



Dedicated to

My Parents

**(Late) Mr. Maibam Kameshor Singh
&
Mrs. Maibam Thambalngoubi Devi**

DECLARATION BY THE CANDIDATE

The hereby declared that the thesis entitled “Development and Characterization of starch-polyphenol complex from gorgon nut (*Euryale ferox*) and its application” submitted to the School of Engineering, Tezpur University in partial fulfillment for the award of the degree of Doctor of Philosophy in Food Engineering and Technology, is a record of bonafide research work accomplished by me under the supervision of Professor S.C. Deka.

All assistance received from various sources have been appropriately acknowledged. No part of this thesis has been submitted elsewhere for award of any other degree.

Date:

Place: Tezpur


(Maibam Baby Devi)

Reg. No. TZ189839 of 2018



तेजपुरविश्वविद्यालय/ TEZPUR UNIVERSITY
(संसदके अधिनियम द्वारा स्थापित केंद्रीय विश्वविद्यालय)
(A Central University established by an Act of Parliament)
तेजपुर-784028 :: असम/ TEZPUR-784028 :: ASSAM

Prof. Sankar Chandra Deka, FRSC, FRSB
Department of Food Engineering and Technology
School of Engineering
Tezpur University

Email: sankar@tezu.ernet.in
Phone: 03712-26-7100

CERTIFICATE OF THE SUPERVISOR

This is to certify that the thesis entitled “**Development and characterization of starch-polyphenol complex from gorgon nut (*Euryale ferox*) and its application**” submitted to the Department of Food Engineering and Technology, School of Engineering, Tezpur University in partial fulfillment for the award of the degree of Doctor of Philosophy in Tezpur University is a record of research carried out by Ms. Maibam Baby Devi under my supervision and guidance.

All the help received by her from various sources has been duly acknowledged.

No part of this thesis has been submitted elsewhere for the award of any other degree.

(Prof. Sankar Chandra Deka)

Date:

Place:

Acknowledgements

First and foremost, I am grateful to God for his blessings and for safeguarding me well during this phase of my life. My aspiration of earning a Ph.D. would become would have never come true without his guidance and blessing.

I would like to express my sincere gratitude to my supervisor, Prof. S.C. Deka for enlightening me with the first glance of research, his guidance, patience, motivation, and continuous support towards research activities.

I want to express my gratitude to the experts on my doctoral committee, Prof. Nandan Sit, Prof. Swapan Kumar Dolui and Prof. Manabendra Mandal for their intelligent criticism and support, which motivated me to broaden my study through various perspectives.

Sincere regards to Prof. Shambhu Nath Singh, Vice-Chancellor, Tezpur University, Dr. Lakshmikant S. Badwaik, Head, Department of Food Engineering & Technology for providing necessary facilities to carry out the research work.

I would like to express my gratitude and pleasure for the assistance I have received from Professors Dr. Rupak Mukhopadhyay and Dr. Suman Dasgupta of the Department of Molecular Biology and Technology, Tezpur University, for sparing their valuable time and constant support especially when it comes to carrying out cell line studies for anti-inflammatory and anti-diabetic studies and granting me access to their laboratories and research facilities.

I express my sincere thanks to all the Doctoral Research Committee for their constant support, valuable suggestions, and insights into my research. Their suggestions and insights have helped me in many ways in articulating and developing the thesis.

I also express my sincere gratitude to SAIC, Tezpur University, Tezpur, Assam, SAIF, IIT Bombay, Maharashtra, NMR, Research Centre, SIF, IISc, Bangalore. Many of the findings in the thesis wouldn't have been accomplished without their assistance.

I would like to extend my thanks to all staff, faculty, and colleagues in the Department of Food Engineering and Technology, Tezpur University for supporting me throughout my research and making my time in the place enjoyable. I particularly would like to thank,

Dr. Sourav Chakraborty, Dr. Arup J Das, Mr. Biju Boro, Dr. C. Nickhil, Dr. Dipankar Kalita, Ms. Archana Sinha, Dr. G.V.S Bhagya Raj, Mr. Manas Jyoti Das, Mr. Manoj Sharma, Ms. Munmi Borah, Ms. Nemnunhoi Haokip, Ms. Honey Gupta, Ms. N. Sophia Devi, Ms. Payel Dhar, Ms. Sangita Muchahary, Mr. Siddharth Kaushik and Ms. Urbashi Neog,

I am indebted to the University Grants Commission, Govt. of India, and Tezpur University for providing financial assistance in the form of UGC-NET-JRF fellowship.

