RESEARCH NOTE

Prophylactic potential of a Panchgavya formulation against certain pathogenic bacteria [version 1; peer review: 3 approved]

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Abstract
A Panchgavya preparation was evaluated for its prophylactic efficacy against bacterial infection, employing the nematode worm Caenorhabditis elegans as a model host. Worms fed with the Panchgavya preparation prior to being challenged with pathogenic bacteria had a better survival rate against four out of five test bacterial pathogens, as compared to the control worms. Panchgavya feeding prior to bacterial challenge was found to be most effective against Staphylococcus aureus, resulting in 27% (p=0.0001) better worm survival. To the best of our awareness, this is the first report demonstrating in vivo prophylactic efficacy of Panchgavya mixture against pathogenic bacteria.

Keywords
Panchgavya, Prophylactic, Anti-infective, Caenorhabditis elegans

Open Peer Review

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Any reports and responses or comments on the article can be found at the end of the article.

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Competing interests: Dr. Palep’s Medical Research Foundation (with whom two of the authors of this manuscript are affiliated) is a nonprofit organization (Trust). Promoters of this trust manufacture ayurvedic formulations. However, at present ‘Panchgavya’ is not part of their product portfolio.

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Introduction
‘Panchgavya’ is a term used to describe a combination of five major substances obtained from cow, including cow’s urine, milk, ghee (clarified butter), curd and dung. Dhanvantari, referred to as the God of Indian Medicine, is said to have offered to mankind this wonder medicine called Panchgavya. In Sanskrit, all its five ingredients are individually called ‘Gaavya’ and collectively termed as Panchgavya (panch means five). Panchgavya products have been claimed to be beneficial in curing several human ailments, enhancing immunity and providing resistance to fight infections (Dhama et al., 2005). Panchgavya therapy (cownopathy) has been indicated as an alternate prophylactic and therapeutic modality for sound livestock and poultry health along with human health (Dhama et al., 2014). Panchgavya Prashan is a common tradition followed by certain communities (e.g. Telugu Brahmins) in India, wherein a Panchgavya dose is taken once every year during monsoon season. The potential applications of Panchgavya as antimicrobials, immune boosters, antidiabetics, anticanccer, anticonvulsant, aphrodisiac, blood purifiers, and as a suitable medium to deliver medicines, have caught the attention of scientists and medical professionals (Dhama et al., 2014). In this context, we undertook an investigation on the prophylactic potential of a Panchgavya preparation against bacterial infections in the nematode host Caenorhabditis elegans.

Methods
Panchgavya preparation
The Panchgavya formulation used in this study was prepared using a method that was different from the one practiced traditionally (which yields a fermented preparation). Fresh cow dung and urine, sourced from a cow fed on cottonseed and sugarcane grass, were mixed thoroughly in a glass beaker. This mix was allowed to stand for 10 min and subjected to filtration through a muslin cloth (the traditional method does not involve filtration). To this filtrate, fresh cow’s milk and fresh curd was added, and mixed until a uniform mixture was formed. Finally, cow ghee was added to this mixture and mixed thoroughly.

Dung, urine, and milk were all sourced from a single cow. From the same batch of milk, curd and ghee were prepared. Cream of this milk was boiled for 30–40 min and filtered; the filtrate was taken as ghee. For curd preparation, one part of this milk was inoculated with previous batch of curd (prepared using milk from the same cow by adding few drops of lemon juice to the milk) followed by overnight incubation at room temperature.

The ratio of dung:urine:milk:curd:ghee in this preparation was 1:2:3:3:1. This Panchagavya mixture was then transferred to a copper vessel (covered with a muslin cloth) and allowed to rest for 30 min. This was followed by freeze-drying at -20 °C to convert the preparation in powder form, which was stored under refrigeration (4–8°C) until used for the microbiological experiments. When required for use, the Panchgavya powder was suspended in sterile distilled water to attain OD 625 = 0.10±0.01.

Test bacteria
Pathogenic bacteria used in this study included: Staphylococcus aureus (MTCC 737); beta-lactamase producing multidrug resistant strains of Chromobacterium violaceum (MTCC 2656) and Serratia marcescens (MTCC 97); multidrug resistant Pseudomonas aeruginosa; and Streptococcus pyogenes (MTCC 1924). P. aeruginosa was sourced from our internal culture collection. All other cultures were procured from MTCC (Microbial Type Culture Collection, Chandigarh, India).

