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Original Research Article

COMPARATIVE *IN-VITRO* BIODEGRADATION OF *PILIOSTIGMA RETICULATUM* FIBRES AND POLYGLACTIN 910 (VICRYL) IN DEXTROSE AND GOAT URINE: IMPLICATIONS FOR VETERINARY SURGERY

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ABSTRACT

Biodegradable sutures play a crucial role in wound closure by providing temporary support to tissues. Natural plant fibres have gained attention as promising alternatives to synthetic biodegradable sutures due to their abundance, biocompatibility, and potential cost-effectiveness. *Piliostigma reticulatum*, a plant species found in various parts of Africa, possesses fibres with potential applications in biomedical science. This study assesses the *in-vitro* biodegradability of *Piliostigma reticulatum* fibre strands in 5% dextrose and goat urine, comparing their tensile strength degradation to that of Polyglactin 910 (Vicryl), to evaluate their potential as a biodegradable suture material for veterinary or medical applications. *In-vitro* biodegradability was assessed by comparing changes in tensile strength over time between *Piliostigma reticulatum* and Polyglactin 910 strands immersed in 5% dextrose and goat urine using tensile testing machine at 1, 2, 3, and 4 weeks. The tensile strength of *Piliostigma reticulatum* fibres in 5% dextrose varied from 27.93±14.57 MPa to 17.10±4.13 MPa, while that of polyglactin 910 varied from 404.6±178.2 MPa to 194.4±99.44 MPa. In goat urine, *Piliostigma reticulatum* fibres tensile strength loss ranged from 23.96±13.83 MPa to 18.56±9.4 MPa, while that of polyglactin 910 ranged from 67.64±16.63 to 00.00. The influence of 5% dextrose and goat urine on *Piliostigma reticulatum* was statistically not significant ($P > 0.05$). The tensile strength of *P. reticulatum* fibres (27.93 ± 14.57 MPa pre-immersion) was substantially lower than that of commercial Vicryl (194.4 ± 99.44 MPa) and falls below the typical range reported for synthetic absorbable sutures (300–600 MPa). This disparity suggests that, although the fibres exhibit stability, their mechanical strength may limit their application in high-tension surgical procedures.

Keywords: *Piliostigma reticulatum* fibre, Polyglactin 910, *In-vitro* biodegradation, pH, suture material, tensile strength,

INTRODUCTION

Surgical sutures are used to facilitate the closure and healing of surgical or trauma-induced wounds by approximating tissues. There is a wide range of sutures for medical purposes, and the main types include absorbable and non-absorbable (Rose & Tuma, 2025).

Natural sutures of animal origin are made from collagen obtained from the intestinal serosa or submucosa of mammals, silk obtained from silkworms, and fibrin (Altman *et al.*, 2003) while sutures of plant origin are made from sources such as cotton, ramie plant, lignin, sisal, and coconut cellulose fibres (Kandimalla *et al.*, 2016; Guambo *et al.*, 2020). Synthetic sutures are made of artificial polymers, which include polyglactin 910 (Vicryl), polyglecaprone 25 (Monocryl), polyglycolic acid (Dexon), polydiaxanone (PDS), and proline (Chellamani *et al.*, 2013; Guambo *et al.*, 2020).

Non-absorbable sutures are used to provide long-term tissue support, remaining walled off by the body's inflammatory processes. They may be removed after a specific time or left permanently (Chu, 2013). The loss of weight and tensile strength profiles and the biocompatibility of degradation products play a major role in biodegradation and absorption of sutures. The suture degradation process can be rapid, moderate, or slow. Significant determinants of suture biodegradation qualities include environmental pH (Tomihata *et al.*, 2001), temperature, rate of application, and amount of strain, suture surface modifications, and presence of bacteria (Miller & Williams, 1984; Chu, 1997). Immersion of suture in sterile or infected milk results in

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reduced suture strength (Nichols & Anderson, 2007). Degradation occurs by hydrolysis and phagocytosis, and the rate of degradation depends on the temperature and pH of the surrounding tissues to the suture (Abellan *et al.*, 2016). While some studies suggest suture degradation is pH-independent (Freudenberg *et al.,* 2004), others noted accelerated hydrolysis in alkaline environments (Tomihata *et al.*, 2001). This discrepancy may depend on suture composition (glycolide-based vs. cellulose). Synthetic absorbable sutures are degraded through hydrolysis by random main-chain scission of ester linkages (Lee & Chu, 2000).

