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MUSICAL INFLUENCE ON PROTEIN DYNAMICS IN GERMINATING FENUGREEK SEEDLINGS UNDER DIFFERENT MUSIC GENRES

Riya Kumari[1]*, Goral Jani[2] and Maulik Gadani[1]
[1]Department of Botany, St. Xavier's College (Autonomous), Ahmedabad, Gujarat, India
[2]Department of Botany, Gujarat Arts & Science College, Ahmedabad, Gujarat, India
*Corresponding author E-mail: itssinghriya25@gmail.com
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ABSTRACT

Sound as an environmental stimulus is being studied more and more for its possible effect on plant growth and development. This study explores the biochemical impact of two different types of music genres soft music and rap music on germinating seedlings of *Trigonella foenum-graecum* L. (Fenugreek). The experiment was carried out for five days, with some key protein-related biochemical parameters monitored: total protein content, enzyme protein levels, protease activity, and free amino acid concentration.

Seeds were categorized into three groups: a control (silence), soft music exposure, and rap music exposure. The results indicated significant variations among the treatments. Total protein content decreased in all groups initially, indicating utilization during germination, followed by a sharp increase on Day 4, with the greatest amount being in rap music-treated seedlings. Enzyme protein content had a steady upward trend, where both music treatments performed better compared to the control. Rap music provoked a faster enzymatic response, and soft music maintained high enzyme activity over time.

Protease activity was higher in the control group initially, reflecting stress-induced protein degradation in the absence of sound stimulation. Rap music resulted in protease level fluctuation, reflecting alternating stimulation and metabolic stress, while soft music showed moderate protease activity, reflecting stable protein turnover. The highest amino acid build-up occurred in music-treated groups on Day 5, with soft music achieving the peak concentration, followed closely by rap music.

These findings show that musical vibrations can influence protein metabolism during early plant development. The genre-specific responses indicate that soft and rap music have different effects on biochemical processes in germinating fenugreek seeds. These results support the notion that auditory stimulation can be used as a non-invasive and eco-friendly approach to promote seedling vigor and this could have future applications in sustainable agriculture and seed treatment technologies. This provides new possibilities for non-invasive biostimulation in agriculture.

Keywords: Fenugreek, Music stimulation, Protein metabolism, Enzyme activity, Seed germination.

Introduction

Plants are highly responsive organisms capable of detecting and reacting to a wide range of environmental stimuli such as light, temperature, touch, and sound. Among these, sound particularly in the form of musical vibrations has gained attention for its potential role in influencing physiological and biochemical processes in plants. Although scientific exploration of plant responses to music dates back to early pioneers like J. C. Bose (1902, 1926), T. C. Singh (1962), and Dorothy Retallack (1973), the field remains relatively underexplored. According to Patel *et al*. (2022), plants appear to be sensitive to music and may exhibit differential responses based on the type and frequency of the sound stimulus. Contemporary studies further support this notion, demonstrating that sound waves can modulate key developmental activities such as seed germination, enzyme activity, protein metabolism, and gene expression (Chowdhury *et al*., 2014; Lai & Wu, 2020).

Seed germination is a crucial developmental stage that involves rapid physiological and biochemical

transformations. Protein metabolism, including synthesis, degradation, and enzyme activation, plays a central role during this phase. French physicist Joël Sternheimer (1992) introduced the concept of *protein music* or *molecular music*, where he proposed that sound frequencies can resonate with amino acid sequences during protein synthesis. He theorized that translating proteins into musical notes based on vibrational frequencies could influence cellular processes, potentially enhancing or regulating protein expression in plants and other organisms. Sternheimer's work laid a conceptual foundation for the scientific exploration of music as a modulator of molecular biology. Inspired by this concept, the present study was undertaken to explore whether different music genres could influence protein dynamics during seed germination.

Fenugreek (*Trigonella foenum-graecum* L.), a leguminous herb of both nutritional and medicinal value, provides an excellent model for studying such responses due to its fast germination and well-documented metabolic profile. In this study, we investigate the effect of two contrasting music genres soft music and rap music on the protein dynamics of germinating fenugreek seedlings over a period of five days.

