



Influence of Quercetin and Caffeine on Absorbable Sutures

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Abstract

Introduction: One of the key factors contributing to surgical site infections is suture material. The surgical site may be shielded from various infections by a suture material with improved wound healing capabilities. Sutures may hinder the healing of wounds in periodontics and other surgical specialties. Numerous variables, including knot design, tensile strength, and compressive suture strength, affect the strength of the sutures. The two most often used biodegradable polymers are PGA and VICRYL. Quercetin is one of the bioflavonoids that is most frequently used to treat metabolic and inflammatory diseases. It is famous for having antioxidant, vasodilator, and anti-inflammatory qualities. Modern pharmacology makes extensive use of caffeine, a plant alkaloid. Our aim is to evaluate the effects of caffeine and quercetin on absorbable sutures.

Materials and Methods: The ethanolic extract was prepared using *Moringaoleifera* leaves and caffeine powder. The extract was analyzed for the anti-inflammatory and antioxidant activity. 15 Sutures each PGA and Vicryl were analyzed. The sutures were split into six pieces of length 1.5cm and 10.5cm. The sutures were coated, immersed for 24 hours, dried for approximately 3 to 4 hours, and then examined for their coating using SEM and tensile strength was analyzed at day 1 and day 7 respectively.

Result: The antioxidant activity of Quercetin (78%) was found to be better than caffeine. The anti-inflammatory activity of caffeine had a higher percentage (95%) than the control group Diclofenac. SEM analysis revealed that the suture material was sufficiently coated with quercetin and caffeine extract. Among the control groups, Vicryl (uncoated) had higher tensile strength than PGA (uncoated). Among the test groups, Vicryl at pH 4.4 showed increased tensile strength when compared to other groups. On day 7 PGA at pH 7.2, showed the least tensile strength among the test groups.

Conclusion: Both quercetin and caffeine have potent anti-inflammatory properties that can aid in wound healing. In wound healing, surgical sutures with a lower degradation degree and

implicitly a higher tensile strength should be utilized, as suture biodegradation varies substantially in different body fluids. As a result, the deterioration potential of various food ingredients will vary.

1. Introduction

Suture, often known as stitches, are sterile surgical threads that are used to close wounds. Suture materials are commonly divided into two types: absorbable threads (PGA and vicryl) and non-absorbable threads (silk). Suture has a well-documented advantage, as having the highest predictable tensile strength consistent with size constraints, superior handling properties, and secure knot tying. (1). The effectiveness of the surgical procedure as a whole depends heavily on the successful suturing of tissues, which is essential to recovery. It also matters how durable the tissues are and what kind of oral environment they are put into. Different suture materials behave differently toward tissues in the oral cavity in terms of persistence. Not just the size of the wound present, but also factors like salivary enzyme, pH, and food intake play a significant impact in tissue inflammation. The best suture material is chosen based on qualities including predictability, adaptability, and low inflammatory reaction (2). Tensile strength is one of the distinguishing characteristics that affects how long a suture material lasts in the oral environment. Tensile strength refers to a material or structure's ability to withstand loads that provide an elongation tendency. This suture material property is a crucial component that will be harmful for the overall healing of tissues because the quicker the suture material loses this property in the oral environment, the faster the tissues will lose their ability to adapt, which will cause them to open more quickly and cause complications and secondary infections (3). Tensile strength has been examined in a number of research using both an in vitro and animal model (4). Several studies have been conducted to investigate the tensile strength and resorption rates of various suture materials, and it has been discovered that the tensile strength of sutures reduced over time and was dependent on the rate of resorption (5). There is no suture material that is suitable for usage in all tissues. A suture with insufficient strength is prone to break during or after an operation (6).