Natural cellulose fibres from different biorenewable sources have attracted considerable attention from the research community all around the globe, owing to their unique intrinsic properties such as biodegradability, easy availability, environmental friendliness, flexibility, easy processing, and impressive physico-mechanical properties (Sionkowska, 2011; Thakur & Thakur, 2014). Also, natural cellulose fibres from coconut and sisal were isolated as an alternative suture material to the conventional natural and synthetic sutures (Guambo *et al.*, 2020).

Piliostigma reticulatum (Camel's foot) is a leguminous plant in the *Cercidoideae* subfamily. It occurs throughout western tropical Africa to Ethiopia (Hepper & Geerling, 1984). The plant is widely distributed in tropical Africa and Asia, most especially in Nigeria (Akinniyi & Sultanbawa, 1983). *Piliostigma reticulatum* can also be found in Mali, Niger, Ghana, Uganda, Botswana, Native: Kenya, Namibia, Senegal, South Africa, Sudan, Tanzania, Uganda, and Zambia (Orwa *et al.*, 2009). The local names (Nigeria) in Hausa, Igbo, and Yoruba include Kalgo or "Kargo", "Abafe", and "Okpoatu" respectively (Akinniyi & Sultanbawa, 1983).

Polyglactin 910 (Vicryl) is a multifilament braided copolymer of 90% glycolide and 10% L-lactide. It is coated with calcium stearate and polyglactic acid to improve its handling characteristics and ease of passage through tissues. It is also coated with antibacterial triclosan (Vicryl Plus) to make them infection-resistant, making them more expensive than traditional sutures (Gómez-Alonso *et al.*, 2007). The irradiated form is rapidly biodegraded (Vicryl Rapide) (Duprez *et al.*, 1988). While synthetic absorbable sutures have well-characterized degradation profiles, the biodegradation behavior of *P. reticulatum* fibres in biological media remains unexplored, limiting their potential for clinical application.

Despite the exploration of plant fibres such as ramie and coconut for suture applications, no studies to date have comprehensively assessed the *in vitro* biodegradation profile of *P. reticulatum* fibres under physiologically relevant conditions. Therefore, this study was aimed at evaluating the biodegradability of *P. reticulatum* fibre strands compared to Polyglactin 910 (Vicryl) when immersed in media of different pH over a four-week period.

MATERIALS AND METHODS

EXPERIMENTAL DESIGN

Piliostigma reticulatum fibres were manually extracted from the stems and cleansed with water. Five replicate fibre samples of each type (Polyglactin 910 by Bencryl, Polyglactine 910, Bencare Medical Concept Nigeria, Limited. and *P. reticulatum* by Anhui Kangning Industrial Group Company Limited, Tianchang City, Anhui, China.) were allocated to each time point (pre-immersion, weeks 1, 2, 3, and 4) and each medium (5% dextrose in water (UNIDEX – 5, Unique Pharmaceuticals Limited. Km 38, Abeokuta road, Sango Ota, Ogun State, Nigeria) and fresh goat urine collected aseptically from healthy goats immediately after slaughter from Maiduguri Ultramodern Abattoir). The pH of the two (2) media was measured using a digital pH meter (OHRUS®) following calibration. Fibers were immersed in 20 mL of the respective medium in sterile universal bottles and kept at room temperature (25±2°C) for the specified duration. Media were not changed during the incubation period to simulate static *in vivo* conditions.

TENSILE STRENGTH LOSS MEASUREMENT

The cross-sectional area of polyglactin 910 and *P. reticulatum* was measured at three different points along each fibre using a digital Vernier calliper (precision: 0.01 mm). At each time point, fibres were removed from immersion media, gently blotted dry with filter paper, and immediately tested for tensile strength using a universal testing machine (TM2101-T7). The fibre strands were clamped between the upper and lower jaws of the Tensile Strength Test machine (TM2101-T7) with a cross-head speed of 60 mm/min, gauge length of 60.00 mm, and a computer for digital output (Figure I). The maximum strength at just the point of breakage of the fibres was measured in megapascals (MPa). Five replicate fibre samples (n=5) were tested for each time point, medium, and fibre type. All experiments were conducted at room temperature (25±2°C).