The main objective of the research is to assess how auditory stimulation influences key biochemical parameters, namely total protein content, enzyme protein concentration, protease activity, and amino acid accumulation. By comparing these responses under different sound treatments and a silent control, the study aims to elucidate genre-specific impacts on metabolic processes during early seedling growth.

Materials and Method

Seed Material and Experimental Setup

Seeds of *Trigonella foenum-graecum* L. (fenugreek) were procured from a local grocery shop for the study. A total of 50 seeds (for each set) were used, divided equally among five sterile, clean Petri dishes (10 seeds per dish), each lined with Whatman No. 1 filter paper. The filter papers were moistened with distilled water to provide the necessary moisture for germination.

Three experimental sets were prepared: Set I (for Control–in Silence), Set II (for Soft Music Exposure) and Set III (for Rap Music Exposure). Each set consisted of multiple Petri dishes placed in laboratory conditions at ambient room temperature. During the daily sound exposure sessions, each set was placed in separate, acoustically isolated areas of the lab to prevent cross-contamination of sound vibrations.

Sound Treatment

Music exposure was conducted for 1.5 hours daily, from 7:00 AM to 8:30 AM:

- Set I (Control) was kept in silence under identical environmental conditions.
- Set II was exposed to tracks of Soft Music which were selected soft songs from Hindi (Old) Cinema belonging to the era of 60s to 80s.
- Set III was exposed to tracks of Rap Music which were selected rap songs from famous rappers like Emiway Bantai, Raftaar, Kr$na and Little Bhatia.

Germination and Growth Conditions

Seeds were allowed to germinate under room temperature with regular monitoring. Distilled water was added daily to maintain adequate moisture levels, ensuring the filter papers remained damp but not waterlogged. Lids of the Petri dishes were opened every day for a short duration to allow proper aeration and avoid fungal growth.

Methodology

Following biochemical parameters were measured from 100 mg germinated seedlings daily for five consecutive days.

1. Total Protein by Lowry's method (1951)
2. Enzyme Protein by Lowry's method (1951)
3. Protease activity by Cruz et. al. method (1970)
4. Free Amino acids by Lee & Takahashi's method (1966)

The entire experiment was repeated three times to ensure reliability and reproducibility. Average values for each parameter were calculated, and standard error (SE) was computed to assess the variability among replicates.

Results and Discussion

Total Protein Content

Fig. 1 shows mg protein per gram plant material in all the sets under experimentation measured every day for a period of 5 days. It was observed that initially total protein content was found to be more in control set with very slight difference in soft music treated set. However, the amount of total protein was found to be in decreasing trend for 3 days in all the cases. This indicates that protein was being broken down and was being utilised in the process of germination. Day 4 showed significant increase in the amount of total protein in all the cases suggesting more of protein synthesis due to metabolic activation.

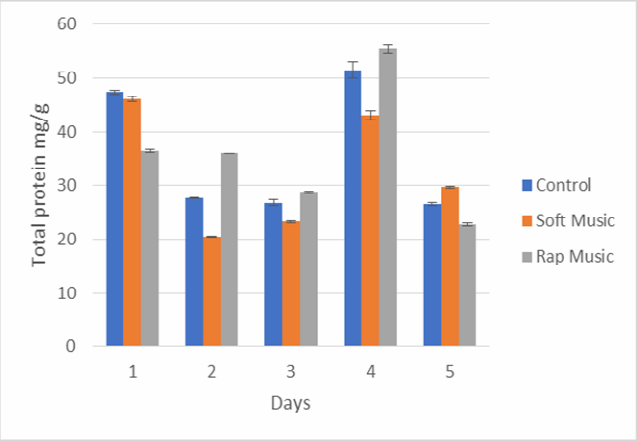

Fig. 1 : Total Protein content (mg/g) under different music genre

Here, set treated with rap music reflected more amounts of total protein as compared to other two sets suggesting more active metabolic state. Sharma *et al.* (2015) also reported higher protein concentrations in music treated ornamental plants as compared to control plants. Since rap music is a genre characterized by rhythmic and rhyming speech often with a fast pace and complex rhyme schemes, it probably caused more of vibrations that facilitated more protein synthesis. Similar findings showing protein content to be positively affected by Indian Classical ragas were also observed for plants such as soya, spinach and wheat. (Creath & Schwartz, 2004; Reddy *et al*., 2013).

