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Germplasm Enhancement with the First Medicinal Crop-Varieties for Prevention and Management of Cancer and Diabetes in Bitter Gourd (Momordica charantia)

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Research Article

Keywords: Bitter gourd, germplasm enhancement, nutraceuticals, medicinal crop-variety, anticancer phytomedicine, antidiabetic phytomedicine, functional food

Posted Date: November 28th, 2025

DOI: https://doi.org/10.21203/rs.3.rs-8161039/v1

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Additional Declarations: No competing interests reported.

Abstract

Incidence of chronic diseases including cancer and diabetes is increasing globally. Fruits and vegetables are potential sources of functional phytochemicals for prevention and management of these diseases. Bitter gourd, *Momordica charantia*, a popular cucurbit crop, is known to contain a number of anticancer and antidiabetic phytomedicines but the popular cultivars in the available germplasm are poor in the content of these phytomedicines. We explored a wild bitter gourd germplasm and developed eight varieties including CBM3, CBM6, CBM10, CBM12, CBM13, CBM18, CBMH10 and CBMH12 with a view to broaden the genetic resources for nutraceuticals. We report here on the comparative contents of one anticancer phytomedicine, Cucurbitacin-B and two antidiabetic phytomedicines, Charantin and Plant Insulin in fresh fruits of 25 varieties in the enhanced germplasm constituting these eights medicinal varieties and 17 popular horticultural cultivars. We also report on their comparative performance with regard to fresh fruit weight, and correlation of the content of these three phytomedicines *inter se* and with fruit weight. Finally, we report on the identification of five varieties including CBMH10, CBMH12, CBM12, CBM10 and CBM13, in that order, for consumption of their fruits of as a source of functional foods for prevention and management of cancer and diabetes from the nutraceutically enhanced germplasm.

1. Introduction

Prevalence of chronic diseases including cancer and diabetes is increasing globally (Giovannucci et al. 2010). There were about 20 million new cases of cancer with 9.7 million deaths due to it in 2022 (Bray et al. 2024). A recent study projects 18.5 million cancer deaths by 2050, an 89.7% increase over 2022 (Bizuayehu et al. 2025). Similarly, 589 million adults were living with diabetes in 2024 and the number of deaths due to it was 3.4 million (https://diabetesatlas.org/). Death due to type-2 diabetes alone is projected at 3.68 million by 2050 (Chen et al. 2025). Utilization of nutraceutical crops, such as fruits and vegetables as a source of medicinally active phytochemicals is a potential alternative for prevention and management of these diseases (Mahmoud and Ibrahim 2021).

Bitter gourd or bitter melon, *Momordica charantia* L, is one potential cucurbit vegetable crop that can be popularized as a functional food crop. This plant contains over 60 phytomedicines active against over 30 diseases (Raman and Lau 1996). Several medicinal properties of bitter gourd including antidiabetic, anticancer, antitumor, antileukemic, antioxidant, antiulcer, anti-inflammatory, hypocholesterolemic and hypotriglyceridemic properties are well documented in research (Behera et al. 2020). Almost all parts of bitter gourd, primarily the fruits, contain Cucurbitacin-B that have proven anticancer actions. They also contain Charantin and Plant Insulin (syn. p-Insulin, Polypeptide-p) that have clinically demonstrated hypoglycemic and antihyperglycemic activities and established beneficial effects on diabetes, especially of type-2. Plant Insulin can control both type I and type II diabetes (Chakraborty 2018). However, the popularly cultivated varieties of bitter gourd in the available germplasm have lower content of phytomedicines (Kole et al. 2010). We explored the wildly grown bitter gourd germplasm for

development of varieties with high contents of these three anticancer and antidiabetic phytomedicines and developed eight varieties reported in this study.

Since the weight of fresh fruits is also an important factor of total yield of a vegetable crop and the total content of phytomedicines in each fruit, we studied on the performance of these eight varieties along with 17 popularly grown varieties from seven countries with regard to both phytomedicine contents and fresh fruit weight, and also the nature and extent of correlation of the content of these three phytomedicines *inter se* and with fruit weight. This facilitated selection of the ideal varieties for consumption of their fruits as a source of functional foods for prevention and management of cancer and diabetes.

