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Comparison of the antioxidant effect of Vitamin C and Garlic extract in hyperglycemic cataractous goat lenses: An experimental study

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Cataractogenesis, oxidative stress, garlic extract, vitamin C, diabetic cataract

ABSTRACT
Background: Cataract remains the leading cause of blindness worldwide, while diabetes mellitus intensifies the development of cataracts. Hyperglycemia triggers oxidative stress that produces ROS, which causes protein aggregation and lipid peroxidation. Garlic Extract (Allium sativum) and Vitamin C present therapeutic potential in the combat of oxidative stress for preventing lens opacification.
Methods: In this study, 30 goat lenses were incubated with TC199 for 72 hours to serve as a control. The experimental group consisted of 3 groups of 30 Goat lenses, each incubated with dextrose, garlic water extract + dextrose, and vitamin C + dextrose, respectively. A study was made on the changes in lens morphology, total soluble proteins MDA level, and activity of Superoxide Dismutase, Glutathione Peroxidase, and Glutathione Reductase.
Results: The dextrose-induced cataract lenses experienced a 25.8% decrease in total soluble proteins and a 28.9% increase in MDA levels, and a significantly lowered activity of SOD, GPx, and GRx as compared to control, indicating that severe oxidative damage occurred. Protein content was preserved in lenses treated with Garlic Extract and Vitamin C in a significant way. At the same time, MDA levels decreased, and activities of all antioxidant enzymes increased in lenses treated with Garlic Extract and Vitamin C.
Conclusion: The experimental findings show that both Garlic Extract and Vitamin C successfully minimize oxidative stress while improving lens transparency in diabetic cataract conditions. Garlic Extract demonstrates better performance than Vitamin C by restoring enzymes and exhibiting stronger antioxidant properties, and thus, it could serve as a natural anti-cataractous agent.

1. Introduction

The world population experiences cataracts as one of the primary causes of blindness, which affects both aging people and those with Diabetes mellitus (Bourne, R. R et al 2016). The development of cataracts through lens opacification depends on oxidative stress together with non-enzymatic glycation and polyol pathway activity imbalances. In diabetics, the lens develops cataracts due to chronic hyperglycemia, which triggers oxidative damage in the lenses The development of cataracts depends on oxidative stress because reactive oxygen species (ROS) accumulate through this process and damage lens proteins and lipids, which causes transparency loss (Forman, 2016). Superoxide Dismutase (SOD), Glutathione Peroxidase (GPx), and Glutathione Reductase (GRx), alongside vitamin C and vitamin E, and glutathione (GSH), are the enzymatic and non-enzymatic components of the lens antioxidant defense system. When hyperglycemia weakens antioxidant defenses, the process of lens opacification occurs more rapidly (Khanam, A. et al 2020). The antioxidants serve to deactivate ROS, which protects proteins and lipids from harm. Vitamin C (ascorbic acid) stands as the most prevalent antioxidant in both aqueous humor and lens tissue since it aids free radical neutralization and prevents lipid peroxidation. Research indicates that vitamin C slows down cataract formation by reducing oxygen-free radical production and maintaining lens clarity (Heruye et al., 2020). In a solution containing one mM vitamin C and Fe^{3+} or Cu^{2+} metal ions, the production of H_2O_2 as a pro-oxidant can lead to cataract development (Halliwell, 2020). Scientists are investigating medicinal plants to determine which antioxidant properties can stop cataracts from forming. The medicinal benefits of Allium sativum (garlic) have received extensive scientific analysis because it helps decrease oxidative stress and enhance antioxidant enzyme performance, according to Dorrigiv et al (2020). Garlic extract active compounds such as allicin, S-allyl cysteine, and diallyl disulfide are known

to possess antioxidant and anti-inflammatory properties well documented by Nadeem M S et al. (2021). It is established that diabetic model studies demonstrate how garlic supplements enhance SOD, GPx, and GRx activity while maintaining antioxidant equilibrium.

The development of cataracts due to hyperglycemia includes three main processes: nonenzymatic glycation of lens proteins, activation of the polyol pathway, and oxidative stress(Mrugacz et al 2023). Aldose reductase transforms excessive glucose from the polyol pathway into sorbitol, leading to osmotic stress and damage of lens fibers during diabetic cataractogenesis (Mathebula S. D 2015). The inhibition of aldose reductase represents a possible approach to postpone diabetic patients' cataract development The redox balance of the lens becomes disrupted through hyperglycemia-induced oxidative stress, which decreases glutathione levels while simultaneously diminishing glutathione-dependent antioxidant enzymes GPx and GRx (Jaisson et al., 2018). The combination of GSH depletion together with increased MDA lipid peroxidation products creates protein aggregation and lens opacity The purpose of this research is to establish the protective mechanisms of Garlic Extract (Allium sativum) and Vitamin C against oxidative stress and biochemical markers linked to cataractogenesis in diabetic cataracts using experimental modeling. The antioxidant effects on vital parameters that include total soluble protein content combined with lipid peroxidation (MDA levels) and measurements of antioxidant enzyme activities of Superoxide Dismutase (SOD), Glutathione Peroxidase (GPx), and Glutathione Reductase (GRx). The biochemical changes during glucose-induced cataracts in goat lenses were studied to identify which treatment between Garlic Extract and Vitamin C provides better protection against lens opacity and oxidative stress.