Enzyme Protein Content

As shown in Figure 2, Enzyme protein content was higher in plants exposed to music compared to control during initial phase. Rap music showed a slightly higher value than soft music on Day 1, but both were significantly above control. During the middle phase, a steady increase is seen in all groups. On Day 3, rap music-treated plants had the highest enzyme protein content (5.4974 mg/g). Day 4 saw the peak levels, with rap music again leading (5.9675 mg/g), followed closely by soft music and control. On Day 5, all groups reached a plateau. Soft music-treated plants showed the highest final enzyme protein content (5.9393 mg/g), indicating sustained enzymatic stimulation.

It can be observed that enzyme proteins showed an increasing trend in all the sets studied where as in music treated sets more enzyme proteins were found as compared to control set. Higher enzyme proteins suggest fastened chemical reactions that are taking place during germination process. Enzyme proteins are vital indicators of metabolic activity, stress adaptation, and growth regulation. The observations suggest that music stimulation (both soft and rap) significantly enhances the biosynthesis or activation of enzyme proteins in fenugreek. Rap music, due to its rhythmic vibrations, may have caused a stronger short-term response, while soft music promoted consistent and sustained enzymatic activity. Coghlan (1994) also reported increased production of protein when music at the appropriate frequency is played.

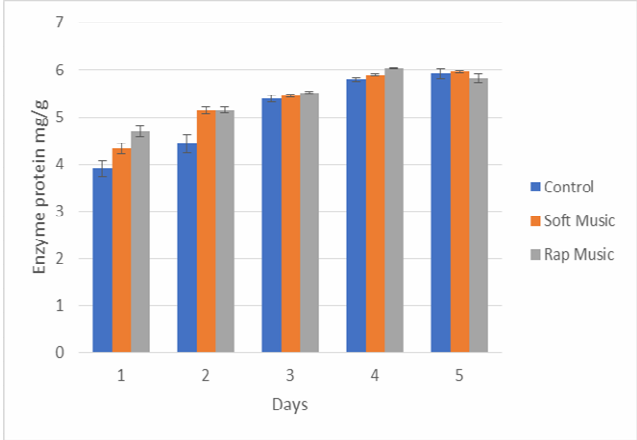

Fig. 2 : Enzyme Protein Content (mg/g) under different music genre

Protease Activity

Fig. 3 shows protease activity in terms of mg protein reduced per gram fresh plant material. Proteases are enzymes that break down proteins into amino acids. High protease activity may indicate accelerated protein degradation, which could occur during stress conditions or metabolic remodelling.

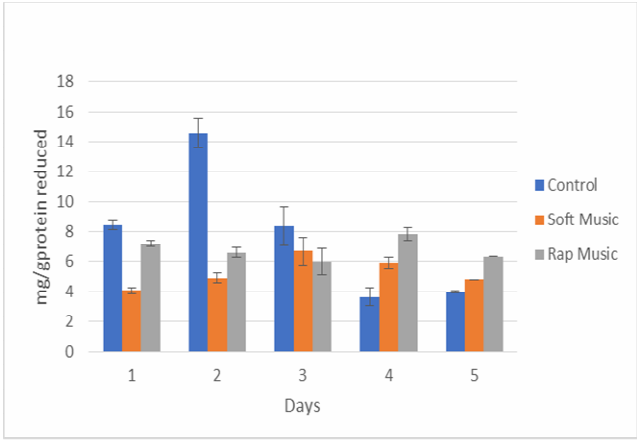

Fig. 3 : Protease activity as mg protein reduced per gm fresh material

It was observed that initially protease activity was found to be more in case of control set as compared to music treated sets. This suggests more breakdown of proteins in case of control than those that were exposed to sound vibrations suggesting possible early stress or initiation of protein turnover. Rap music triggered moderate protease activity, slightly decreasing on Day 2. Soft music had the lowest activity, indicating less

proteolysis, which may be associated with reduced stress and stable protein levels. On day 3, Soft music now shows increased protease activity (6.69), possibly reflecting normal protein remodelling during active growth. Rap music and control saw reduced activity, possibly due to stabilization or adaptation. At the later stages, rap music caused a notable increase in protease activity on Day 4 (7.86), suggesting renewed protein turnover or stress-induced activity. In Control plants the activity declined sharply, and soft music remained moderate and stable. By Day 5, rap music maintained higher activity, while control remained low, possibly due to protein resource depletion. It is known that germination can lead to changes in the types and amounts of proteins present, with some proteins being broken down and others being synthesized.