2. Materials and Methods

2.1. Plant Materials

Six wildly grown plants belonging to *Momordica charantia* L. var. *muricata*, an allied botanical variety of the domesticated bitter gourd botanical variety, *M.c.* var. *charantia* were used for breeding of the first six medicinal varieties used in this study. Two of these medicinal varieties and a popularly grown variety, Taiwan White, belong to *M.c.* var. *charantia* were used for crossing to develop two dual-purpose hybrids. These eight varieties were grown under controlled conditions in a greenhouse following Complete Randomized Design with four replications along with 17 horticultural varieties grown popularly in seven Asian countries (**Supplementary Table 1**).

2.2. Extraction and quantification of phytomedicines

Quantification of the contents (mg/g) of one anticancer phytomedicine including Cucurbitacin-B and two antidiabetic phytomedicines including Charantin and Plant Insulin was done by HPLC analysis of lyophilized powders from fresh fruits of the 25 varieties in two replications. Detailed methods of extraction and quantification are described elsewhere (Kole et al. 2013).

2.3. Statistical analysis

Statistical analysis of variation of phytomedicine contents was done by analysis of variance (ANOVA) following Completely Randomized Design (CRD). The varietal effects were compared post hoc using Duncan's Multiple Range Test (DMRT) and assigned alphabetical grouping ranks. Correlation analysis was done following routine statistical analysis.

3. Results

3.1. Enhancement of germplasm with medicinal varieties

Pure-line selection from six wildly grown plants belonging to *Momordica charantia* var. *muricata*, an allied botanical variety of *M.c.* var. *charantia* to which most of the popularly grown horticultural varieties

of bitter gourd belong led to the development of six bitter gourd varieties including CBM3, CBM6, CBM10, CBM12, CBM13 and CBM18. Preliminary studies exhibited smaller fruit size and higher phytomedicine contents of these varieties as compared to the popular cultivars. Two varieties, CBM10 and CBM12, selected from them based on higher phytomedicine contents were hybridized with Taiwan White, a popularly grown cultivated variety (cultivar) with the largest fruit size belonging to *M.c. charantia* var. *charantia* that resulted in two hybrid varieties, CBMH10 and CBMH12. Results of evaluation of these eight varieties with regard to phytomedicine contents and fresh fruit weight are presented below.

3.2. Variation in phytomedicine contents in the enhanced germplasm

Statistical analysis of the contents of the three phytomedicines as mg/g of lyophilized powers of fresh fruits of the 25 bitter gourd varieties including the eight CBM varieties and 17 popular cultivars revealed highly significant variation (Fig. 1, **Supplementary Table 1).** The contents of Cucurbitacin-B were significantly the highest in CBM10 (0.645mg/g) and CBMH10 (0.615mg) followed by CBM13 (0.5mg). Two popular cultivars, Hybrid White Pearl and Taiwan White were equally the lowest performing varieties containing 0.12mg and 0.13mg, respectively. With respect to Charantin, CBMH10 (8.0mg) again exhibited significantly the highest content closely followed by CBM12 (7.88mg). Hybrid India Star (4.2mg) followed by Hybrid Baby Doll (5.37mg) had the lowest Charantin content. CBMH10 (4.0mg) had the highest content of Plant Insulin and was seconded by CBMH12 (0.3mg) that was closely followed by CBM12 and CBM3 with similar (0.26mg) content. Six cultivars including Hybrid Beauty Winner, Hong Kong Green, Taiwan White, Hybrid Bangkok Large, Hybrid India Star and Hybrid Taiwan White had equally the least (0.11-0.12mg) contents.

3.3. Variation in fruit sizes in the enhanced germplasm

Fresh fruit weight also exhibited highly significant variation among the varieties (Fig. 2, **Supplementary Table 1**). The varieties belonging to *M.c. charantia* bore, in general, larger fruits weighing from 60.6g to 146.33g. The *M.c. muricata* varieties had varied sizes ranging from 3.48g to 78.59g. The six CBM varieties bore smaller fruit weighing from 3.48g to 41.67g. Statistically six varieties including CBM12 (3.84g), CBM10 (4.90g) and CBM18 (5.89g) had the smallest fruits whereas Taiwan White (146.33g) had by far the largest fruits among all. Interestingly, the two hybrid varieties, CBMH12 (74.36g) and CBMH10 (64.47g) had moderate sized fruits (**Supplementary Fig. 1**).