The objective was to assess how garlic and Vitamin C influence hyperglycemic cataracts. The effect of Garlic Extract and Vitamin C on protein stability, lipid peroxidation, and enzymatic antioxidant defense mechanisms could generate knowledge about natural therapeutic methods to prevent or delay diabetic cataracts.

2. Materials and Methods

2.1 Study Design and Sample Collection

A glucose-induced cataract model was used involving 120 fresh goat lenses. The goat eyeballs from the slaughterhouse were taken to the laboratory and put into an ice box for storage to keep them intact. Then, an intracapsular lens extraction was done, and the lenses were weighed before they were placed on sterile petri dishes with dark-colored nylon nets. The Lens Organ Culture Technique was employed to incubate lenses in a tissue culture medium (TC-199) for 72 hours. Distilled water was used to prepare for reconstituting TC-199 powder. The solution received penicillin and myostatin as additives to stop microbial growth and fungal development. The medium pH was maintained between 7.2 to 7.4. Standard autoclaving procedures were followed to include sterility of all materials and solutions needed for the lens organ culture.

Table1. Experimental Groups and Treatment Conditions for Cataract-Induced Goat Lenses

Sr. No	Group	No. of lenses
1	Normal lenses: lenses incubated in TC-199 for 72 hours	30
2	Experimental diabetic cataract: lenses incubated in TC-199 + 110mM Dextrose for 72 hours	30
3	Experimental cataract with plant extract:	
	a) Lenses incubated in TC-199 + 110mM Dextrose + 0.25% A.sativum (Garlic) aqueous extract for 72 hours	30
4	Experimental cataract with Vitamin C: Lenses incubated in TC-199 + 110mM Dextrose + 0.25% Vit. C for 72 hours	30

2.2 Experimental Groups

The study consisted of 120 goat lenses and was divided into 4 groups of 30 lenses each. The first group termed normal control was maintained in TC-199 alone for a 72-hour incubation. The diabetic cataract treatment was achieved by incubating the second experimental group in TC-199 solution and 110 m dextrose to develop cataracts. The third experimental group used lenses that received TC-199 solution containing 110mM dextrose and 0.25% aqueous extract of (Allium sativum). The fourth group of lenses received Vitamin C treatment

through incubation in TC-199 solution containing 110mM dextrose and 0.25% Vitamin C. The lens transparency was noted by counting visible grid squares through the lenses that were positioned on a net. The additional morphological traits, such as hazing along with opacity swelling and rupture after the 72-hour incubation period, were documented.

2.3 Lens Homogenization and Sample Preparation

After 72 hours of incubation, the lenses were removed from the culture medium and gently rolled on the filter paper to remove the remaining fluid. Homogenization of each lens was done with 0.1 M Sodium phosphate solution at pH 7.4. using the weight-to-volume ratio of 10% (w/v). A refrigerated centrifuge processed the homogenate at 10,000 × g during thirty minutes of centrifugation at -4 degrees Celsius. The supernatant solution was stored at −20°C before proceeding with further estimations. Total soluble protein concentration, together with MDA levels and antioxidant enzyme activities, was assessed.

2.4 Biochemical Analysis

2.4.1 Total Soluble Protein and MDA measurement

The standardized biochemical methods were employed to evaluate total soluble protein, lipid peroxidation, and antioxidant enzyme activity in control lenses and those with dextrose, Garlic Extract, and Vitamin C treatment. The protein content analysis was done by Lowry's method (1951), which utilized the biuret reaction followed by the reduction of phosphomolybdic-phosphotungstic reagent by tryptophan and tyrosine residues in the protein molecules. The colored complex was measured spectrophotometrically at 660 nm. The Kei Satoh (1978) method was used to measure Malondialdehyde (MDA) levels that indicate oxidative stress through lipid peroxidation. The analysis through the MDA-TBA reaction produced a pink-colored complex, which was measured at 530 nm.

2.4.2 Antioxidant Enzyme Activity Assays

The measurement of Superoxide Dismutase (SOD) activity was done through an analysis of pyrogallol auto-oxidation inhibition using the method of Marklund and Marklund (1974). GPx activity measurements were conducted using the Randox kit according to Paglia and Valentine (1967), which measured the oxidation of GSH through cumene hydroperoxide at 340 nm. The Randox kit measured Glutathione Reductase (GRx) activity through its ability to reduce oxidized Glutathione (GSSG) with NADPH to generate NADP+ and reduced Glutathione (GSH) based on the method of Goldberg and Spooner., (1983).

2.4.3 Preparation of Garlic Extract

The aqueous extract of Allium sativum (Garlic) was done as per the guidelines given in the Ayurved Pharmacopoeia of India. The extract was prepared with 100 ml of distilled water in which 25 grams of fresh, peeled garlic cloves were ground. The extract was filtered to remove any particulate matter. The total dissolved solids (TDS) and purity of the extract were analyzed at the Indian Drugs Research Association & Laboratory, Pune. The study was done using a 0.25% (w/v) solution of the extract.

2.5 Statistical Analysis

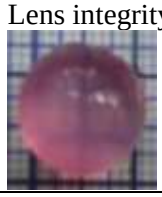
Student's t-tests evaluated differences between normal and hyperglycemic cataract lenses, while the analysis of experimental group data utilized analysis of Garlic Extract and Vitamin C's impact was evaluated with way one-way analysis of variance (ANOVA) followed by Tukey's post hoc test for multiple comparisons. Results were mean ± SD and statistical significance at $p < 0.05$.