DATA ANALYSIS

The data obtained were expressed as mean ± standard deviation (mean ± S.D.) and were statistically analyzed using a two-way mixed-effect model analysis of variance (ANOVA), with Bonferroni used for multiple comparisons. *A p-value* less than 0.05 was considered significant using GraphPad Prism Version 8.0.2. (263), 2019.

RESULTS

The biodegradation assessment, based on the loss of tensile strength in media of varying pH (6.9 for goat urine and 4.0 for 5% dextrose), was presented in Table I. The initial tensile strength before immersion in both media was 194.4 ± 99.44 MPa for Polyglactin 910 and 27.93 ± 14.57 MPa for *P. reticulatum* fibre. The tensile strength of Polyglactin 910 in 5% dextrose was 404.6 ± 178.2 MPa, 262.1 ± 130.4 MPa, 279.3 ± 143.0 MPa, and 323.5 ± 28.33 MPa at week one, two, three, and four, respectively; however, the changes in tensile strength were not statistically significant compared with pre-immersion values ($P > 0.05$). The tensile strength of *P. reticulatum* fibre one week after immersion in 5% dextrose was 17.10 ± 4.13 MPa, which was not significantly different from its pre-immersion value of 27.93 ± 14.57 MPa ($P > 0.05$). This slight, non-significant change was maintained at weeks two, three, and four, with values of 17.23 ± 8.08 MPa, 20.51 ± 9.65 MPa, and 20.72 ± 10.77 MPa, respectively.

The mean tensile strength of Polyglactin 910 afterone week post-immersion in goat urine decreased non-significantly to 67.64 ± 16.63 MPa ($P > 0.05$). The tensile strength continued to decrease progressively over the subsequent weeks, reaching 13.93 ± 0.27, 2.39 ± 0.34 MPa, and 0.00 ± 0.00 at weeks two, three, and four, respectively.

The decrease was statistically significant at weeks three and four (2.39 ± 0.34 MPa and 0.00 ± 0.00 MPa, respectively; $P < 0.05$). For *Piliostigma reticulatum* fibre, the change in tensile strength one week post-immersion in goat urine (23.96 ± 13.83 MPa) was not significant compared with the baseline value of 27.93 ± 14.57 ($P > 0.05$). The tensile strength values were 18.56 ± 9.40 MPa, 21.12 ± 5.61 MPa, and 18.81 ± 9.98 MPa at weeks two, three, and four, respectively.

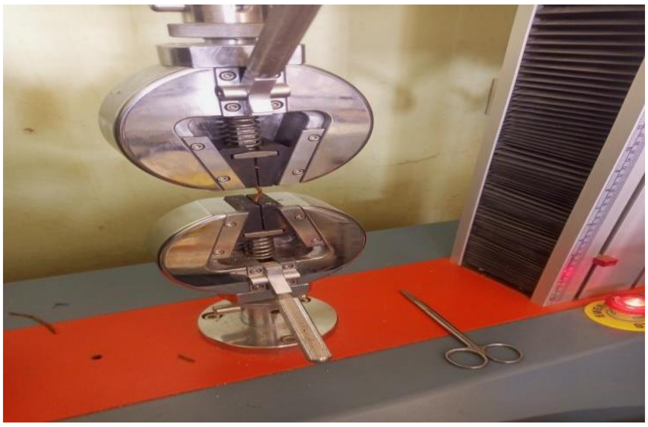

Figure I: The Universal Testing Machine used to measure the tensile strength of the experimental samples

DISCUSSION

This study compared the i*n vitro* biodegradation profiles of synthetic Polyglactin 910 (Vicryl) sutures and natural *Piliostigma reticulatum* fibres when immersed in 5% dextrose (pH 4.0) and goat urine (pH 6.9) over four weeks. Vicryl underwent rapid, complete degradation in goat urine by week 4 but maintained or increased tensile strength in dextrose; *P. reticulatum* fibres exhibited remarkable stability in both media throughout the study period, with no significant loss of tensile strength; and the degradation patterns differed fundamentally between the two fibre types, reflecting their distinct chemical compositions and degradation mechanisms.