3.4. Correlations among phytomedicine contents fruit weight

Correlation analysis among the contents of three phytomedicines and fruit weight revealed highly significant positive association ($r = 0.672$) between cucurbitacin-B content and Plant Insulin content. Charantin content and Plant Insulin content were also highly and positively correlated ($r = 0.518$).

Interestingly, fruit weight had highly significant negative association with Cucurbitacin-B (r = -0.65). Correlations of other combinations were statistically non-significant (Fig. 3, **Supplementary Table 2**).

4. Discussion

The eight bitter gourd varieties of the CBM series had, in general, higher contents of all the three anticancer and antidiabetic phytomedicines in comparison to the 17 popularly grown cultivars belonging to both *M.c muricata* and *M.c. charantia* botanical varieties. Among them, CBMH10 was found to be universally the richest. CBM12 ranked second for Charantin content and third for Plant Insulin content. Other three varieties including CBMH12, CBM3 and CBM13 had also considerable content of the phytomedicines. Therefore, consumption of fresh fruits of the varieties of the CBM series, particularly the above five varieties and their extracts or powders may help in mitigation of the problems of cancer and diabetes. Since diabetes leads also to blindness, kidney failure, heart attacks, stroke and lower limb amputation (https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases), use of these varieties as functional foods may help in controlling these diseases.

Fruit weight is an important factor of fruit yield and total phytomedicine contained in fruits. The CBM varieties had, in general, smaller fruits as compared to the popular cultivars. However, the two hybrids CBMH12 and CBMH10 bore heavier fruits equaling to many popular cultivars. These two hybrids, therefore, emerged as superior to all the varieties considering both medicinal and horticultural traits and may be recommended as dual-purpose varieties.

The correlation study has led to an interesting observation of negative correlation between fruit weight and Cucurbitacin-B content indicating the requirement of compromising fruit yield for utilization of bitter gourd varieties as a source of this anticancer phytomedicine. Another interesting observation was the positive correlation of the contents of the two antidiabetic phytomedicines, Charantin and Plant Insulin suggesting future studies on genetic and biochemical mechanisms underlying their production.

All the CBM varieties were developed by either selection or hybridization, both traditional breeding methods, and so their fruits and fruit products can be safely consumed and these varieties may enjoy acceptance by both the farmers and consumers.

5. Conclusion

The results from this study demonstrates the importance of developing crop varieties with higher contents of medicinally active bioactives for prevention and management of chronic and fatal diseases for their use as sources of functional foods. They also evidenced that wild germplasm could be a potential genetic resource for developing functional food varieties in crops.

Declarations

Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

Funding

The first author acknowledges USDA-SAC for financial support for the work. The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Author Contribution

Both the authors contributed to the study conception and design; material preparation, data collection and analysis; and manuscript preparation. Both the authors read and approved the final manuscript.

Acknowledgement

The authors acknowledge Prof. (Rtd.) Albert G. Abbot of the Department of Genetics and Biochemistry and Prof. (Rtd.) Richard K Marcus of the Department of Chemistry, Clemson University, Clemson, SC, USA for laboratory facilities; Dr. Bode Olukolu for assistance in extraction and quantification of phytomedicines –while working at the Department of Genetics and Biochemistry, and Prof. Deb Sankar Gupta from the Uttar Banga Krishi Viswavidyalaya, India for assistance in statistical analysis.

Data Availability

The detailed data are not publicly available but we will be happy to share data on reasonable request.

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Figures



Figure 1

Comparative contents of Cucurbitacin-B (1a) and Charantin (1b) and Plant Insulin (1c) in 25 bitter gourd varieties of the enhanced germplasm. The vertical lines (error bars) indicate mean±std on top of each bar in the figure. Details about the genotypes are mentioned in Supplementary Table 1.