In vivo assay
C. elegans worms (received gift from the Biology Division, Sophia College, Mumbai) maintained on NGM (Nematode Growing Medium; 3 g/L NaCl, 2.5 g/L peptone, 1 M CaCl2, 1 M MgSO4, 5 mg/mL cholesteral, 1 M phosphate buffer of pH 6, 17 g/L agar-agar; this medium was prepared by us using the listed ingredients purchased from Merck, Mumbai or HiMedia, Mumbai) agar plate with E. coli OP50 (LabTIE B.V., JR Rosmalen, the Netherlands) as food, were kept unfed 24h prior to being used for experiments.

These worms were fed with Panchgavya by mixing this formulation (100 µL) with M9 medium (800 µL) and placed in a 24-well plate (sterile, non-treated polystyrene plates; HiMediaTPG24) containing 10 worms per well. Duration of exposure of worms to Panchgavya was kept 24, 48, 72 or 96 h, followed by addition of pathogenic bacteria (100 µL of bacterial suspension with OD600 = 1.50). Appropriate controls i.e. worms previously not exposed to Panchgavya, but exposed to pathogenic bacteria; worms exposed neither to Panchgavya nor bacteria; and worms exposed to Panchgavya, but not to bacterial pathogens, were also included in the experiment. Incubation was carried out at 22°C.

Number of live vs. dead worms were counted every day for 5 days by putting the plate (with lid) under a light microscope (4X). Straight worms were considered to be dead. Plates were gently tapped to confirm lack of movement in the dead-looking worms. On the last day of the experiment, when plates could be opened, their death was also confirmed by touching them with a straight wire, wherein no movement was taken as confirmation of death.

Statistical analysis
Values reported are means of four independent experiments, whose statistical significance was assessed using t-test performed through Microsoft Excel (2013). P values ≤0.05 were considered to be statistically significant.

Results
Worms fed on Panchgavya for 24 or 48 h registered no different (p>0.05) survival rates in the face of bacterial challenge as compared to control worms (Appendix A and Appendix B). However, worms with 72 or 96 h Panchgavya exposure registered a 15–27% (p<0.05) better survival upon challenge with different pathogenic bacteria, except for S. pyogenes as compared with control worms (Figure 1; Appendix C and Appendix D). These results demonstrate the prophylactic potential of Panchgavya against four different gram-positive and gram-negative bacterial infections, wherein previous exposure of C. elegans to this formulation was found to confer statistically significant protection on this worm against subsequent bacterial attack.
However, when administered to *C. elegans* already infected by these pathogens, *Panchgavya* was not found to offer any survival benefit to the nematode host (Appendix E). Additionally, the *Panchgavya*-exposed worm population was able to generate progenies in absence as well as presence of pathogenic bacteria, which did not happen in control wells containing *Panchgavya*-unexposed worms, suggesting overall higher fitness of *Panchgavya*-exposed worms.

**Figure 1.** *Panchgavya*-exposed *Caenorhabditis elegans* exhibit better resistance to pathogenic bacteria. Previous exposure to *Panchgavya* (for 72 or 96 h) enabled *C. elegans* population to register better survival in the face of bacterial challenge: (A) 42.50±2.52% (p=0.001) better survival till third day, and 17.50±3.54% (p=0.002) better survival on fifth day, against *P. aeruginosa*; (B) 27.30±1.86% (p=0.0001) better survival on fifth day, against *S. aureus*; (C) 21.50±1.04% (p=0.0003) better survival on fifth day, against *C. violaceum*; (D) 23±1.50% (p=0.002) higher survival on fifth day, against *S. marcescens*; (E) *Panchgavya*-exposure was not found to confer any protection on *C. elegans* against *S. pyogenes* challenge. Results pertaining to 72 h and 96 h exposure of worms to *Panchgavya*, prior to bacterial challenge, were not statistically different. Values reported are means of four independent experiments, whose statistical significance was assessed using *t*-test performed through Microsoft Excel. *P* values ≤0.05 were considered to be statistically significant.
Conclusions

Though there are few reports mentioning in vitro antimicrobial activity of either Panchagavya mixture (Gajbhiye et al., 2018) or its individual components (Deepika et al., 2016), to the best of our knowledge, the present study is the first report demonstrating in vivo anti-infective efficacy of Panchagavya mixture. The observed protective effect of Panchagavya against bacterial infection may in part stem from its immunomodulatory potential (Gajbhiye et al., 2015). This short study validates the therapeutic potential of Panchagavya mentioned in Ayurved (Susruta Samhita, 1885). Further studies for characterization (e.g. generating its metagenomic, which may reveal presence of beneficial microbes, and chemical profile) of this ancient formulation can provide insights into the mechanisms underlying its anti-infective efficacy.