The rapid degradation of Vicryl in goat urine (pH 6.9) compared to dextrose (pH 4.0) aligns with previous reports on the pH sensitivity of glycolide-based polymers. Tomihata *et al.* (2001) demonstrated that synthetic absorbable sutures undergo accelerated hydrolysis in alkaline environments due to base-catalyzed ester bond cleavage.

The complete loss of tensile strength by week 4 in urine (0.00 ± 0.00 MPa) is consistent with the reported absorption profile of Vicryl, which typically retains only 25-40% of its strength at 2-3 weeks post-implantation in vivo (Duprez *et al.*, 1988). However, the degradation rate observed here exceeds that reported by Freudenberg *et al.* (2004), who found Vicryl retained approximately 50% strength after 28 days in pH 7.4 buffer. This discrepancy may reflect the complex composition of goat urine, which contains urea, ammonia, electrolytes, and enzymes that could accelerate hydrolysis beyond simple pH effects (Naser *et al.*, 2024).

The unexpected increase in Vicryl tensile strength following immersion in 5% dextrose warrants careful consideration. The apparent increase may represent measurement artefact due to fibre swelling.

Dextrose solutions are hypertonic relative to physiological fluids, potentially causing water efflux from the polymer matrix and temporary fibre stiffening. Chu (1982) observed similar apparent strength increases in polyglycolic acid sutures exposed to acidic media, attributed to reduced plasticization and increased polymer chain alignment. The high variability (standard deviations exceeding 50% of means) suggests possible outlier influence.

TABLE I: TENSILE STRENGTH (MPA) OF POLYGLACTIN 910 AND *PILIOSTIGMA RETICULATUM* FIBRES FOLLOWING IMMERSION IN 5% DEXTROSE AND GOAT URINE

Time Point	**Polyglactin 910 (Vicryl)**		***Piliostigma reticulatum*fibre**	
	5% Dextrose	**Goat Urine**	**5% Dextrose**	**Goat Urine**
Pre-immersion	194.4 ± 99.44	194.4 ± 99.44	27.93 ± 14.57	27.93 ± 14.57
Week 1	404.6 ± 178.2	67.64 ± 16.63*	17.10 ± 4.13	23.96 ± 13.83
Week 2	262.1 ± 130.4	13.93 ± 0.27*,#	17.23 ± 8.08	18.56 ± 9.40
Week 3	279.3 ± 143.0	2.39 ± 0.34*,#,†	20.51 ± 9.65	21.12 ± 5.61
Week 4	323.5 ± 28.33	0.00 ± 0.00*,#,†,‡	20.72 ± 10.77	18.81 ± 9.98

[1]Data presented as mean ± SD (n=5). *Significantly different from pre-immersion (p<0.05); #Significantly different from Week 1 (p<0.05); †Significantly different from Week 2 (p<0.05); ‡Significantly different from Week 3 (p<0.05).

The coefficient of variation for Vicryl in dextrose ranged from 32-44%, compared to 9-44% for other conditions, indicating less reliable measurements, consistent with the known variability of polyglactin 910 in different environments and the interpretation of higher CV values as lower precision (Blomstedt & Jacobsson, 1977; Tsugawa & Verstraete, 2012). Repeating these measurements with larger sample sizes (n≥10) would help distinguish true biological variation from technical artefacts.

The acidic conditions may actually slow hydrolytic degradation of glycolide-based polymers. The ester hydrolysis reaction is acid-catalyzed but requires water penetration; at very low pH, polymer chain mobility may be reduced, slowing degradation (Lee and Chu, 2000). This could explain the maintained strength in dextrose (pH 4.0) versus rapid degradation in urine (pH 6.9).