The absorbable sutures used in this investigation are Vicryl and PGA. Polyglactin 910 (Vicryl) was created as part of the hunt for a more absorbable suture material. Polyglactin 910 is created by copolymerizing lactide and glycolide, which are cyclic intermediates produced from lactic and glycolic acids, respectively. The intermediates are first converted into a fiber-forming polymer before being formed into uniform particles. A purple colorant is added to some Polyglactin 910 (Vicryl) to boost its visibility against injured tissues. Because monofilament construction generated a suture that was too rigid for good surgical handling, Vicryl is made as a braided suture. It satisfies every requisite standard for an absorbable suture material. A study concluded that Compared to other fluids, the suture specimens that were submerged in saliva showed a faster decrease in Tensile strength (7).

Polyglycolic acid (PGA) is a semicrystalline, bioresorbable polymer that has found widespread use in a variety of applications. In tissue engineering, no alternative bioresorbable materials can completely replace PGA. Understanding PGA degradation mechanisms is critical for enhancing efficiency and efficacy in a variety of disciplines, including implantation (low Y.J. et al 2020).

Flavonoids are polyphenolic compounds present in a variety of fruits, vegetables, and drinks. They have a variety of beneficial biochemical and antioxidant properties that are linked to many diseases such as cancer, Alzheimer's disease (AD), atherosclerosis, and so on (8). One of the most extensively used bioflavonoids for the treatment of metabolic and inflammatory illnesses is quercetin. It is also renowned for its anti-inflammatory, anti-oxidant, and vasodilator properties (9).

Alkaloids are low-molecular-weight nitrogenous chemicals. They are primarily produced for defense by plants and animals. Caffeine, a plant alkaloid, is widely used in modern pharmacology. Caffeine competes with the neurotransmitter adenosine at adenosine receptors. The chemical is used as a supplement in pharmaceuticals and food. Caffeine is a methylxanthine medication that is used to treat a range of ailments, including preterm newborn respiratory problems, pain relief, and tiredness (10). As a result, the purpose of this research is to determine the effect of quercetin and caffeine on absorbable sutures. To the best of our knowledge, there is limited data available comparing the tensile strengths of absorbable suture materials under simulated oral circumstances, as well as the effect of quercetin and caffeine on sutures. Hence our aim is to evaluate the influence of quercetin and caffeine on absorbable sutures.

2. Material and Methods

Ethanol Extract Preparation

Using a mortar and pestle, *Moringa oleifera* leaf material was dried and powdered. This powder, 50g, was combined with 100ml of alcohol and shaken for 24 hours. The quercetin ethanol extract was made. Caffeine ethanol extract was created in a similar manner. In distilled water, the two extracts were combined in a 1:1 ratio. To examine the impact of these extracts on PGA and Vicryl sutures, the mixture was divided into two test tubes (25 ml of alkaloid and 75 ml of flavonoid) using immersion dip method. The alkaloid utilized in this study is caffeine, and the flavonoid used is quercetin.

Preparation of Artificial Saliva

1000 ml of synthetic saliva were created by combining 8.035 g of sodium chloride and 0.355 g of sodium bicarbonate, 0.311 g of magnesium chloride, 0.225 g of potassium chloride, and 0.231 g of potassium hydrogen phosphate, 6.118 g of Trizma Base, 0.292 g of calcium chloride, 0.072 g of sodium sulfate, and 40 ml of 1.0 M hydrochloric acid were used. The synthetic saliva was separated into two 500-ml beakers, one with a pH of 7.4 and the other with a pH of 4.4. In order for the sutures to function normally, this created the necessary oral environment. The flavonoids and alkaloids, in this case quercetin and caffeine, that are naturally present in the food we eat are either increased or kept relatively flat by the presence of artificial saliva.