Figure 2

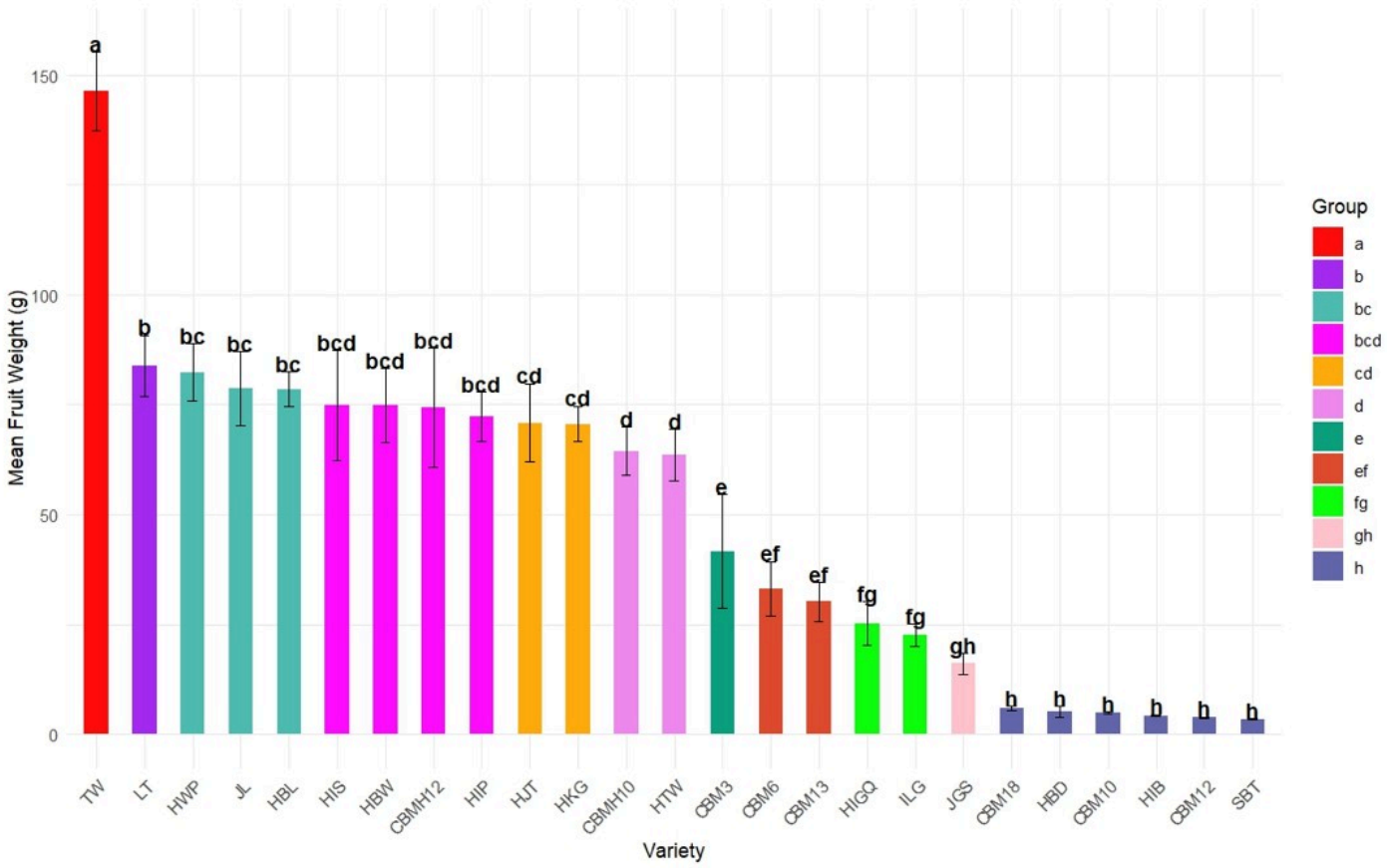


Figure 2

Variation in fruit weights among 25 varieties of bitter gourd in the enhanced germplasm. The vertical lines (error bars) indicate mean±std on top of each bar in the figure. Details about the genotypes are mentioned in Supplementary Table 1.