I would like to express my gratitude to my mother, family, uncles, aunts, cousins, and friends for all of their help, support, motivation, and encouragement to persevere through the challenging moments of my PhD journey.

A special thanks to my brother Dr. Maibam Wanta Khuman, my sister-in-law Dr. Vandhana Kumari Leitanthem, my sisters Dr. Yendrebam Latika, and Dr. Yendrebam Krishnakumari, who helped me in many special ways.

Tezpur

June, 2023

(Maibam Baby Devi)

List of Tables

Table No.	Title	Page No.
2.1	Chemical composition and amylose content of <i>Euryale ferox</i> kernel starch	2.7
2.2	Gelatinization properties of <i>Euryale ferox</i> kernel starch	2.11
2.3	Swelling power and solubility index of <i>Euryale ferox</i> kernel starch	2.13
2.4	Pasting properties of <i>Euryale ferox</i> kernel starch	2.14
2.5	Color parameters of <i>Euryale ferox</i> kernel starch	2.16
2.6	<i>In vitro</i> starch digestibility of <i>Euryale ferox</i> kernel starch	2.17
3.1	Total phenolic content and total flavonoid content of <i>Euryale ferox</i> seed shell extract	3.13
3.2	DPPH radical scavenging activity of <i>Euryale ferox</i> seed shell extract	3.15
3.3	ABTS scavenging activity of <i>Euryale ferox</i> seed shell extract	3.16
3.4	FRAP reducing activity of <i>Euryale ferox</i> seed shell extract	3.16
3.5	Phytochemicals screening of EFSSE by HR-LCMS	3.20
3.6	Retention time of standard polyphenols at 254 nm by RP-HPLC method	3.21
3.7	Quantification of polyphenols by RP-HPLC	3.22
4.1	Starch fractions of <i>Euryale ferox</i> kernel starch-polyphenols complex	4.52
4.2	Determination of predicted glycemic index (pGI) of the <i>Euryale ferox</i> kernel starch-polyphenols complex	4.55
4.3	Color properties of <i>Euryale ferox</i> kernel starch-polyphenols complex	4.58
4.4	Swelling power and solubility index of <i>Euryale ferox</i> kernel starch-polyphenols complex	4.60
5.1	Physical properties of bread fortified with <i>Euryale ferox</i> seed shell extract	5.9
5.2	Color properties of bread fortified with <i>Euryale ferox</i> seed shell extract	5.11

5.3	<i>In vitro</i> starch digestibility of bread fortified with <i>Euryale ferox</i> seed shell extract	5.12
5.4	Digestion kinetics of bread fortified with <i>Euryale ferox</i> seed shell extract	5.14
5.5	Determination of pGI of bread fortified with <i>Euryale ferox</i> seed shell extract	5.15
5.6	Selection of swarm intelligence supervised neural network (SISNN) best architecture	5.18
5.7	Determination of reaction rate and predicted GI of bread fortified with <i>Euryale ferox</i> seed shell extract based on swarm intelligence supervised neural network (SISNN) predicted data	5.19
5.8	Reaction rate constant and predicted GI associated with swarm intelligence supervised neural network (SISNN) sensitivity analysis-based data	5.20
5.9	Determination of extracted Eigen vectors of principal component analysis (PCA)	5.23
5.10	Selection of proportional odds modeling (POM) coefficients	5.23
6.1	Moisture content, specific volume, and textural properties of gluten free bread incorporated with starch-polyphenol complex	6.7
6.2	Color parameters of gluten free bread incorporated with <i>Euryale ferox</i> kernel starch- <i>Euryale ferox</i> seed shell extract complex	6.8
6.3	Starch fractions of gluten free bread incorporated with <i>Euryale ferox</i> kernel starch- <i>Euryale ferox</i> seed shell extract complex	6.9
6.4	Determination of predicted glycemic index (pGI) of gluten free bread incorporated with <i>Euryale ferox</i> kernel starch- <i>Euryale ferox</i> seed shell extract complex	6.10
6.5	Total phenolic content (mg GAE/100g) of gluten free bread incorporated with <i>Euryale ferox</i> kernel starch- <i>Euryale ferox</i> seed shell extract complex	6.12
6.6	Total flavonoid content (mg QE/100g) of gluten free bread incorporated with <i>Euryale ferox</i> kernel starch- <i>Euryale ferox</i> kernel starch- <i>Euryale ferox</i> seed shell extract complex	6.12