3. Results

3.1 Observation of lens morphology

The medicinal plant extracts alongside Vitamin C affected lens morphology. The lenses treated with 110mM dextrose became severely opaque as they developed mature cataracts, which almost ruptured making the grids completely invisible The A. sativum (Garlic extract) treated lenses showed excellent visual characteristics as the lenses retained their structural integrity, maintaining lens transparency as shown in Table 2. The application of Vitamin C to lenses protected their structure while causing faint opaqueness that reduced grid visibility. The Garlic extract, as a cataract prevention agent, surpassed Vitamin C in its ability to protect lens clarity by stopping oxidative damage.

Table 2: Observation of lens morphology when incubated with medicinal plant extracts and vitamin C, respectively

Group	Transparency & Clarity
Dextrose	Opaque, mature cataract, nearing rupture (grids not visible) 
Dextrose + A. Sativum	Transparency and lens integrity maintained (grid visible) 
Dextrose + Vit. C	Lens integrity maintained, opacity (grids faintly visible) 

3.2 Total Soluble Proteins and Lipid Peroxidation

An analysis of MDA levels and total soluble proteins in normal control lenses and dextrose-induced cataract lenses was done. Total soluble protein measurements of dextrose-induced cataract lenses reached 255 ± 62.46 mg/lens, which was lower than the control group at 344 ± 62.56 mg/lens and demonstrated statistical significance with p-value < 0.0001 as shown in Table 3. The study showed elevated MDA levels of 13.45 ± 3.0 nmol/gm lens in dextrose-induced cataractous lenses. MDA in the control group was 9.56 ± 3.43 nmol/gm lens MDA. The observed difference proved that substantial oxidative damage occurred ($p < 0.0001$). The study showed that dextrose-induced cataracts weakened protein stability and increased lipid peroxidation to cause lens damage.

Table 3. Lens Total Soluble Proteins and Malondialdehyde (MDA) Levels in Normal Control and Dextrose induced cataract Lenses.

Sr. No	Group	N	Total Soluble Proteins (mg/lens) Mean + SD	MDA (n moles /gm lens) Mean ± SD
1	Control (Normal Lenses)	30	344 ± 62.56	9.56 ± 3.43
2	Dextrose Cataract lenses	30	255 ±62.46	13.45 ± 3.0
	P - value		< 0.0001	< 0.0001

$p < 0.0001$

3.3 The activity of Antioxidant defense enzymes

The Superoxide Dismutase (SOD), Glutathione Peroxidase (GPx), and Glutathione Reductase (GR) enzyme activities of normal control and dextrose-induced cataract lenses were measured. The control group demonstrated superior enzymatic activity than the group with cataract lenses. The activity of SOD measured in dextrose-induced cataract lenses decreased compared to control from 0.41 ± 0.14 units/mg lens to 0.30 ± 0.15 units/mg lens with $p < 0.01$ significance according to Table 3. The research showed Glutathione Peroxidase activity levels dropped from 36.16 ± 9.90 to 29.71 ± 13.92 units/mg lens ($p < 0.05$). The activity levels of GR showed a substantial decrease from 13.32 ± 3.55 to 10.49 ± 2.11 units/mg lens with statistical significance ($p < 0.001$). The dextrose-induced cataracts reduced antioxidant enzyme performance, thus causing increased oxidative damage to the lens.

Table 4. The specific activity of Superoxide Dismutase, Glutathione peroxidase, and Glutathione reductase in Normal Control and Dextrose induced cataract lenses.

Sr. No	Group	N	Superoxide dismutase (units/mg lens) Mean ± SD	Glutathione peroxidase (units/mg lens) Mean ±SD	Glutathione reductase (units/mg lens) Mean ± SD
1	Control (Normal Lenses)	30	0.41±0.14	36.16 ± 9.90	13.32 ± 3.55
2	Dextrose (Experimental Cataract lenses)	30	0.30±0.15	29.71±13.92	10.49 ±2.11
	P-value		< 0.01	< 0.05	p< 0.001

p< 0.001

3.4 Restorative Effects of Garlic Extract and Vitamin C in Diabetic Cataract Lenses

3.4.1 Effect on Total Soluble Protein Content

The examined protein content in experimental diabetic cataract lenses, which received combinations of A. sativum (garlic) water extract and Vitamin C versus lenses in the dextrose-induced cataract group. The incubation with dextrose at 110mM levels resulted in a measurable decrease of protein content in the lenses to 255.00 mg/lens with a standard deviation of 62.46. The protein content of experimental diabetic cataract lenses treated with Garlic extract reached 298.00 mg/lens (SD = 34.58), and Vitamin C-treated lenses reached 303.27 mg/lens (SD = 40.20), as shown in Table 5. The obtained results demonstrated that Garlic extract and Vitamin C successfully stabilized proteins within cataractous lenses.

