

Abdul Kalam Technology Innovation National Fellowship

Executive Summary



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1): Title of the Project:

Prototype development for catechins extraction and production of low-cost antioxidant health supplements

2): Date of Start of the Project: 01/10/2020

3): Aims and objectives of the proposed work with timeline:

Objectives and work plan		Timeline (Months)	Status of the project as of 30 th September, 2023 (% completion)
Objective 1: Separation and purification of catechins compounds (antioxidants) from green tea leaves.		0-11	100%
i)	Development of an aqueous-based extraction technique for efficient extraction of catechins.	0-4	100%
ii)	Stabilization study of extracted catechins	5-11	100%
iii)	Production of catechins powder	10-11	100%
Objective 2: Production of low-cost antioxidant health supplements		11-42	70%
i)	Pre-formulation of catechins for dispensing antioxidant health supplements	12-16	100%

ii)	Selection of appropriate biocompatible excipients for the pre-formulation of catechins-based health supplements.	15-18	100%
iii)	Formulation of catechins-based health supplements	19-24	100%
iv)	Evaluation of <i>in-vitro</i> bioavailability of catechins from the antioxidant-based health supplements.	30 - 42	40%
v)	Long-term stability study at different stress conditions to determine the self-life of catechins-based health	30 - 52	20%
vi)	Bioavailability studies of catechins from capsule formulation with suitable animal studies models	32 - 55	10%
vii)	Polyherbal formulation of catechins-based health supplements with other compatible antioxidants such as anthocyanins, chlorogenic acid etc	32 - 51	30%
viii)	Optimization of powder flow properties (micromeritics) of extracted catechins with pharma-grade activated carbon and establish activated carbon as a potential diluent for the capsule formulation	32 - 54	30%
ix)	3D- printed solid dosage form with catechins	48-60	0%
x)	Evaluation of the market potential for the developed catechins-based health supplements.	25-30	100%
Objective 3: Establishment of linkage with renowned tea gardens of Assam for field trial and demonstration of catechins-based health supplements from their green tea leaves.		6-48	60%
i)	Identification and shortlisting of feasible tea gardens to implement the project on a pilot scale	6-18	100%
ii)	Meeting and brainstorming with the tea gardens for the implementation of pilot-scale production	8-18	100%
iii)	Field visits to the tea gardens to develop the blueprint for implementation of the pilot-scale facility	12-30	100%
iv)	Initiate the operation of Pilot scale project development with the tea garden	48 - 60	0%
Objective 4: Establishment of a startup company for commercial production of catechins-based health supplements.		36 - 60	0%

4): Significant achievements (not more than 500 words to include a List of patents, publications and prototype deployment etc.)

- An aqueous-based technique for efficient catechins extraction has been developed. The average catechins content of green tea leaves is ~ 200 mg/g of tea leaves. ~150 mg catechins/g of tea leaves i.e. ~75% extraction efficiency achieved with aqueous extraction).
- Stabilization of green tea extract has been made successfully with natural ingredients such as organic acids and fresh fruit juices with ~30% enhancement in the stabilization of green tea catechins during the long-term stability studies.
- Utilization of the tea industry's generated waste tea leaves for valorization into lightweight and high-surface activated carbon for food and pharmaceutical formulations. The manufactured carbon has a pore volume of 0.69 cc/ g and a pore size of 2.65 nm in the mesoporous range. The lightweight carbon is suitable to be incorporated as a diluent into solid dosage forms with a bulk density of 0.15 g/ cc.
- Controlling the physicochemical deterioration of catechins powder for its successful formulation into solid dosage forms. The inherent hygroscopic characteristics of the catechins powder were controlled to maintain sufficient flow properties during the manufacturing of solid dosage forms. With the incorporation of activated carbon in catechins-based capsule formulation, an enhancement in % (yield) score of 62.04, 56.67 and 68.05 was obtained for Carr's index, Hauser ratio and angle of repose, respectively.
- Development of *in-vitro* bioavailability protocol based on the *in-vitro* multiple-stage digestion model in the presence and absence of food (pre-digested food) to access the bioaccessibility and bioavailability of the formulated bioactive (i.e. catechins, anthocyanin and chlorogenic acids) in our lab facilities.
- Collaboration with 3 renowned tea gardens of Assam is in the advanced stage for field trial and demonstration of antioxidant powder production from the green tea leaves in their garden premises.

Publications:

- **Patents: 3** (Granted = 1, Submitted = 2), 2 more are under preparation
- **Authored Books: 4** (Academic Press = 1, Elsevier = 1 and CRC press = 2)
- **Book Chapters: 3**
- **Journal Papers: 14** (Published = 12, Under review = 2)

5) Concluding remarks

The main objectives of the project are to develop a prototype for catechins extraction from green tea leaves and the production of low-cost antioxidant health supplements. The project emphasizes the utilization of green and sustainable technology by using water as a solvent for extraction instead of conventional organic solvents. The outcome includes a patent application for the extraction and purification technology, as well as research papers and a book on green extraction methods.

Another objective of the project is to formulate catechins extracts into solid dosage forms such as powders, capsules, and tablets. This involves pre-formulation studies and evaluating the antioxidant potential, stability, shelf-life, and bioavailability of the formulations. A patent for enhancing the shelf-life of catechins and polyphenolic content in a health juice-based supplement has been applied for. Additionally, the project explores the utilization of waste tea leaves after catechins extraction. This includes the production of pharmaceutical-grade activated carbon from waste tea leaves, leading to a patent application. Three books and three journal papers have been published on various uses of tea waste.

The future objectives for 2023-2025 include conducting experiments on the in-vitro bioavailability of antioxidant formulations, assessing the shelf life of capsules under different conditions, and studying bioavailability using animal models. The project also aims to develop polyherbal formulations, optimize powder flow properties using activated carbon, and explore 3D-printed tablet dosage forms for personalized medicine.

The project is actively exploring to establish partnerships with tea gardens in Assam for field trials and demonstrations of the developed formulations, with a focus on technology transfer and capacity building. Negotiations for a startup company for commercial production and marketing of catechins-based health supplements are underway, with assistance in obtaining incubation space and startup funds.

In summary, the project aims to develop sustainable technology for catechins extraction, formulate health supplements, utilize tea waste, and establish collaborations for production and marketing, ultimately promoting the utilization of catechins for their antioxidant benefits.

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