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Evaluation of various platelet additive solutions for *in vitro* storage of caprine platelets

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Abstract

Caprine platelet concentrates (PCs) are valuable tools in veterinary transfusion medicine and regenerative therapies. However, platelets experience deleterious changes during storage, known as the platelet storage lesion (PSL). This study evaluated the efficacy of three distinct platelet additive solutions (PAS) InterSol, M-sol, and SSP+ compared to standard caprine plasma for the *in vitro* preservation of caprine platelets over a 7-day storage period at 22°C under continuous agitation. Quality parameters including platelet count, mean platelet volume (MPV), pH, extracellular glucose, lactate accumulation. The third-generation PAS formulation, SSP+, demonstrated superior preservation of caprine platelets. It maintained optimal pH homeostasis (7.02 ± 0.05) and significantly reduced lactate production compared to plasma controls by Day 7 ($p < 0.05$). These findings indicate that specific PAS formulations can successfully mitigate PSL in caprine species, extending structural and functional shelf life for targeted clinical and emergency applications.

Keywords: Platelet additive solution, platelet storage lesion, caprine platelets, platelet rich plasma, veterinary transfusion medicine

1. Introduction

Platelet transfusions and platelet-rich plasma (PRP) therapies are vital components of modern veterinary clinical science. They are widely used to manage severe thrombocytopenia, coagulopathies, acute hemorrhage, and localized musculoskeletal trauma in caprine species ^[5, 12]. In small ruminant herd management and emergency veterinary medicine, maintaining a reliable supply of highly viable platelet concentrates (PCs) is necessary to ensure successful therapeutic outcomes.

However, a major barrier in veterinary blood banking is the rapid degradation of blood components during *ex vivo* storage ^[5]. Platelets are metabolically active, highly sensitive fragments that undergo progressive morphological, biochemical, and functional degradation when isolated outside their native vascular environment ^[10]. This phenomenon is known collectively as the platelet storage lesion (PSL) ^[6]. PSL is driven by systemic cellular stress, which causes rapid metabolic substrate exhaustion and accelerated glucose depletion ^[8]. A shift to anaerobic glycolysis leading to uncontrolled lactic acid accumulation ^[9]. A critical decline in extracellular pH, undermining membrane function ^[3, 10]. Premature degranulation, cellular swelling, and microaggregate formation ^[4, 11].

To preserve functional viability, standard human and veterinary protocols mandate storing PCs at room temperature (20–24 °C) with continuous lateral agitation to maximize gas transport across storage containers ^[2, 4]. Under these parameters, storing platelets in 100% autologous plasma often leads to rapid, premature deterioration ^[7]. The native bicarbonate buffer capacity of plasma is relatively limited and becomes quickly overwhelmed by the accumulation of hydrogen ions, driving the environment below the critical survival threshold of 6.8 ^[3, 9].

To address these limitations, human transfusion medicine has increasingly transitioned toward utilizing synthetic Platelet Additive Solutions (PAS) ^[3]. These crystalloid electrolyte formulations substitute 60% to 80% of the native plasma volume, offering distinct metabolic substrates and precise chemical buffers designed to interrupt the progression of PSL ^[9].

Essential additives include acetate, which provides alternative mitochondrial fuel to suppress the rate of glycolysis, and phosphate ions, which stabilize environmental pH [3, 9]. Additionally, specific formulations integrate magnesium and potassium to stabilize resting cell membranes and lower baseline activation rates [4, 9].

While the advantages of consecutive PAS generations are thoroughly detailed for human and canine platelets, comparative performance evaluations for caprine-specific platelets are remarkably sparse. Caprine blood platelets display distinct baseline sizes, metabolic profiles, and surface receptor characteristics that demand targeted evaluation.

This study evaluates and compares the *in vitro* quality and metabolic stability of caprine platelets stored in three commercially available PAS formulations—InterSol (first-generation), M-sol (second-generation), and SSP+ (third generation)—against a standard 100% autologous caprine plasma control over a 7-day storage period.

2. Materials and Methods

2.1 Ethical Approval and Animal Selection

The present investigation was carried out after obtaining approval from the Institutional Animal Ethics Committee of the Veterinary College and Research Institute, Tirunelveli. Experimental procedures were performed in accordance with CPCSEA guidelines governing the use of animals for research.