Table 5. Total Soluble lens proteins (mg/lens) in experimental diabetic cataract lenses incubated with A.sativum (garlic) water extracts and Vitamin C, respectively, compared with the Dextrose group

Group	N	Mean (mg/lens)	SD + -
Dextrose	30	255.00	62.46
Garlic	30	298.00	34.58
Vitamin C	30	303.27	40.20

p<0.001

3.4.2 Malondialdehyde (MDA) levels in the lens

Laboratory analysis of the MDA levels in diabetic cataract lenses treated with A. sativum (Garlic) extract and Vitamin C measured lipid peroxidation against dextrose-induced cataract control samples. The MDA levels in the dextrose group reached a high value of 13.46 nmoles/gm lens accompanied by a standard deviation of 3.06, which demonstrates intense oxidative stress during hyperglycemic conditions. The MDA levels decreased substantially in lenses treated with Garlic extract because they measured 10.25 nmoles/gm lens with a standard deviation of 3.56, indicating beneficial antioxidant protection as shown in Table 6. The lipid peroxidation levels decreased more in the Vitamin C-treated group, which exhibited MDA levels of 10.17 nmoles/gm lens with a 3.33 standard deviation. The antioxidant potential of diabetic cataract lenses received support from Garlic extract and Vitamin C through their ability to decrease MDA levels.

Table 6. Malondialdehyde (MDA) levels (n moles/gm lens) as an index of lipid peroxidation in experimental diabetic cataract lenses incubated with A.sativum (garlic) water extracts and Vitamin C respectively, compared with Dextrose group.

Group	N	Mean (n moles/ gm lens)	SD ±
Dextrose	30	13.46	3.06
Garlic	30	10.25	3.56
Vitamin C	30	10.17	3.33

$p < 0.001$

3.4.3 The specific activity of Superoxide dismutase

The Superoxide Dismutase (SOD) activity in diabetic cataract lenses treated with A. sativum (Garlic) water extract and Vitamin C were studied through analysis and compared against dextrose-induced cataract lenses. During the study period, the dextrose group exhibited a major reduction in SOD activity which produced a mean value of 0.31 units/mg lens with a standard deviation of 0.15. The application of Garlic extract to lenses produced substantial SOD activity increase with mean values of 0.87 units/mg lens and standard deviation of 0.37, as shown in Table 7, thus demonstrating its high potential for protecting against oxidative damage. The SOD restoration outcome from Vitamin C-treated lenses demonstrated weak performance because the recorded mean activity measurement was 0.33 units/mg lens, and the standard deviation remained at 0.19, and these values were lower than those observed in Garlic extract-treated lenses. The protective effects of Garlic extract exceeded those of Vitamin C, as demonstrated by its ability to elevate SOD activity at higher levels.

Table 7. The specific activity of Superoxide dismutase (units/mg lens) in experimental diabetic cataract lenses incubated with A.sativum (garlic) water extract and Vitamin C respectively, compared with the Dextrose group.

Group	N	Mean (units/ mg lens)	SD ±
Dextrose	30	0.31	0.15
Garlic	30	0.87	0.37
Vitamin C	30	0.33	0.19

$p < 0.001$

3.4.4 The specific activity of Glutathione Peroxidase

The Glutathione Peroxidase (GPx) specific activity in diabetic experimental cataract lenses treated with A. sativum (Garlic) water extract and Vitamin C was measured and compared against the dextrose-induced cataract group. The GPx activity in the dextrose group showed a substantial decrease because the mean value reached 29.72 units/mg lens while the standard deviation was 13.9, which signifies diminished antioxidant protection and enhanced oxidative stress during hyperglycemic states. The activity level of GPx rose significantly when lenses received Garlic extract treatment, revealing a mean value of 62.51 units/mg lens while displaying a standard deviation of 17.9, as shown in Table 8. This data suggests excellent protection against oxidative damage. The GPx levels in Vitamin C-treated lenses remained relatively low because these lenses showed a mean GPx activity of 31.96 units/mg lens with a standard deviation of 10.9. The Garlic extract proved much more potent than Vitamin C at boosting GPx activity to deliver superior antioxidant defense for diabetic cataract lenses.

Table 8. Glutathione Peroxidase specific activity (units/mg lens) in experimental diabetic cataract lenses incubated with A. sativum (garlic) water extracts and Vitamin C respectively, compared with the Dextrose group.

Group	N	Mean (units/ mg lens)	SD ±
Dextrose	30	29.72	13.9
Garlic	30	62.51	17.9
Vitamin C	30	31.96	10.9

$p < 0.001$

3.4.5 The specific activity of Glutathione Reductase

An examination and comparison of Glutathione Reductase (GRx) activity levels in diabetic cataract lenses treated with A. sativum (Garlic) extract solution and cataract lenses with Vitamin C and dextrose exposure was done. The redox cycle function declined significantly in the dextrose-treated group as measured by GRx activity, which dropped to 10.50 units/mg lens with a standard deviation of 2.1. The Garlic extract treatment of experimental diabetic cataract lenses achieved an outstanding outcome through 20.19 units/mg lens GRx activity, which showed a 4.8 standard deviation, thus implying strong defensive protection against oxidative stress. Lenses treated with Vitamin C demonstrated an improved GRx activity compared to the control but maintained lower levels than Garlic extract treatment. They matched a mean value of 16.72 units/mg lens with a standard deviation of 4.7, as shown in Table 9. The Garlic extract boosted GRx activity at a higher level than Vitamin C, thus offering superior antioxidant protection and redox balance in diabetic cataract lenses.