Incorporating the Extract to Absorbable Sutures

15 samples of PGA (Uniglyde®) and Vicryl (Ethicon Inc®) were taken. Six pieces of PGA (Uniglyde®) and Vicryl (Ethicon Inc®) suture were isolated into three threads measuring 10.5 cm and three threads measuring 1.5 cm. The quercetin-caffeine extract was applied to the suture using the immersion dip method of coating. Six separate categories were created from the 1.5 cm suture threads:

GROUP	SPECIMEN LABEL
i	Uncoated VICRYL Sutures
ii	Uncoated PGA Sutures
iii	Coated VICRYL Sutures At Ph 4.4
iv	Coated VICRYL Sutures At Ph 7.2
v	Coated PGA Sutures At Ph 4.4
vi	Coated PGA Sutures At Ph 7.2

Anti-Inflammatory and Antioxidant Activity

Both quercetin (a flavonoid) and caffeine (an alkaloid) were examined for their antioxidant and anti-inflammatory capabilities.

It is proposed to integrate bovine serum albumin (control group) as a screening assay for the discovery of anti-inflammatory effects in plant extracts. Ascorbic acid/vitamin C served as the control group for antioxidant analyses. This was chosen due to its rich content and tissue healing and collagen production characteristics. Diclofenac, a non-steroid, was employed as the control group in the anti-inflammatory investigation. A test for the antioxidant DPPH was performed. This is the most often used antioxidant assay for plant extract 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay. In this experiment, a molecule or antioxidant with weak A-H bonding will react with a stable free radical, DPPH, causing the molecule to discolor (11).

$$\% \text{ scavenging activity} = \frac{\text{Absorbance of control} - \text{Absorbance of sample}}{\text{Absorbance of control}} \times 100$$

SEM Analysis

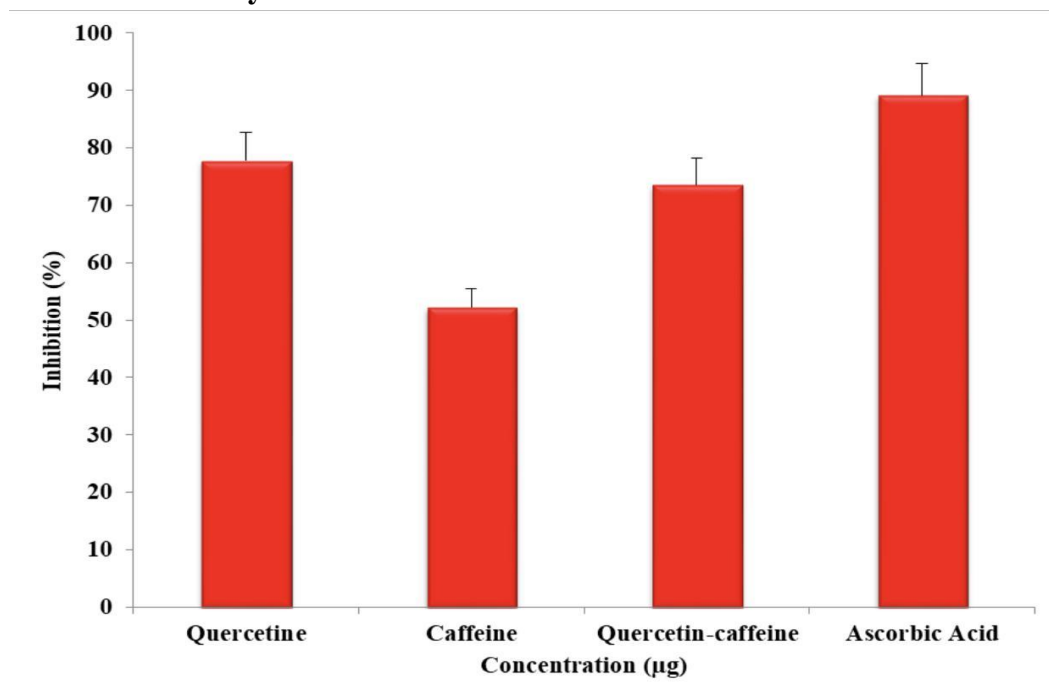
The 1.5-cm-long suture threads were covered in a platinum sputter coat to make the sample electrically conductive before the SEM investigation. At a distance of 100 m and an optical density of x120, the suture was next observed. The extent of coating the sutures with a mixture of quercetin and caffeine was compared to the control group using the JEOLIT 800 FESEM pictures.