Ten healthy, adult, non-pregnant caprine donors ($n = 10$), weighing between 35 and 45 kg, were selected from a farm maintained at the District Livestock Farm, Abishekapatti, Tirunelveli and Livestock Farm Complex, Veterinary College and Research Institute, Tirunelveli. All donor animals underwent physical examinations, complete blood counts (CBC), and fecal evaluations to ensure they were free of systemic parasites or underlying blood-borne infections.

2.2 Blood Collection and Processing

Whole blood ($15 \text{ mL} \pm 10\%$) was collected via jugular venipuncture into collection tubes pre-filled with Citrate-Phosphate-Dextrose-Adenine (CPDA-1) anticoagulant. Whole blood units were balanced and subjected to light-spin centrifugation ($250 \times g$ for 10 minutes at 22°C) with the brake deactivated to separate platelet-rich plasma (PRP) from red blood cells. The PRP was transferred into another tube and centrifuged using a heavy spin ($1200 \times g$ for 15 minutes at 22°C) to sediment the platelets into a dense pellet. Supernatant plasma was carefully removed into another tube, leaving behind a calculated residual plasma fraction. The platelet pellets rested undisturbed at 22°C for 60 minutes before manual resuspension.

2.3 Experimental Group Allocation

The resuspended platelet concentrates were distributed into four equal aliquots and reconstituted into parallel storage environments:

- **Control Group:** Reconstituted in 100% autologous caprine plasma.
- **InterSol Group:** Reconstituted to a final ratio of 65% InterSol / 35% plasma.
- **M-sol Group:** Reconstituted to a final ratio of 65% M-sol / 35% plasma.
- **SSP+ Group:** Reconstituted to a final ratio of 65% SSP+ / 35% plasma.

Units were standardized to a uniform final volume with a target platelet concentration of approximately $1.15 \times 10^{12}/\text{L}$. The units were placed on a flatbed shaker at 22°C with continuous lateral agitation (60 rpm) for 7 days [4].

2.4 Sampling and Analytical Assays

Aseptic sampling was performed on Days 0, 3, 5, and 7 of storage. At each interval, the following metrics were assessed:

Hematological Analysis: Total platelet counts and mean platelet volume (MPV) were determined using an automated veterinary hematology analyzer (Exigo Boule H 400, Sweden) calibrated for caprine hemograms. Samples were gently vortexed prior to analysis to disrupt any reversible sediment.

Biochemical and Gas Analysis: Extracellular pH, glucose concentrations, and lactate accumulation were measured immediately post-sampling using an automated blood gas and electrolyte analyzer at 37°C (Epoc Host blood gas analyzer, Ottawa, Canada)

2.5 Statistical Analysis

All experimental data were analyzed using GraphPad Prism (Version 9.0, GraphPad Software, San Diego, CA, USA). Data are expressed as mean $\pm$ standard deviation (SD) derived from ten independent caprine blood donors ($n = 10$).

3. Results

3.1 Platelet Yield and Hematological Stability

Initial platelet counts across all four preparation groups on Day 0 were standardized to ensure uniformity, yielding an average baseline of $1.15 \pm 0.12 \times 10^{12}/\text{L}$.

Platelet counts remained stable across all groups through Day 3 ($p > 0.05$). By Day 7, the Control group (100% plasma) exhibited a sharp, statistically significant decrease in recoverable single platelets ($0.74 \pm 0.09 \times 10^{12}/\text{L}$), driven by the visual appearance of microaggregates in the storage bags. In contrast, the SSP+ group demonstrated optimal preservation of platelet counts ($1.08 \pm 0.06 \times 10^{12}/\text{L}$), outperforming M-sol ($0.96 \pm 0.08 \times 10^{12}/\text{L}$) and InterSol ($0.91 \pm 0.07 \times 10^{12}/\text{L}$; $p < 0.01$).