Table 9. Glutathione Reductase specific activity (units/mg lens) in experimental diabetic cataract lenses incubated with A. sativum (Garlic) water extracts and Vitamin C, respectively, compared with the Dextrose group.

Group	N	Mean (units/mg lens)	SD ±
Dextrose	30	10.50	2.1
Garlic	30	20.19	4.8
Vitamin C	30	16.72	4.7

$p < 0.001$

Effect of Garlic Extract on Protein Stability, Lipid Peroxidation, and Antioxidant Enzymes in Dextrose-Induced Cataract Lenses

A biochemical investigation examined how Garlic extract affects dextrose-induced cataract lenses. The total soluble protein content showed a 14.42% increase, while MDA levels decreased by 23.84% in the sample. The antioxidant enzyme activity reached remarkable improvements as Superoxide dismutase (SOD) increased by 64.36%, Glutathione peroxidase (GPx) by 52.45%, and Glutathione reductase (GR) by 47.9%, as shown in Fig 1. The study results indicated that garlic extract improved the function of antioxidant defenses as a means to prevent cataract development. Statistical data demonstrated that the therapeutic effects of garlic for cataract prevention were statistically significant according to the results.

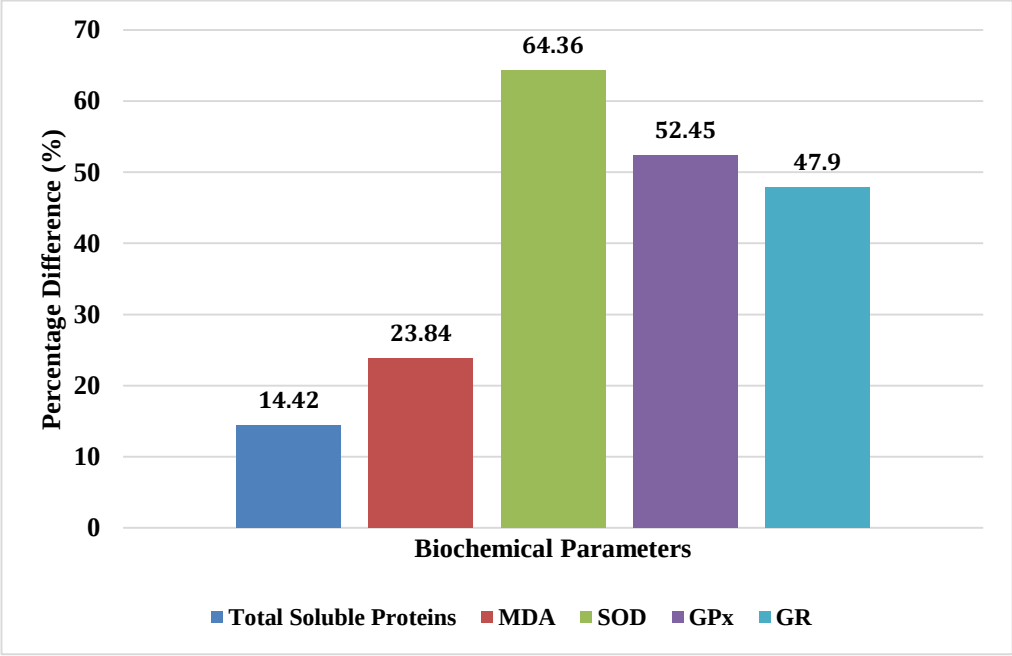


Fig. 1: Garlic Extract's Impact on Protein Stability, Lipid Peroxidation, and Antioxidant Enzymes in Dextrose-Induced Cataract Lenses

Impact of Vitamin C on Protein Stability, Lipid Peroxidation, and Antioxidant Enzymes in Dextrose-Induced Cataract Lenses

The biochemical effects of Vitamin C treatment applied to dextrose-induced cataract lenses. Total soluble protein levels increased by 15.84% simultaneously MDA levels declined by 24.4% which suggests reduced lipid peroxidation. SOD activity increased by 6% while GPx activity rose by 7% under minimal changes in antioxidant enzyme activity. The activity of Glutathione reductase (GRx) rose significantly by 37.2% as shown in Fig 2. Vitamin C exhibited antioxidant effects that reduced oxidative stress yet its influence on antioxidant enzyme activities remained lower than what garlic extract achieved. Statistical tests proved the meaningful nature of these changes.