List of Figures

Fig. No.	Title	Page No.
1.1	(a) <i>Euryale ferox</i> fruit (b) Cross section of <i>Euryale ferox</i> fruit	1.2
2.1	Herbarium of <i>Euryale ferox</i>	2.6
2.2	(A) <i>Euryale ferox</i> seeds of Assam (B) <i>Euryale ferox</i> kernel of Assam (C) <i>Euryale ferox</i> shell of Assam (D) <i>Euryale ferox</i> kernel starch of Assam (E) <i>Euryale ferox</i> seeds of Manipur (F) <i>Euryale ferox</i> kernel of Manipur (G) <i>Euryale ferox</i> shell of Manipur (H) <i>Euryale ferox</i> kernel starch of Manipur	2.7
2.3	(a) SEM micrograph of <i>Euryale ferox</i> kernel starch of Assam; (b) SEM micrograph of <i>Euryale ferox</i> kernel starch of Manipur	2.9
2.4	X-ray diffraction (XRD) pattern of <i>Euryale ferox</i> kernel starch	2.10
2.5	FT-IR spectra of <i>Euryale ferox</i> kernel starch	2.11
2.6	DSC thermogram of <i>Euryale ferox</i> kernel starch	2.12
2.7	Thermogravimetric analysis of <i>Euryale ferox</i> kernel starch	2.12
3.1	DPPH radical scavenging activity of <i>Euryale ferox</i> seed shell extract	3.14
3.2	ABTS scavenging activity of <i>Euryale ferox</i> seed shell extract	3.15
3.3	HR-LCMS chromatogram of <i>Euryale ferox</i> seed shell extract	3.19
3.4	α -amylase inhibition of <i>Euryale ferox</i> seed shell extract	3.23
3.5	α -glucosidase inhibition of <i>Euryale ferox</i> seed shell extract	3.24
3.6	DPP-IV enzyme inhibition of <i>Euryale ferox</i> seed shell extract	3.25
3.7	MTT assay of L6 muscle cell treated with <i>Euryale ferox</i> seed shell extract	3.27

3.8	Glucose uptake assay of <i>Euryale ferox</i> seed shell extract	3.27
3.9	MTT assay of THP-1 cell treated with <i>Euryale ferox</i> seed shell extract	3.29
3.10	Real Time PCR analysis showing Cox-2 mRNA level in THP-1 macrophage pre-treated with or without <i>Euryale ferox</i> seed shell extract in varied concentration, in presence or absence of LPS (100 ng/mL) for 4 h.	3.30
3.11	Real Time PCR analysis showing TNF- α mRNA level in THP-1 macrophage pre-treated with or without <i>Euryale ferox</i> seed shell extract in varied concentration, in presence or absence of LPS (100 ng/mL) for 4 h.	3.30
3.12	Real Time PCR analysis showing IL-6 mRNA level in THP-1 macrophage pre-treated with or without <i>Euryale ferox</i> seed shell extract in varied concentration, in presence or absence of LPS (100 ng/mL) for 4 h.	3.31
3.13	Real Time PCR analysis showing IL-23 mRNA level in THP-1 macrophage pre-treated with or without <i>Euryale ferox</i> seed shell extract in varied concentration, in presence or absence of LPS (100 ng/mL) for 4 h.	3.31
3.14	Real Time PCR analysis showing IL-34 mRNA level in THP-1 macrophage pre-treated with or without <i>Euryale ferox</i> seed shell extract in varied concentration, in presence or absence of LPS (100 ng/mL) for 4 h.	3.32
3.15	Real Time PCR analysis showing IL-1 β mRNA level in THP-1 macrophage pre-treated with or without <i>Euryale ferox</i> seed shell extract in varied concentration, in presence or absence of LPS (100 ng/mL) for 4 h.	3.32