Data availability

F1000Research: Dataset 1. Raw data has been provided in Appendices A-E., http://dx.doi.org/10.5256/f1000research.16485.d220622 (Patel et al., 2018).

Appendix A: Bacterial challenge to C. elegans fed on Panchagavya for 24 h
Appendix B: Bacterial challenge to C. elegans fed on Panchagavya for 48 h
Appendix C: Bacterial challenge to C. elegans fed on Panchagavya for 72 h
Appendix D: Bacterial challenge to C. elegans fed on Panchagavya for 96 h
Appendix E: Panchagavya tested as a therapy for already infected C. elegans

Grant information

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References

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The study on *Panchgavya* by Patel et al. is an interesting observation. The formulation seems to have positive effect on the worms with bacterial infections, however, at this point the authors have not elucidated the mechanism. A follow-up study could answer the following questions:

1. What are the genes that *Panchgavya* may target?
2. Is the protection by killing the bacteria?
3. Does *Panchgavya* change antibiotic resistant patterns in the bugs used in the study?
4. Can it be used with polymicrobial infections and biofilm forming bacteria?

Additional comments:

1. *The study design is appropriate and the work is technically sound.*
2. *The conclusions drawn are adequately supported by the results.*

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Antibiotic-resistant infections are a global threat, and novel antibiotic, as well as non-antibiotic approaches to deal with the problem of antimicrobial resistance (AMR), are urgently needed. In this pursuit, taking insights from traditional wisdom seems to be a logical effort. This particular research note describes an investigation of the prophylactic efficacy of a traditional Indian formulation - Panchgavya and using the nematode worm model has demonstrated such a prophylactic effect to be there against some of the pathogenic bacteria. I appreciate that they have selected important pathogens like P. aeruginosa, and S. marcescens (Enterobacteriaceae).

Despite Panchgavya being an ancient formulation, it seems to be under-investigated by modern-day scientists. Studies like this one attempting to validate the traditional medicine claims are welcome. As mentioned in the conclusion part by authors, they should take up in near future further characterization of this formulation. If such a standardized formulation can be made available for public use, it may help in reducing the overall infection burden of human populations.

- The formulation concentration \([OD_{625} = 0.10±0.01]\), is it right? The authors may use w/v units for clarity.
- Will there be any effect of different doses of Panchgavya?
- There are many interesting questions that are yet to be addressed, most possibly by taking up this research further and analyzing the mechanism, bioactive component etc.
- An independent experiment similar to MIC using a CFU-based method for each of the selected pathogens would have shed more light.
- Differential behavior on Gram +ve bacteria is quite interesting and must be studied further.

Is the work clearly and accurately presented and does it cite the current literature? Yes

Is the study design appropriate and is the work technically sound? No
Are sufficient details of methods and analysis provided to allow replication by others?  
Yes

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Are the conclusions drawn adequately supported by the results?  
Yes

**Competing Interests:** No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

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- Authors have used beta-lactamase producing antibiotic-resistant strains in their study. That is good, as resistant strains of *P. aeruginosa* and *S. marcescens* have also been listed by WHO as of high priority.
- Use of *C. elegans* as a model host by authors is also logical, as there is some overlap among the virulence factors of pathogenic bacteria damaging *C. elegans*, and those damaging human cells.
- While the current study may be approved for publication as a research note, in future authors should try to investigate the mechanisms through which 'Panchgavya' imparts protection to *C. elegans* against infectious bacteria.

Is the work clearly and accurately presented and does it cite the current literature?  
Yes

Is the study design appropriate and is the work technically sound?  
Yes

Are sufficient details of methods and analysis provided to allow replication by others?  
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?  
Yes

Are the conclusions drawn adequately supported by the results?  
Yes

**Competing Interests:** No competing interests were disclosed.

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