Tensile Strength Analysis

A 10.5 cm long suture was stretched under a tensile load at a cross-sectional speed of 0.5 mm per minute for the tensile strength study. The greatest force in Newtons at which the suture ruptured was noted. Tensile strength analysis and SEM's final results were analyzed and tabulated. From day 0 to day 7, the tensile strength of the sutures was examined using Instron E3000 ETM post coating, and the outcomes were tabulated.

3. Result

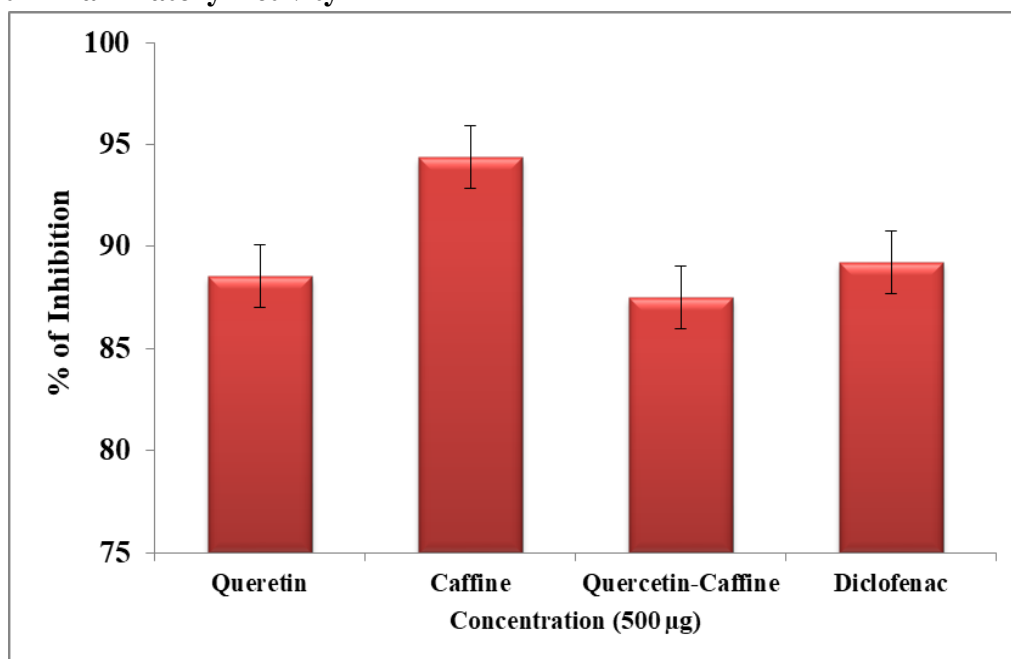
Antioxidant Activity



Graph 1. Antioxidant activity of Quercetin and Caffeine and their combination against the control group ascorbic acid.

Graph 1 shows Quercetin, caffeine and Quercetin-caffeine combination with the standard ascorbic acid. The control has 90% of antioxidant activity. Quercetin is found to have 78% of activity whereas caffeine has 50% of antioxidant activity. The Quercetin-caffeine combination has the least antioxidant activity 75%.

Anti Inflammatory Activity



Graph 2. Anti-inflammatory activity of quercetin and Caffeine compared to standard drug Diclofenac

Graph 2 describes the anti-inflammatory effects of quercetin, caffeine, and their mixture with the standard drug, diclofenac. Quercetin is found to have 88% of anti-inflammatory activity whereas caffeine has 95% of anti-inflammatory activity which is higher than the control group diclofenac (90%). The quercetin-caffeine complex has the least anti-inflammatory activity 87% among the group.

Surface Coating SEM Images

SEM images of PGA and VICRYL coated with quercetin, caffeine and quercetin-caffeine complex.