4.1	Preparation and characterization of <i>Euryale ferox</i> kernel starch-polyphenols complex	4.8
4.2	(F1) <i>Euryale ferox</i> kernel starch-ferulic acid complex; (Q1) <i>Euryale ferox</i> kernel starch-quercetin complex; (GA1) <i>Euryale ferox</i> kernel starch-gallic acid complex; (RT1) <i>Euryale ferox</i> kernel starch-rutin complex; (CT1) <i>Euryale ferox</i> kernel starch-catechin complex; (ES1) <i>Euryale ferox</i> kernel starch- <i>Euryale ferox</i> seed shell extract complex	4.9
4.3	(a) XRD pattern of ferulic acid; (b) XRD pattern of <i>Euryale ferox</i> kernel starch-ferulic acid complex	4.10
4.3	(c) XRD pattern of quercetin; (d) XRD pattern of <i>Euryale ferox</i> kernel starch-quercetin complex	4.11
4.3	(e) XRD pattern of gallic acid; (f) XRD pattern of <i>Euryale ferox</i> kernel starch-gallic acid complex	4.13
4.3	(g) XRD pattern of rutin; (h) XRD pattern of <i>Euryale ferox</i> kernel starch-rutin complex	4.14
4.3	(i) XRD pattern of catechin; (j) XRD pattern of <i>Euryale ferox</i> kernel starch-catechin complex	4.15
4.3	(k) XRD pattern of <i>Euryale ferox</i> seed shell extract; (l) XRD pattern of <i>Euryale ferox</i> kernel starch- <i>Euryale ferox</i> seed shell extract complex	4.17
4.4	(a) FTIR spectra of ferulic acid; (b) FTIR spectra of <i>Euryale ferox</i> kernel starch-ferulic acid complex	4.19
4.4	(c) FTIR spectra of quercetin; (d) FTIR spectra of <i>Euryale ferox</i> kernel starch-quercetin complex	4.20
4.4	(e) FTIR spectra of gallic acid; (f) FTIR spectra of <i>Euryale ferox</i> kernel starch-gallic acid complex	4.22

4.4	(g) FTIR spectra of rutin; (h) FTIR spectra of <i>Euryale ferox</i> kernel starch-rutin complex	4.23
4.4	(i) FTIR spectra of catechin; (j) FTIR spectra of <i>Euryale ferox</i> kernel starch-catechin complex	4.24
4.4	(k) FTIR spectra of <i>Euryale ferox</i> seed shell extract; (l) FTIR spectra of <i>Euryale ferox</i> kernel starch- <i>Euryale ferox</i> seed shell extract complex	4.25
4.5	(a) ¹ H NMR spectra of pregelatinized-EFKS; (b) ¹ H NMR spectra of ferulic acid; (c) ¹ H NMR spectra of <i>Euryale ferox</i> kernel starch with-ferulic acid complex	4.28
4.5	(d) ¹ H NMR spectra of quercetin; (e) ¹ H NMR spectra of ‘Q1’ <i>Euryale ferox</i> kernel starch-quercetin (2.5%) complex	4.30
4.5	(f) ¹ H NMR spectra of gallic acid; (g) ¹ H NMR spectra of <i>Euryale ferox</i> kernel starch-gallic acid (2.5%) complex	4.31
4.5	(h) ¹ H NMR spectra of rutin; (i) ¹ H NMR spectra of <i>Euryale ferox</i> kernel starch-rutin (2.5%) complex	4.32
4.5	(j) ¹ H NMR spectra of catechin; (k) ¹ H NMR spectra of <i>Euryale ferox</i> kernel starch-catechin (2.5%) complex	4.33
4.5	(l) ¹ H NMR spectra of EFSSE (<i>Euryale ferox</i> seed shell extract); (m) ¹ H NMR spectra of <i>Euryale ferox</i> kernel starch- <i>Euryale ferox</i> seed shell extract (2.5%) complex	4.34
4.6	(a) DSC thermogram of ferulic acid; (b) DSC thermogram of <i>Euryale ferox</i> kernel starch-ferulic acid complex	4.36
4.6	(c) DSC thermogram of quercetin; (d) DSC thermogram of <i>Euryale ferox</i> kernel starch-quercetin complex	4.38