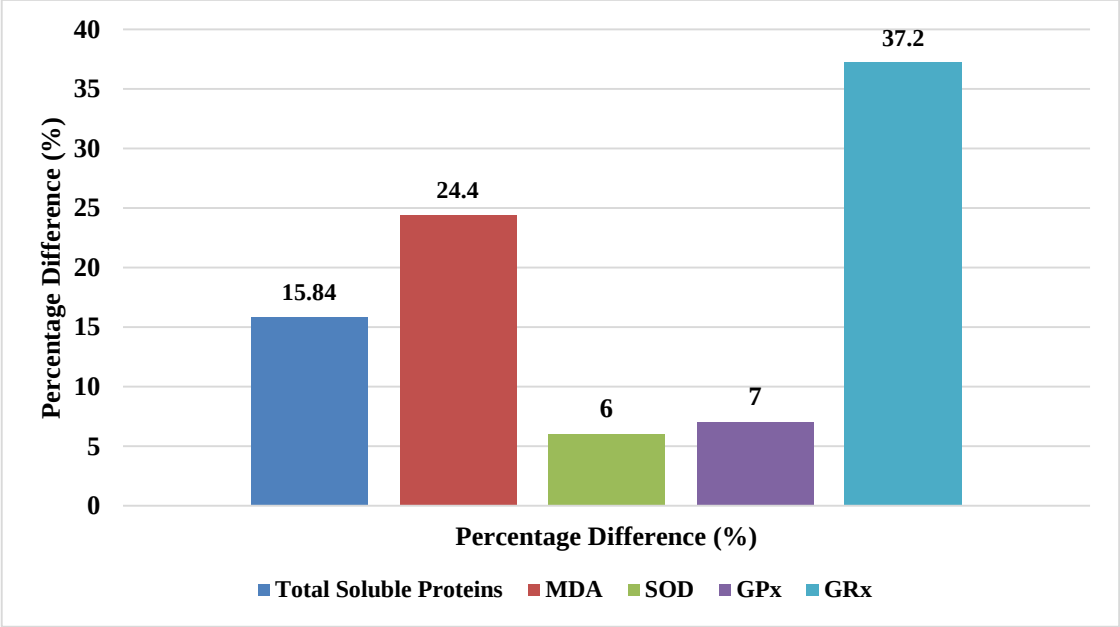


Fig. 2: Vitamin C's Effect on Protein Stability, Lipid Peroxidation, and Antioxidant Enzymes in Dextrose-Induced Cataract Lenses

4. Discussion

The antioxidant properties of Vitamin C and Garlic Extract (Allium sativum) on hyperglycemic cataract genesis in goat lenses were studied. The development of cataracts in diabetic patients relates directly to high oxidative stress levels and increased lipid peroxidation combined with decreased antioxidant enzyme function. The study brought forth the effectiveness of Garlic Extract as a natural antioxidant against the established antioxidant Vitamin C in preventing cataract development. The groups demonstrated different levels of biochemical and morphological measurements according to the analysis results. The cataract development caused by dextrose treatment and significant reductions in total soluble proteins and antioxidant enzymes while increasing lipid peroxidation levels indicate severe oxidative damage to lens proteins. Protection against diabetic cataracts occurred when lens specimens received Garlic Extract or Vitamin C treatment since these interventions successfully decreased MDA levels while rejuvenating antioxidant enzyme activities. The antioxidant properties of Garlic Extract surpassed those of Vitamin C in the restoration of Superoxide Dismutase (SOD), Glutathione Peroxidase (GPx), and Glutathione Reductase (GRx) activities thus making Garlic Extract an effective therapeutic option to prevent diabetic cataracts.

Multiple studies in the literature demonstrate that antioxidants effectively slow down the progression of cataracts. Research demonstrates that non-enzymatic antioxidant Vitamin C defends the lens from oxidative stress through ROS scavenging and lipid peroxidation reduction (Shahidi, 2015). The Vitamin C reaches elevated levels in aqueous humor which successfully protects the lens against photochemical and oxidative stress (Álvarez et al., 2021). However, some scientific studies indicate that Vitamin C functions as a pro-oxidant substance during specific situations involving metal ions and hydrogen peroxide. (J C van der Pols 1999). The medical community shows growing interest in using various medicinal plants as a substitute for antioxidant therapies. In our earlier study, the antioxidant effect of Emblica officinalis (amla- Indian gooseberry) was demonstrated in vitro on hyperglycemic goat lenses. (Hajarnavis A M, 2013). The aqueous extracts of Syzigium cumini (Jamun) seeds and Agele marmelos (Bael) leaves reduced lipid peroxidation and

enhanced activities of antioxidant enzymes in goat lenses in experimental diabetic cataracts. (Hajarnavis AM & Bulakh PM 2020). Another study by Bhadada S V, Vyas V K, et al (2016) showed that the alcoholic extract of Tephrosea purpurea (Sharpunkha) helped to prevent cataracts in the lenses of STZ-induced diabetic rats. The research conducted by Raju T N et al. (2008) established that Garlic Extract enhanced diabetic rat antioxidant enzymes and decreased lipid peroxidation while protecting the rats from oxidative damage. In our current study, the data confirms that Garlic Extract effectively restored antioxidant enzyme function better than Vitamin C. The strong capacity of Garlic Extract to eliminate free radicals stems from its bioactive compounds which include allicin S-allyl cysteine and organosulfur compounds. Data shows that Garlic Extract promotes substantial improvements in SOD, GP,x, and GRx enzyme activities thus proving its anti-stress mechanism by protecting antioxidant enzymes throughout treatment periods.