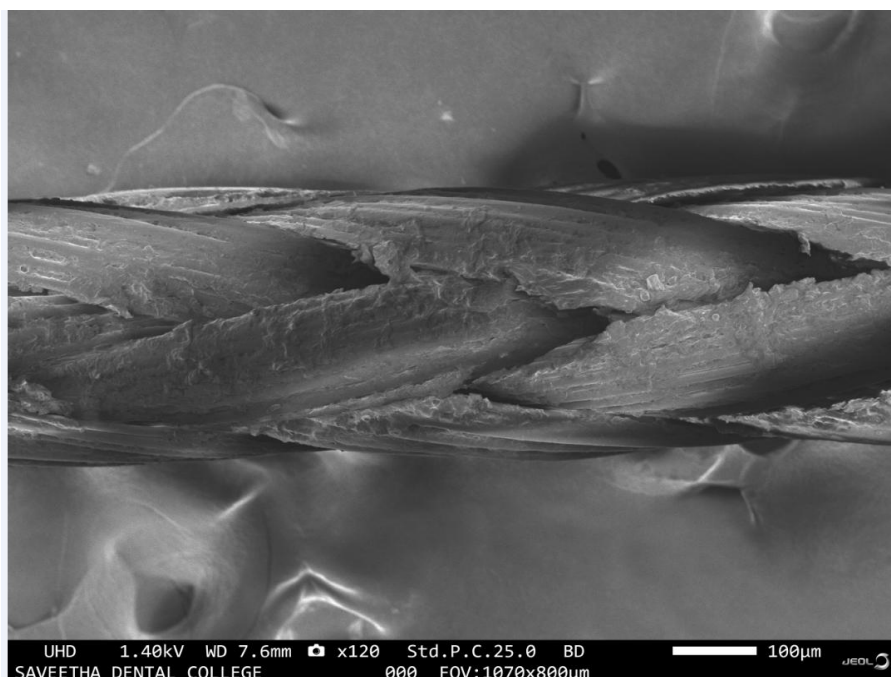


Figure 1.SEM image of PGA coated at day 0.

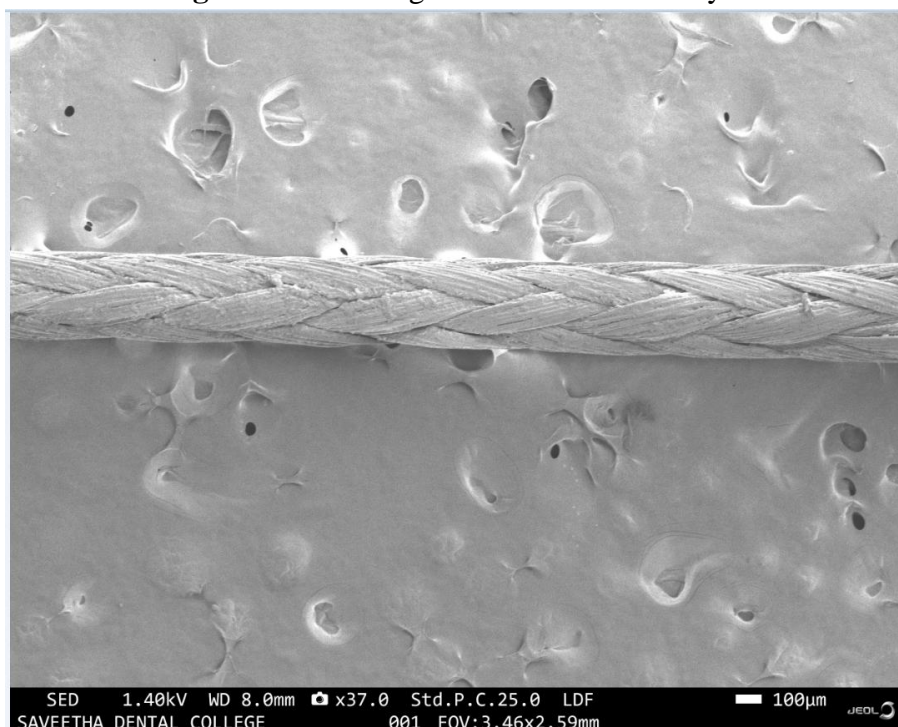


Figure 2.SEM images of VICRYL coated at day 0.