MPV trends reflected structural swelling over time. On Day 0, the baseline MPV across all groups was $7.6 \pm 0.2 \text{ fL}$. By Day 7, the Control group experienced severe swelling, reaching $10.2 \pm 0.5 \text{ fL}$. Storage in PAS significantly attenuated this structural shift ($p < 0.05$). The SSP+ group demonstrated the tightest control over volume changes, restricting Day 7 MPV to $8.4 \pm 0.3 \text{ fL}$, followed by M-sol ($8.9 \pm 0.4 \text{ fL}$) and InterSol ($9.3 \pm 0.4 \text{ fL}$).

3.2 Metabolic Profiles and Extracellular Buffering

The evaluation of biochemical parameters showed distinct differences in anaerobic glycolysis rates and chemical buffering capacities among the storage environments by the end of the 7-day storage period (Table 1).

Table 1: Metabolic Parameters of Caprine Platelets on Day 7 of Storage

Parameters on Day 7	Control (Plasma)	InterSol	M-sol	SSP+
pH	6.42 ± 0.08	6.81 ± 0.06	6.89 ± 0.04	7.02 ± 0.05
Glucose (mmol/L)	1.8 ± 0.3	3.2 ± 0.4	3.5 ± 0.2	4.1 ± 0.3
Lactate (mmol/L)	18.4 ± 1.2	12.1 ± 0.9	11.5 ± 0.7	9.8 ± 0.6

Baseline pH for all units on Day 0 was 7.24 ± 0.03 . The Control group suffered a rapid, linear drop in pH, falling below the critical viability threshold to 6.42 ± 0.08 on Day 7 ($p < 0.001$). All three PAS formulations successfully mitigated this acidification. SSP+ achieved the highest buffering capacity, maintaining a stable physiological pH of 7.02 ± 0.05 on Day 7. This was significantly higher than M-sol (6.89 ± 0.04) and InterSol (6.81 ± 0.06 ; $p < 0.05$).

Extracellular glucose declined across all groups as storage progressed. The Control group experienced the highest rate of substrate depletion, falling from a baseline of 5.4 ± 0.4 mmol/L down to 1.8 ± 0.3 mmol/L on Day 7. The PAS groups preserved higher remaining concentrations by Day 7: SSP+ (4.1 ± 0.3 mmol/L), M-sol (3.5 ± 0.2 mmol/L), and InterSol (3.2 ± 0.4 mmol/L). Lactate generation inversely mirrored pH trends. The Control group showed severe accumulation by Day 7 (18.4 ± 1.2 mmol/L), indicating uninhibited anaerobic metabolism. SSP+ effectively suppressed lactate production (9.8 ± 0.6 mmol/L), which was significantly lower than the accumulation observed in InterSol (12.1 ± 0.9 mmol/L) and the plasma control ($p < 0.01$).

4. Discussion

This study presents a comprehensive evaluation of *in vitro* quality and metabolic profiles of caprine platelet concentrates (PCs) stored in three commercially available platelet additive solutions (PAS) InterSol, M-sol, and SSP+ relative to traditional 100% autologous plasma storage over a 7-day period. The development of a severe Platelet Storage Lesion (PSL) in the control group underscores the structural limitations of using standard caprine plasma as an extended preservation medium [6, 10]. The rapid onset of anaerobic glycolysis, and microaggregate formation collectively demonstrate that standard plasma fails to satisfy the prolonged metabolic demands of caprine platelets during room temperature storage [10, 12]. A primary indicator of platelet viability during storage is structural stability, which was monitored via changes in Mean Platelet Volume (MPV) and total platelet counts [1, 4]. The control group exhibited a sharp rise in MPV by Day 7 alongside a concurrent drop in platelet counts. This phenomenon is a direct consequence of the "sphering effect" or shape change, wherein platelets lose their resting discoid structure, swell, and form microaggregates [1, 4]. Conversely, platelets preserved in SSP+ maintained stable MPV values closely mimicking their Day 0 baseline. This structural preservation indicates that the osmotic and chemical formulation of SSP+ protects the structural integrity of the caprine platelet membrane against storage-induced swelling [3, 7].