The development of cataracts depends heavily on lipid peroxidation because oxidative stress causes MDA to build up as an essential marker of oxidative damage (Nita, M., & Grzybowski, A. 2016). Dextrose-induced cataract lenses displayed 28.9% higher MDA levels than normal controls according to the findings. The findings support diabetic cataract development studies that show elevated ROS production from high glucose concentrations leading to protein and lipid damage in the lens. The MDA levels showed substantial reduction in treatment groups with Garlic Extract demonstrating a marginally superior reduction effect than Vitamin C. The activities of SOD, GPx, and GRx showed significant reductions in dextrose-induced cataract lenses because antioxidant defenses became compromised while oxidative stress reached excessive levels. Research by Imelda et al. (2022) confirmed that diabetic cataractous lenses show decreased SOD activity because of elevated ROS generation. Oxidative stress disrupts redox homeostasis which leads to protein oxidation and cataract genesis according to the hypothesis supported by decreased GPx and GRx activities The antioxidant enzyme restoration from Garlic Extract treatment exceeded Vitamin C levels in its ability to restore SOD, GPx, and GRx activities. The research showed that Garlic Extract increases the enzymatic antioxidant activity in tissues of the eye. The better performance of Garlic Extract in restoring enzymatic antioxidants stems from its sulfur compounds that boost glutathione synthesis and shield cellular thiol groups against oxidative damage.

The outcomes demonstrate that Garlic Extract represents an organic therapeutic approach to preventing cataracts among diabetic patients. Future studies need to investigate the pharmacokinetics together with bioavailability of Garlic Extract in vivo due to its demonstrated superior antioxidant capabilities. The long-term effects of Garlic Extract supplements should be studied in diabetic patients who face cataract risks according to protocols. Future research needs to investigate how Garlic Extract functions together with multiple antioxidants including lipoic acid, quercetin, and curcumin to establish whether combined therapy provides better protection against cataracts caused by oxidative stress. Scientific research must confirm the proper amounts along with testing the safety aspects of Garlic Extract when used by humans.

The study applied an ex vivo lens organ culture system as its experimental model but this method cannot duplicate all human eye physiological conditions. Further research must confirm these results through studies on animals along with human trials. The study only compared Vitamin C and Garlic Extract as antioxidants and other popular antioxidants including Vitamin E, remained absent from evaluation. Additional research needs to evaluate multiple antioxidant substances to identify the best treatment approach for cataract genesis caused by oxidative stress. This study used Garlic Extract and Vitamin C at their selected dosage amount of 0.25%. Future research needs to explore different concentration levels of Garlic Extract to determine the most effective protective dosage. The experimental period included only 72 hours of incubation time. The duration of Garlic Extract protection needs to be extended to verify its prolonged effectiveness.

The findings showed that Garlic Extract displayed better antioxidant capabilities than Vitamin C while protecting hyperglycemia-induced cataract lenses from oxidative damage. The experimental results validate the notion that Garlic Extract functions as an effective compound which reduces lipid peroxidation while restoring antioxidant enzyme activity and protects lens proteins from oxidative stress damage. The combination of high efficacy and natural origin and potential safety features of Garlic Extract makes it a promising therapeutic agent for preventing diabetic cataracts.

5. Conclusion

This research shows Garlic Extract (Allium sativum) and Vitamin C successfully reduce oxidative stress which develops in hyperglycemic cataractous goat lenses. Oxidative stress is shown to be a major factor in cataract formation through its effects on total soluble protein levels, its increase of lipid peroxidation (MDA levels), and its negative impact on antioxidant enzyme activities (SOD, GPx, GRx). Garlic Extract and Vitamin C treatment use leads to recovery of protein stability, reduction of MDA level enhancement of antioxidant enzyme activity, and hence better lens transparency. The antioxidant protective effects of Garlic Extract surpass

those of Vitamin C while treating cataracts which indicates its potential value as a better natural therapy for cataract prevention. Future research needs to conduct in vivo studies that will prove the clinical effectiveness of Garlic Extract. Further work needs to be done to determine the best Garlic Extract dosage levels and its absorption rates in the body as well as its extended impact on cataract development prevention. Research should investigate how Garlic Extract synergy with other antioxidants like Vitamin E could improve its protective properties. The evaluation of the Garlic Extract safety profile together with its interactions with existing medications requires additional study. The path to integrating Garlic Extract into dietary or pharmacological approaches for cataract prevention requires human clinical trials to establish its practical medical value.