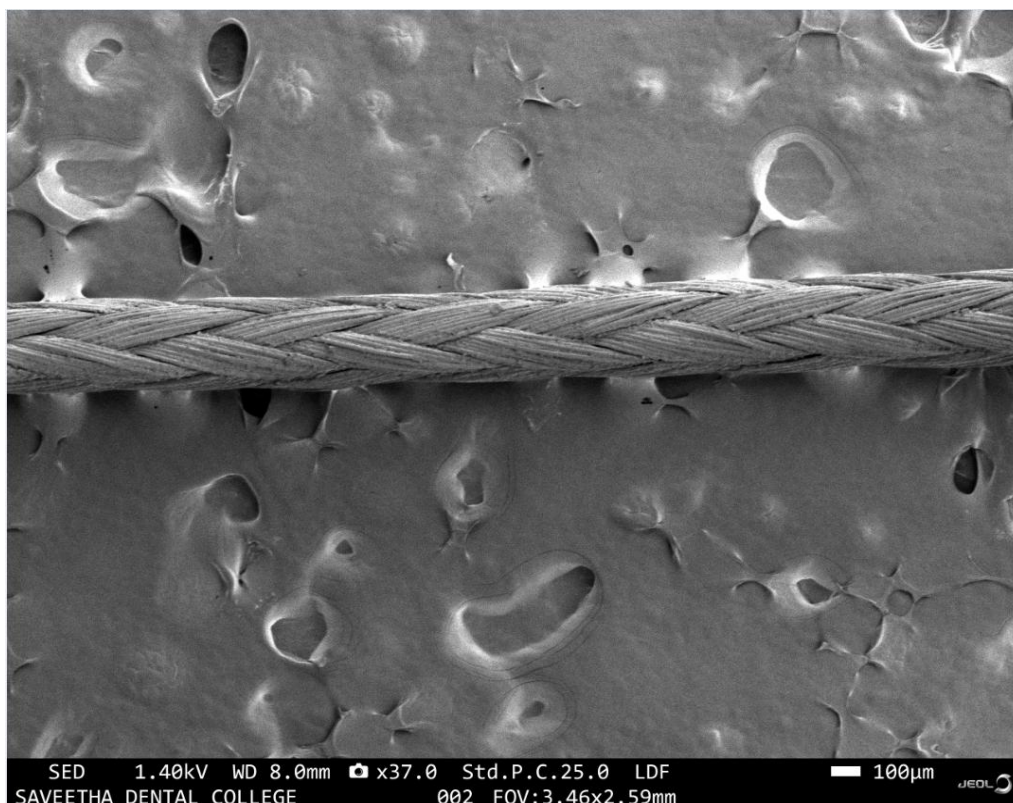


Figure 3.SEM images of VICRYL coated at day 7.