Figure 3

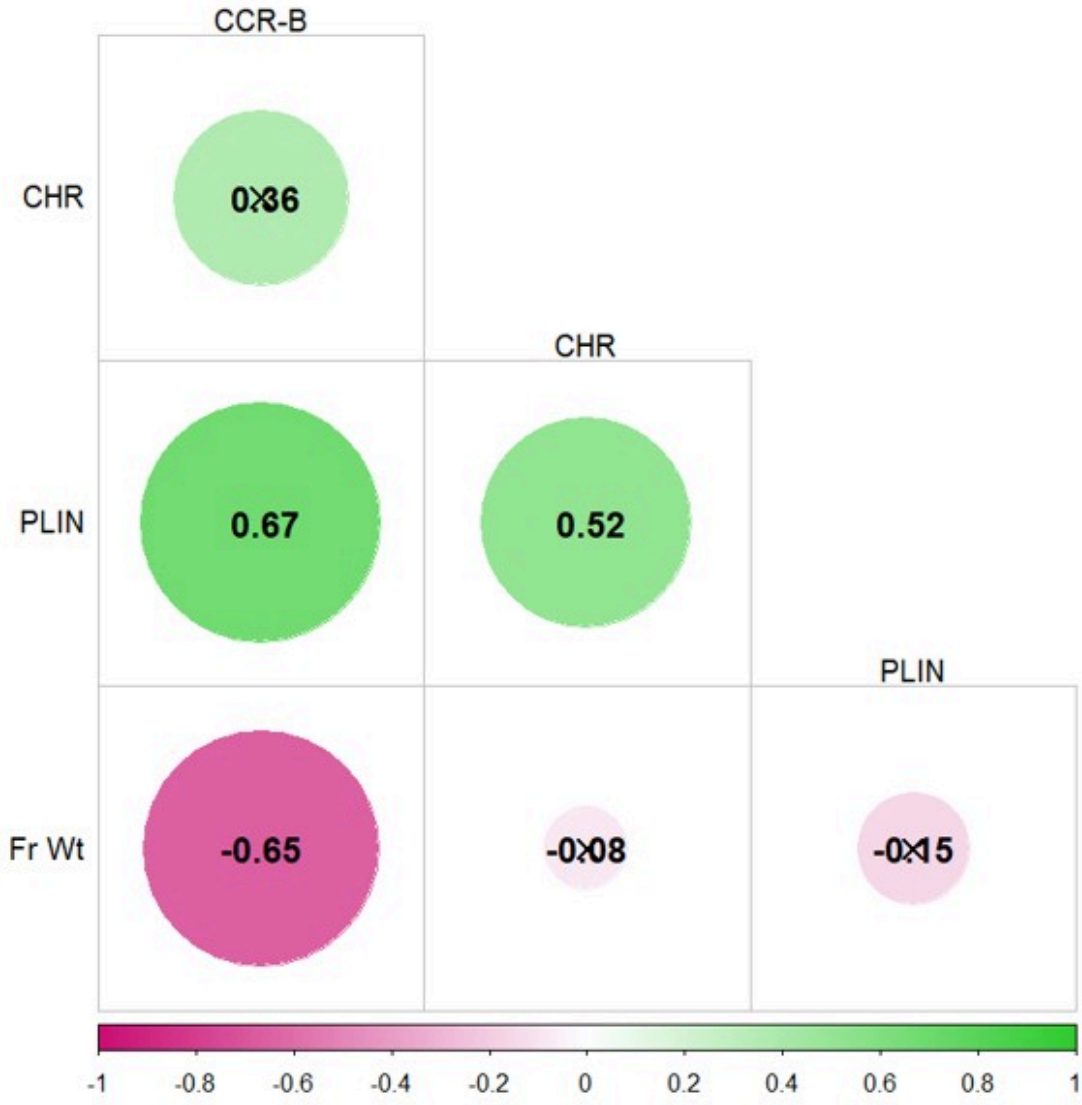


Figure 3

Correlation of the contents of Cucurbitacin-B (B), Charantin (CHR) and Plant Insulin (PLIN) *inter se* and with fruit weight (Fr Wt) in bitter gourd. Correlation coefficient (*r*) values at the center.

Supplementary Files

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