High protease activity in control early on suggests stress-induced degradation without music treatment. Soft music may promote protein conservation, shown by consistently lower activity. Rap music leads to a dynamic pattern, possibly due to alternating stimulation and stress, causing fluctuations in protease levels.

Free Amino Acids

Figure 4 illustrates the changes in free amino acid concentration (mg/g fresh weight) during fenugreek seed germination under different music exposures. On Day 1, the control group exhibited the highest amino acid level (54.17 mg/g), representing baseline metabolic activity in the absence of auditory stimuli. Both music-treated sets soft (49.73 mg/g) and rap (46.65 mg/g) showed slightly reduced levels initially, possibly reflecting early-stage stress adaptation to sound vibrations. From Day 2 onward, clear variations emerged. The soft music group showed a steady rise, peaking at 66.82 mg/g on Day 3, indicating enhanced biosynthesis linked to stable nitrogen metabolism. In contrast, the rap music group maintained lower amino acid levels initially, suggesting delayed activation of protein catabolism or conversion. However, a sharp spike in amino acid content was observed in the rap music group on Day 4 (82.48 mg/g), surpassing both soft music and control treatments. This delayed but pronounced increase suggests rhythmic vibrations from rap music may trigger metabolic acceleration at later stages, possibly due to stress-induced protein breakdown or intensified biosynthetic responses.

On Day 5, both music-treated groups recorded their highest amino acid levels soft music (88.82 mg/g) and rap music (88.54 mg/g) significantly higher than the control (74.38 mg/g). These observations confirm that musical exposure enhances amino acid accumulation, either through increased protein hydrolysis or elevated synthesis, thereby supporting metabolic readiness during germination. The results align with the enzyme and total protein trends, highlighting a coordinated protein turnover process in response to auditory cues, ultimately promoting seedling vigor.

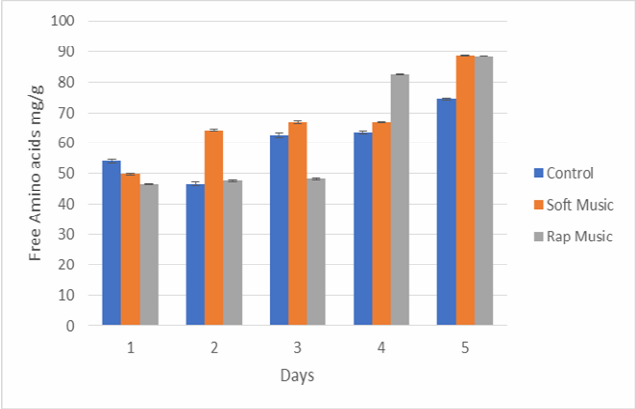

Fig. 4 : Free Amino acids (mg / g) under different music genre

Conclusion

The study concludes that exposure to music-both soft and rap-significantly influences protein dynamics during fenugreek seed germination. Music-treated seedlings exhibited higher total and enzyme protein levels, indicating enhanced biosynthesis and metabolic activity. Protease activity patterns suggested that rap music triggered more dynamic responses, while soft music maintained stable protein turnover. Amino acid content was also elevated in both music treatments by the end of the experiment, reflecting improved nitrogen metabolism. Overall, these results suggest that musical vibrations, depending on genre, can serve as effective, non-invasive stimulants to enhance early seedling development. While the present findings highlight the potential of music as a non-invasive modulator of protein dynamics during germination, further investigation is needed to understand the underlying molecular mechanisms. Continued studies in this direction may help establish music-based bio enhancement as a scientifically grounded approach in sustainable agriculture and seed technology.

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