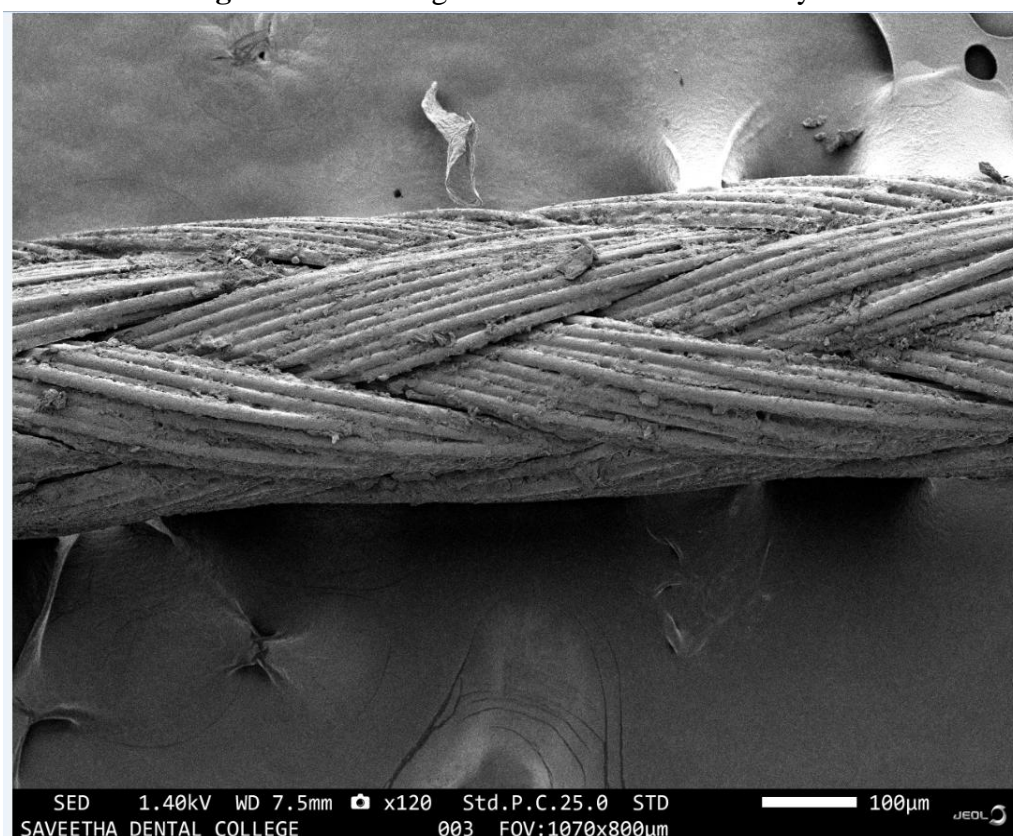


Figure 4.SEM images of PGA coated at day 7.

The coating is uniform, as shown by the SEM photos. The image has an added set of coating on it, which denotes that the material is applied with the extract.

Tensile Strength

Table 1. Tensile strength values of PGA and Vicryl sutures coated with quercetin-Caffeine complex extract in artificial saliva at Day 0 are shown

Specimen label	Maximum force [N]	Tensile stress at Tensile strength [M P a]	Tensile strain (Displacement) at break (Standard) [%]
VICRYL (GROUP 1)	20.26	4135.67	11.86
PGA (GROUP 2)	11.07	2258.64	25.87
VICRYL 4.4(GROUP 3)	21.38	4356.76	14.96
VICRYL 7.2(GROUP 4)	16.79	3424.64	13.43
PGA 4.4(GROUP 5)	9.11	1853.28	21.53
PGA 7.2(GROUP 6)	9.44	1898.31	22.51

As shown in table 1 the tensile strength of suture group on day 1 after coating with Quercetin-caffeine combination and immersing in artificial saliva at pH 4.4 and pH 7.2

Between the control group. Uncoated Vicryl (group1) shows maximum tensile strength (4135.67) when compared to that of uncoated PGA (2258.64). Among test groups, at Ph 4.4 coated Vicryl (group 3) showed increased tensile strength (4356.76) when compared to coated PGA (group 5) (1853.28). At PH 7.2 coated Vicryl and PGA (group 4 and group 6) showed slight decrease in tensile strength (3424.64) and (1898.31), when compared to that of control groups.

Table 2. shows the tensile strengths of PGA and Vicryl sutures at Day 7 after coating with the extract at pH 4.4 and 7.2.