References

1. Álvarez-Barrios, A., Álvarez, L., García, M., Artime, E., Pereiro, R., & González-Iglesias, H. (2021). Antioxidant defenses in the human eye: A focus on metallothioneins. Antioxidants, 10(1), 89.
2. Bhadada, S. V., Vyas, V. K., & Goyal, R. K. (2016). Protective effect of Tephrosia purpurea in diabetic cataract through aldose reductase inhibitory activity. Biomedicine & Pharmacotherapy, 83, 221-228.
3. Bourne, R. R., Taylor, H. R., Flaxman, S. R., Keeffe, J., Leasher, J., Naidoo, K., et al. (2016). Number of people blind or visually impaired by glaucoma worldwide and in world regions 1990–2010: a meta-analysis. PloS one, 11(10), e0162229.
4. Chen, Y., Feng, J., Liu, J., Zhou, H., Luo, H., Xue, C., & Gao, W. (2021). Effects of neutron radiation on Nrf2-regulated antioxidant defense systems in rat lens. Experimental and Therapeutic Medicine, 21(4), 1-1.
5. Dorrigiv, M., Zareiyan, A., & Hosseinzadeh, H. (2020). Garlic (Allium sativum) as an antidote or a protective agent against natural or chemical toxicities: A comprehensive update review. Phytotherapy Research, 34(8), 1770-1797.
6. Forman, H. J. (2016). Redox signaling: An evolution from free radicals to aging. Free Radical Biology and Medicine, 97, 398-407.
7. Hajarnavis, A. M & Bulakh P M (2013). Antioxidant potential of Emblica officinalis (amla) aqueous extract delays cataractogenesis in hyperglycemic goat lenses. IOSR Journal of Pharmacy and Biological Sciences, 6, 32-35.
8. Hajarnavis, A. M., & Bulakh, P. M. (2020). Anticataract effects of S. cumini and A. marmelos on goat lenses in an experimental diabetic cataract model. Journal of Ayurveda and Integrative Medicine, 11(4), 421-425.
9. Halliwell, B. (2020). Reflections of an aging free radical. Free Radical Biology and Medicine, 161, 234-245.
10. Heruye, S. H., Maffofou Nkenyi, L. N., Singh, N. U., Yalzadeh, D., Ngele, K. K., Njie-Mbye, Y. F. & Opere, C. A. (2020). Current trends in the pharmacotherapy of cataracts. Pharmaceuticals, 13(1), 15.
11. Imelda, E., Idroes, R., Khairan, K., Lubis, R. R., Abas, A. H., Nursalim, A. J., & Tallei, T. E. (2022). Natural antioxidant activities of plants in preventing cataractogenesis. Antioxidants, 11(7), 1285.
12. JC van der Pols. A possible role for vitamin C in age-related cataract. Proc Nutr Soc. 1999 May;58(2):295-301. doi: 10.1017/s0029665199001354. PMID: 10466170.
13. Jaisson, S., Pietrement, C., & Gillery, P. (2018). Protein carbamylation: chemistry, pathophysiological involvement, and biomarkers. Advances in clinical chemistry, 84, 1-38.
14. Johnson, E. J. (2015). Nutrition and the aging eye. Handbook of Clinical Nutrition and Aging, 57-79.
15. Kei, S. (1978). Serum lipid peroxide in cerebrovascular disorders determined by a new colorimetric method. Clinica chimica acta, 90(1), 37-43.
16. Khanam, A., Ahmad, S., Husain, A., Rehman, S., Farooqui, A., & Yusuf, M. A. (2020). Glycation and antioxidants: hand in the glove of antiglycation and natural antioxidants. Current Protein and Peptide Science, 21(9), 899-915.
17. Lowry, O. H., Rosebrough, N. J., Farr, A. L., & Randall, R. J. (1951). Protein measurement with the Folin phenol reagent. J biol Biol Chem, 193(1), 265-275.
18. Marklund, S., & Marklund, G. (1974). Involvement of the superoxide anion radical in the autoxidation of pyrogallol and a convenient assay for superoxide dismutase. European journal of biochemistry, 47(3), 469-474.
19. Mathebula, S. D. (2015). Polyol pathway: A possible mechanism of diabetes complications in the eye. African vision and eye health, 74(1), 5.
20. Mrugacz, M., Pony-Uram, M., Bryl, A., & Zorena, K. (2023). The current approach to the pathogenesis of diabetic cataracts. International Journal of Molecular Sciences, 24(7), 6317.

21. Nadeem, M. S., Kazmi, I., Ullah, I., Muhammad, K., & Anwar, F. (2021). Allicin, an antioxidant and neuroprotective agent, ameliorates cognitive impairment. Antioxidants, 11(1), 87.
22. Nita, M., & Grzybowski, A. (2016). The role of the reactive oxygen species and oxidative stress in the pathomechanism of age-related ocular diseases and other pathologies of the anterior and posterior eye segments in adults. Oxidative medicine and cellular longevity, 2016(1), 3164734.
23. Paglia, D. E., & Valentine, W. N. (1967). Studies on the quantitative and qualitative characterization of erythrocyte glutathione peroxidase. The Journal of laboratory and clinical medicine, 70(1), 158-169.
24. Raju TN, Kanth VR, Lavanya K. Effect of methanolic extract of Allium sativum (AS) in delaying cataract in STZ-induced diabetic rats. J Ocul Biol Dis Infor. 2008 Mar;1(1):46-54. doi: 10.1007/s12177-008-9003-5. Epub 2008 Jul 19. PMID: 20072634; PMCID: PMC2802412.
25. Shahidi, F. (Ed.). (2015). Handbook of antioxidants for food preservation. Woodhead Publishing.
26. Spooner, R. J., Delides, A., & Goldberg, D. M. (1981). Heat stability and kinetic properties of human serum glutathione reductase activity in various disease states. Biochemical medicine, 26(2), 239-248.
27. Tanito, M., Takayanagi, Y., Ishida, A., Ichioka, S., Takai, Y., & Kaidzu, S. (2022). Linear association between aging and decreased blood thiol antioxidant activity in patients with cataracts. Journal of Clinical Biochemistry and Nutrition, 72(1), 54.
28. Tran, L., Zielinski, A., Roach, A. H., Jende, J. A., Householder, A. M., Cole, E. E., ... & Thompson, E. E. (2015). Pharmacologic treatment of type 2 diabetes: oral medications. Annals of Pharmacotherapy, 49(5), 540-556.
29. Vashist, P., Senjam, S. S., Gupta, V., Gupta, N., Shamanna, B. R., Wadhwani, M., ... & Bharadwaj, A. (2022). Blindness and visual impairment and their causes in India: Results of a nationally representative survey. PLoS One, 17(7), e0271736.