The remarkable stability of *P. reticulatum* fibres in both media throughout the four-week study period contrasts sharply with the synthetic vicryl. Natural cellulose fibres degrade primarily through enzymatic hydrolysis *in vivo*, but *in vitro* degradation in simple aqueous media is typically slow due to the crystalline cellulose structure resistant to non-enzymatic hydrolysis (Thakur & Thakur, 2014; Mohanty *et al.*, 2002). Similarly, Guambo *et al.* (2020) reported that coconut and sisal fibres retained >80% of their initial tensile strength after 28 days in phosphate-buffered saline.

The cellulose-rich structure of *P. reticulatum* fibres consists of highly ordered crystalline regions interspersed with amorphous domains (Klemm *et al.*, 2005; Hossain *et al.*, 2025). Water penetration occurs primarily in amorphous regions, but without cellulase enzymes, chain scission proceeds slowly via random hydrolysis of glycosidic bonds (Kandimalla *et al.*, 2016). The absence of significant strength loss over four weeks suggests the amorphous regions constitute a small fraction of the fibre volume or that the crystalline regions provide structural reinforcement even as amorphous regions slowly degrade.

The fundamentally different degradation patterns observed reflect distinct polymer chemistries. Polyglactin 910 is a copolymer of glycolide (90%) and L-lactide (10%) with ester linkages susceptible to hydrolysis.

Degradation proceeds by random chain scission, reducing molecular weight until mechanical integrity is lost (Chu, 2013). This explains the progressive strength loss in urine. In contrast, cellulose in *P. reticulatum* consists of β-1,4-linked glucose units with extensive hydrogen bonding between chains, creating crystalline microfibrils resistant to hydrolysis. Without cellulolytic enzymes, degradation requires harsh conditions (strong acids, elevated temperatures) rarely encountered in physiological settings (Thakur and Thakur, 2014). Thus, the observed stability is expected for *in vitro* conditions lacking cellulases.

The slow biodegradation profile of *P. reticulatum* fibres suggests potential applications where prolonged wound support is required, such as in veterinary orthopaedic procedures, fascial closures, or patients with impaired healing (e.g., diabetes, malnutrition). Natural cellulose fibres may also offer advantages in contaminated wounds, where rapid suture degradation could precipitate wound dehiscence (Chu, 1997). However, the lack of degradation over four weeks raises questions about eventual absorption. Complete degradation of cellulose *in vivo* requires phagocytosis by macrophages and giant cells, a process taking months to years depending on fibre characteristics (Tomihata & Ikada, 2001). Previous investigations of plant-based sutures have yielded variable results. Kandimalla *et al*. (2016) reported that ramie fibres retained adequate tensile strength for wound closure with good biocompatibility in rat models. Guambo *et al*. (2020) demonstrated that coconut and sisal fibres supported fibroblast attachment and proliferation, suggesting potential for tissue integration. Our findings extend this work by characterizing degradation in biologically relevant media and comparing directly with a clinical gold standard.

The tensile strength of *P. reticulatum* fibres (27.93 ± 14.57 MPa pre-immersion) was lower than that of commercial Vicryl (194.4 ± 99.44 MPa) and below the typical range for surgical sutures (300-600 MPa for most synthetic absorbable). However, knot holding capacity, tissue reactivity, and handling characteristics are equally important determinants of clinical utility and were not assessed here.

CONCLUSION

This study demonstrates fundamentally different *in vitro* biodegradation profiles between synthetic Polyglactin 910 sutures and natural *P. reticulatum* fibres. Vicryl underwent rapid, pH-dependent degradation in goat urine (complete loss of tensile strength by week 4) while maintaining strength in acidic dextrose solution. In contrast, *P. reticulatum* fibres exhibited remarkable stability in both media throughout the four-week study period, with no significant loss of tensile strength. The slow biodegradation profile of *P. reticulatum* fibres, combined with their natural origin and potential biocompatibility, suggests they may be suitable for veterinary surgical applications requiring prolonged wound support. However, the tensile strength of native fibres is considerably lower than commercial sutures, and complete degradation kinetics remain unknown.For clinical application further studies are required to characterize long-term (>6 months) degradation behaviour; assess biocompatibility in appropriate animal models; evaluate handling and knotting characteristics; develop standardized fibre processing methods.

With appropriate optimization, *P. reticulatum* fibres may offer a low-cost, bio-renewable alternative to synthetic absorbable sutures in selected veterinary applications.

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