	Specimen label	Tensile stress at Break(standard) [M P a]
1	VICRYL (GROUP 1)	3916.83
2	PGA(GROUP 2)	2190.75
3	VICRYL 4.4(GROUP 3)	4124.98
4	VICRYL 7.2(GROUP 4)	3372.79
5	PGA 4.4(GROUP 5)	1836.55
6	PGA 7.2(GROUP 6)	1815.90

On Day 7, Among control groups, PGA (group 2) showed less tensile strength (2190.75) when compared to Vicryl (3916.38) (group 1). Among test groups, At pH 4.4, group 3 showed increased tensile strength (4124.98) when compared to Group 5 and control groups 1 and 2.

At pH 7.2, Group 6 showed the least tensile strength of 1815.90 when compared to group 4 and other groups.

4. Discussion

In this study, the tensile strength was evaluated by incorporating the suture in the extract by immersion dip method. The results revealed that uncoated Vicryl has the highest tensile strength (4135.67) at day 0. At day 7 there was a reduction in the tensile strength of sutures. PGA sutures at pH 7.2 showed least tensile strength when compared to other groups. The antioxidant activity of quercetin(85%) is found to be higher than caffeine and their

combination. Caffeine is found to have significantly higher anti-inflammatory activity 95%, which is higher than the control group ascorbic acid (90%).

The tensile properties of a different kind of solution are influenced by its temperature. Saliva appears to alter the sutures' gradation property, lowering their tensile strength. Since they can naturally dissolve and be absorbed by the body as the wound heals, absorbable sutures are frequently chosen for use. The fast-absorbing suture PGA lost its tensile strength in just seven days. The greater tensile strength of PGA has been demonstrated by studies. In a study on the impact of bodily fluids on absorbable sutures, PGA and Vicryl quickly lost their tensile strength in jejunum, bile, and pancreatic juice(12).

In our study the suture had a gradual decrease in tensile strength, among which PGA at day 0 had tensile strength 2258.64 and at day 7 the tensile strength after immersion was 2190.75 which reduced slowly the 7th day. In a previous study done on tensile strength and durability of suture in various PH demonstrated slower and more consistent loss of Tensile strength with polyglactin and Vicryl(13). The tensile strength of the coated Vicryl suture utilized in this investigation was higher than that of the PGA. A similar study reported reduced tensile strength of Vicryl when soaked in saliva compared to other liquids like saline. That states, saliva appears to degrade suture material resulting in reduced tensile strength(7). In another in vitro study, Vicryl sutures showed a decrease in the Tensile Strength in simulated oral condition (7). Other studies that looked into the influence of the secondary metabolites on the suture material showed slight decrease in tensile strength of both the suture and less tensile strength loss in PGA(14)(14,15) (R akshaya et al ;2022) .

Anti-inflammatory effects may influence how quickly a wound heals, which is why they are advantageous for reducing scar tissue. The importance of caffeine for fibroblast activation is demonstrated by research on the substance. It affects the thickness of rat skin graft healing when consumed often. But individuals who consumed coffee showed increased collagen production. The study found that coffee significantly reduces the tensile strength of suture material. Even after being exposed to coffee, PGA suture maintains their tensile strength (16). In our study, caffeine's anti-inflammatory activity was also found to be much higher. On the other hand, its presence had an impact on the chromic and plain gut sutures. During the healing process, it is advised to stay away from them for the first postoperative week. PGA sutures are preferred for usage when exposed to them. Our team has extensive knowledge and research experience that has translated into high quality publications(17–25)(26) .

5. Conclusion

The absorbable suture material is affected by certain alkaloids and flavonoids. We can conclude that the degradation qualities of suture materials have an effect on them. The anti-inflammatory effects of caffeine is superior to that of the drug diclofenac. Therefore, nutrients quercetin and caffeine have an effect on wound healing.

6. Future Scope of Study

Future in vivo research on many additional flavonoids and alkaloids combinations in absorbable sutures can be done to expand the potential.

Conflict of Interest:

There is no conflict of interest.

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