, B. N., 2022; Shamshidinov, I. T., & Arislanov, A. S., 2022; Sobirov, M. M., Bakhridinov, N. S., & Rozikova, D. A., 2020; Sadriddinovich, B.N., 2022; Bakhriddinov, N.S., & Turgunov, A.A., 2022).

Figure 1. Change in boiling temperature during vacuum evaporation of EPA: A – 45%, B – 50%, C – for EPA with a concentration of 55% P_2O_5



Two methods were used to concentrate the EPA: the evaporation process under normal conditions and under vacuum conditions. Evaporation under normal conditions, i.e. at P_0 = 101.3 kPa, with an increase in the content of the EPA from 45% to 55% P_2O_5, it is clear that its boiling point changes from 120 °C to 160 °C, and with a decrease in pressure to 20 kPa – from 85 °C to 110 °C, respectively (Fig. 1). This, in turn, shows that the vacuum process saves energy for evaporation. Experiments have shown that the amount of volatile substances in the EPA is the same as under normal conditions, based on the corresponding change in saturated vapor pressure with concentration.

Figure 2. *Dependence of fluorine release in EPA on the type of vaporization: A – normal and vacuum-heating evaporation; B – evaporation with heated air*



If we look at the example of fluorine, we can see that the amount of fluorine in the EPA with a concentration of 27.67% P_2O_5 is 2.26%, but as a result of evaporation to 55% P_2O_5, the amount of fluorine decreases to an average of 0.47%. This can be explained as follows:

–0.46% under normal conditions;

–0.47% under vacuum conditions.

In modern technologies, it is expected that any process will be carried out taking into account energy efficiency, cost reduction and environmental requirements. With this in mind, another type of evaporation was used – a method of supplying heated air to the EFC and removing the water contained in it. The most important thing is that the level of fluorine in this EPA increases as the temperature of the heated air increases. This is shown in Figure 2 below.

The result of chemical analysis shows that the fluorine contained in EPA is released during the evaporation process. 1.5÷2.5% of volatile fluorine relative to the total amount of EPA can also have a negative impact on the environment. That is why it is good to absorb volatile fluorides in a simple water absorbent.

The transformation of the monophosphates contained in it into polyphosphates during evaporation of EPA is also important. According to the type of evaporation process, the amount of polyphosphate during evaporation by simple heating is given in (table 2).

Table 2. *Change in the amount of polyphosphates during the process of increasing the concentration of EPA to 55% by the method of thermal evaporation*

Concentration of EPA, %	40	45	50	55
Amount of polyphosphate in EPA, %	3–4	9–15	22–28	31–39

The second side of the changes that occur during the evaporation of the EPA obtained for the experiment to 55% P_2O_5 is the transition of phosphoric acid from the orthoform to the polyform. This mainly begins when the concentration of EPA reaches 40% P_2O_5.

Based on the results obtained by the chromatographic method of physicochemical analysis of concentrated acids obtained on the basis of the experiment, it was confirmed that when the concentration reaches 40% P_2O_5, the phosphates contained in it are converted into polyforms (Table 2).

Therefore, as a result of the increase in temperature, the precipitation of fluorine contained in the evaporating acid in the form of K_2SiF_6, $KNaSiF_6$, MgF_2, K_3SiF_6 accelerates and flies out of the system. The composition of the sediment isolated from 40% EPA was studied based on infrared-IR and X-ray structural analysis data.

Therefore, measures are taken to collect sediments formed during the evaporation of EPA, with the aim of processing and preventing pollution of the atmospheric air by the released fluorine using absorbers, i.e. sorbents.

The above fluorine content in concentrated 55% EPA can be considered acceptable for the resulting concentrated EPA from 0,5 to 1%, and these acids can be used not only as mineral fertilizers, but also as animal feed. However, when preparing livestock feed, the amount of fluorine should be as small as possible.

The chemical composition of the Central Kyzylkum phosphorites may vary depending on the location of the mineral and the amount of substances and elements in it. For example, a magnesium content of 0.52% allows increasing the concentration of the first stage of the evaporation process of such EPA to 45% P_2O_5, while the magnesium content does not reach 1% when extracting EPA from this phosphorite. In addition, the evaporation temperatures of EFA with the same magnesium content may also be different.

A second look at the experience:

When observing the evaporation process by spraying air at a temperature of 150–160 °C through a tube made of acid-resistant alloy steel, the growth of the concentration of the obtained EPA, as well as the amount of polyphosphates in it, accelerated. A further increase in the temperature of the heated air leads to an increase in the rate of fluorine evaporation. For this purpose, a chrome-plated electric heater with an asbestos coating is used on the surface of this tube.

This was done by spraying the acid into the reactor using an air atomizing pump.

The result obtained showed the formation of concentrated EPAs with high polyphosphate content. When this resulting acid was also subjected to chemical analysis, the results shown in table 3 were seen.

Table 3. *Change in the amount of polyphosphates in the process of increasing the concentration of EPA to 55% P_2O_5 by steaming with heated air*

Concentration of EPA, %	40	45	50	55
Amount of polyphosphate in EPA, %	7–9	16–19	29–35	38–47

According to the results of the second experiment, the production of mineral fertilizer from this acid by obtaining concentrated acid with an increase in the amount of polyphosphate due to spraying with heated air is good.

3. Conclusion

The obtained initial stage EPA was poured into 3 cups of 100 grams each and each of them was evaporated using separate methods:

1. The concentration reached 55% when the temperature of the mass in the reactor increased from 115 °C to 198 °C during its evaporation in the oil heater bath under atmospheric pressure conditions P_0=96.7 kPa (723 mm Hg). However, the total mass reached a state in which it lost its fluid state.

2. Evaporation was carried out in a similar way, reducing the pressure to 20 kPa, and the temperature was changed from 80 °C to 110 °C, respectively. In this case, the mass in the reactor was also in a thick state.

3. The temperature was the same as in the first case when using the method of evaporating heated air under atmospheric pressure conditions P_0 = 96.7 kPa (723 mm Hg). When the resulting concentrated EPA was cooled and the transparent part was analyzed, it was found that the amount of fluorine it contained was less than that of the acid obtained by concentrating it using the conventional method. It is evident that acids obtained by such methods can be used to produce phosphorus-containing feed for livestock. Experiments have shown that when evaporating EPA to a concentration of 39÷46%, a precipitate is formed that is easy to separate. After separating the precipitates, it turned out that the highly concentrated EPA obtained does not lose its fluidity.

The second group cations and fluorine in concentrated EPA have a negative effect on the fluidity. Therefore, the fluidity is maintained when the precipitate formed during the separation of the first stage of evaporation is separated from EPA. Most importantly, evaporation using heated air ensures that the fluorine content of the resulting concentrated EPA is significantly lower.

It can be said that the boiling point changes depending on the amount of magnesium in the EPA. For example, 0,54% MgO is 110 °C, and 1,50% is 154 degrees. The main reason why evaporation can be continued to the initial stage of the evaporation process of 45% with a magnesium content in the evaporated EPA of 0,54% is its high fluidity at high temperature. Accordingly, with its 1,24% MgO, it was found in the experiment that it is forced to separate from the sediment when the EPA concentration reaches 40%.

The most important thing is that, firstly, the amount of magnesium in concentrated EPA precipitates at the first stage of the concentration process, and experience has shown that it does not exceed 1,5%, and secondly, evaporation under vacuum conditions leads to energy savings.

On the other hand, the experiment showed that the amount of polyphosphate in the concentrated EFC obtained by using heated air during heating and steaming and feeding it to the EPA inside the reactor can be 5–7% more than in the previous case.

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