The metabolic divergence observed between the experimental groups highlights the mechanism by which PAS formulations mitigate PSL [3, 8]. In the plasma control group, the fast depletion of glucose was accompanied by an accelerated accumulation of lactate [3, 9]. This shift to anaerobic pathways causes a catastrophic drop in extracellular pH down to 6.42 ± 0.08 by Day 7 [3, 9]. In human and veterinary transfusion medicine, a pH falling below 6.8 is considered a critical threshold that irreversibly compromises *in vivo* post-transfusion survival [2, 5]. The drop in pH is driven by the fact that plasma possesses finite bicarbonate buffering capacity, which is quickly overwhelmed by caprine platelet metabolic byproducts under closed bag conditions [3, 9].

Among the tested additives, SSP+ demonstrated the most robust metabolic maintenance, sustaining a physiological pH of 7.02 ± 0.05 on Day 7. This superior performance is directly

attributable to its chemical composition, specifically the presence of acetate and phosphate buffers. Acetate acts as an effective mitochondrial fuel source, allowing caprine platelets to utilize oxidative phosphorylation rather than relying exclusively on glycolysis [3, 8]. This metabolic shift limits the production rate of lactic acid [3]. Concurrently, the phosphate ions within SSP+ act as a heavy chemical buffer that neutralizes free hydrogen ions, actively preventing acidification of the medium. While M-sol and InterSol offered significantly better pH stabilization than plasma, they fell short of the strict homeostasis provided by SSP+, likely due to differences in their specific electrolyte ratios and buffering strengths.

Collectively, these findings demonstrate that optimizing the *in vitro* environment via PAS significantly delays the progression of the platelet storage lesion in caprine species [5, 7]. These results have immediate practical implications for veterinary blood banking, where extended shelf life can maximize resource availability for emergency transfusions and regenerative therapies [5, 12].

5. Conclusion

The utilization of platelet additive solutions significantly improves the *in vitro* storage quality of caprine platelets compared to standard plasma storage. Out of the evaluated solutions, SSP+ demonstrated the highest efficacy in maintaining pH stability, suppressing lactate accumulation, and minimizing premature platelet activation over a 7-day storage period. Implementing SSP+ in veterinary blood banking can optimize the availability and quality of caprine platelet concentrates for clinical therapeutic use.

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Conflict of Interest

Not available

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References

1. Slichter SJ, Harker LA. Preparation and storage of platelet concentrates: II. Storage variables influencing platelet viability and function. *Br J Haematol*. 1976;34(3):403-419.
2. Murphy S, Gardner FH. Room temperature storage of platelets. *Transfusion*. 1976;16(1):2-3.
3. van der Meer PF, de Korte D. Platelet additive solutions: A review of the latest developments and their clinical implications. *Transfus Med Hemother*. 2018;45(2):98-102.
4. Holme S, Vaidja K, Murphy S. Platelet storage at 22 degrees C: Effect of type of agitation on morphology, viability, and function *in vitro*. *Blood*. 1978;52(2):425-435.
5. Brooks MB, Harr KE, Seelig DM, Wardrop KJ, Weiss DJ, editors. *Schalm's Veterinary Hematology*. 7th ed. Hoboken (NJ): Wiley-Blackwell; 2022.

6. Seghatchian J, Krailadsiri P. The platelet storage lesion. *Transfus Med Rev.* 1997;11(2):130-144.
7. Gulliksson H, AuBuchon JP, Cardigan R, van der Meer PF, Murphy S, Prowse C, *et al.* Storage of platelets in additive solutions: A multicentre study of the *in vitro* effects of potassium and magnesium. *Vox Sang.* 2003;85:199-205.
8. Rinder HM, Snyder EL, Tracey JB, Dincecco D, Wang C, Baril L, *et al.* Reversibility of severe metabolic stress in stored platelets after *in vitro* plasma rescue or *in vivo* transfusion: Restoration of secretory function and maintenance of platelet survival. *Transfusion.* 2003;43(9):1230-1237.
9. van der Meer PF. PAS or plasma for storage of platelets? A concise review. *Transfus Med.* 2016;26(5):339-342.
10. Devine DV, Serrano K. The platelet storage lesion. *Clin Lab Med.* 2010;30(2):475-487.
11. Linden MD. Platelet flow cytometry. *Methods Mol Biol.* 2013;992:241-262.
12. Hux BD, Martin LG. Platelet transfusions: Treatment options for hemorrhage secondary to thrombocytopenia. *J Vet Emerg Crit Care.* 2012;22(1):73-80.

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