BIOAVAILABILITY OF VITAMIN C IN VARIOUS SUPPLEMENTATION FORMS

OBJECTIVE

To compare the bioavailability of various Vitamin C supplements in the liquid liposomal, powdered liposomal, and non-liposomal forms.

METHODS

Study Design

- Participants were randomly and evenly assigned to four study groups- one of two different formulations of liquid liposomal vitamin C (LLA and LLB), powdered liposomal vitamin C (PL) or non-liposomal vitamin C (NL). They were given a single oral 1 000mg dose of the corresponding supplement. Blood was taken at baseline and every two hours for 24 hours after supplement administration. Plasma ascorbic acid (AA) levels were measured.

Participants

- Forty metabolically healthy adults between 20 and 50 years of age were enrolled in the study.

Active Substances

- **Liposomal Product A (LLA)** Plantacorp GmbH Liposomal Vitamin C 1 000mg in liquid form
- **Liposomal Product B (LLB)** 1 000mg in liquid form
- **Powdered Liposomal Product (PL)** 1 000 mg in capsule form
- **Non-Liposomal Product (NL)** 1 000mg in tablet form

Statistical Analysis

- Pharmacokinetic parameters of C_{max} and T_{max} were determined from the raw data.
- The area under the curve from baseline to 24 hours (AUC_{0-t}) and incremental AUC_{0-t} ($iAUC_{0-t}$) were both calculated using the trapezoidal rule. Significant differences in AUC and iAUC between groups were analyzed by repeated measures ANOVA.
- Oral bioavailability value (OBV) was determined as study group 1 $iAUC_{0-t}$ / study group 2 $iAUC_{0-t}$.
- A two-way ANOVA was performed to determine the difference between groups in mean plasma AA levels at each time point. Statistical significance was calculated using a Tukey post-hoc test.
- A repeated measures ANOVA was performed to determine the change from baseline at each time point for each supplement group. Statistical significance was calculated using a Tukey post-hoc test.

RESULTS

- Between group analysis showed that plasma AA levels were significantly higher in LLA than LLB from hour 10 through hour 20. Plasma levels from LLA group were significantly higher than PL and NL from hour 4 through the end of the study.
- Within group analysis showed that the LLA group had plasma AA levels significantly higher than baseline from hour 2 to hour 24. LLB group had significantly higher plasma AA from baseline from hour 4 to hour 16. PL and NL only had values significantly higher from baseline at hour 2 to hour 6.

Table 1. Vitamin C Pharmacokinetic Parameters

Measurements	LLA	LLB	PL	NL
C_{max} (mg/dL)	2,78	2,51	0,97	1,12
T_{max} (hours)	12	8	4	4
AUC_{0-t} (mg*hr/dL)[a]	51,86	34,51	15,19*	17,61*
$iAUC_{0-t}$ (mg*hr/dL)[a]	36,76	19,15	1,70*	3,02*

[a] AUC and iAUC calculated using trapezoidal rule
* Value is significantly different from group LLA.

Table 2. Oral Bioavailability[a]

Supplement Group	OBV of LLA[b]
LLB	1,92
PL	21,64
NL	12,17

[a] Calculated as PlantaCorp iAUC/iAUC of each study arm
[b] OBV for LLA compared to the other supplement groups

Figure 1. Plasma AA Levels Over Time

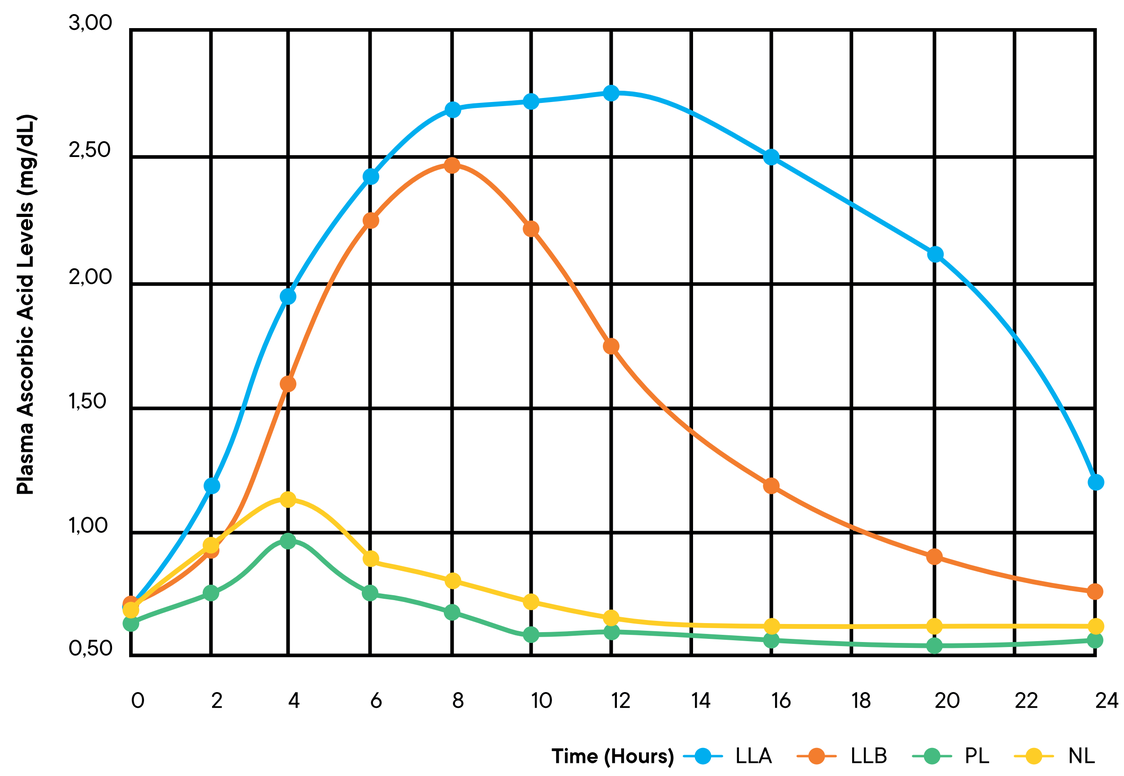

Figure 1. Plasma AA levels over time after administration of a 1 000mg supplement in various forms.*
***LLA was significantly more bioavailable than PL and NL. Although there was no significant difference in AUC between LLA and LLB, LLA plasma AA concentrations remained significantly higher than LLB up to the end of the study.**

DISCUSSION

- Overall, the PlantaCorp GmbH Liposomal Vitamin C supplement (LLA) had the highest bioavailability compared to the other supplement groups.
- AUC data indicates that not only did participants in the LLA group reach a higher level of AA in their blood, but it remained in their blood for the longest period of time, resulting in an overall greater exposure to vitamin C than any other group.
- The PL group had the lowest C_{max} and AUC compared to the other groups. Powdered liposomes are marketed as being as bioavailable as liquid liposomal supplements with the advantage of being shelf-stable and user-friendly. However, the manufacturing process can often disrupt the structure and integrity of the liposomes. This could explain why the PL group performed only as well as the NL group.

CONCLUSIONS

PlantaCorp's liquid-based liposomes are an effective way to deliver vitamin C to the blood stream and can maintain elevated blood levels for up to 24 hours. Based on these data, we see that liquid liposomal supplements significantly increased the bioavailability of vitamin C when compared to powdered liposomal or non-liposomal products.

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