4.6	(e) DSC thermogram of gallic acid; (f) DSC thermogram of <i>Euryale ferox</i> kernel starch-gallic acid complex	4.40
4.6	(g) DSC thermogram of rutin; (h) DSC thermogram of <i>Euryale ferox</i> kernel starch-rutin complex	4.42
4.6	(i) DSC thermogram of Catechin; (j) DSC thermogram of <i>Euryale ferox</i> kernel starch-catechin complex	4.43
4.6	(k) DSC thermogram of <i>Euryale ferox</i> seed shell extract; (l) DSC thermogram of <i>Euryale ferox</i> kernel starch-catechin complex	4.44
4.7	SEM image of pregelatinized <i>Euryale ferox</i> kernel	4.46
4.8	SEM images of <i>Euryale ferox</i> kernel starch-ferulic acid complex, F1, F2, F3 and F4 indicated <i>Euryale ferox</i> kernel starch complexed with 2.5, 5, 7.5 and 10 g ferulic acid per 100 g starch respectively	4.47
4.9	SEM images of <i>Euryale ferox</i> kernel starch-Quercetin complex; Q1, Q2, Q3 and Q4 indicated <i>Euryale ferox</i> kernel starch complexed with 2.5, 5, 7.5 and 10 g quercetin per 100 g starch respectively	4.47
4.10	SEM images of <i>Euryale ferox</i> kernel starch-gallic acid complexes; GA1, GA2, GA3 and GA4 indicated <i>Euryale ferox</i> kernel starch complexed with 2.5, 5, 7.5 and 10 g gallic acid per 100g starch respectively	4.48
4.11	SEM images of <i>Euryale ferox</i> kernel starch-rutin complexes; RT1, RT2, RT3 and RT4 indicated <i>Euryale ferox</i> kernel starch complexed with 2.5, 5, 7.5 and 10 g rutin per 100 g starch respectively	4.48
4.12	SEM images of <i>Euryale ferox</i> kernel starch-catechin complexes; CT1, CT2, CT3 and CT4 indicated <i>Euryale ferox</i> kernel starch	4.49

	complexed with 2.5, 5, 7.5 and 10 g catechin per 100 g starch respectively	
4.13	SEM images of <i>Euryale ferox</i> kernel starch- <i>Euryale ferox</i> seed shell extract complexes; ES1, ES2, ES3 and ES4 indicated <i>Euryale ferox</i> kernel starch complexed with 2.5, 5, 7.5 and 10 g <i>Euryale ferox</i> seed shell extract per 100 g starch respectively	4.49
4.14	(a) Starch hydrolysis kinetics of <i>Euryale ferox</i> kernel starch-ferulic complex; (b) <i>Euryale ferox</i> kernel starch-quercetin complex (c) <i>Euryale ferox</i> kernel starch-gallic acid complex; (d) <i>Euryale ferox</i> kernel starch-rutin complex (e) <i>Euryale ferox</i> kernel starch-catechin complex (f) <i>Euryale ferox</i> kernel starch- <i>Euryale ferox</i> seed shell extract complex	4.54
4.15	DPPH radical scavenging activity of <i>Euryale ferox</i> kernel starch-polyphenols complex	4.57
5.1	Bread fortified with <i>Euryale ferox</i> seed shell extract (EFSSE)	5.9
5.2	(a) Starch hydrolysis (%) pattern of different bread samples fortified with <i>Euryale ferox</i> seed shell extract	5.13- 5.14
	(b) Fitting plots between experimental and predicted data for starch hydrolysis kinetics of different bread samples fortified with <i>Euryale ferox</i> seed shell extract on mathematical modeling	
5.3	Methodology for the determination of swarm intelligence supervised neural network (SISNN) based reaction rate constant (k) and predicted glycemic index (pGI)	5.17
5.4	Architecture for the predictive modeling <i>in vitro</i> digestion kinetics of bread fortified with <i>Euryale ferox</i> seed shell extract	5.17

5.5	Plots of experimental and estimated starch hydrolysis kinetics of bread fortified with <i>Euryale ferox</i> seed shell extract based on Swarm Intelligence Supervised Neural Network (SISNN)	5.18
5.6	Sensitivity analysis of starch hydrolysis and predicted GI associated with swarm intelligence supervised neural network (SISNN)	5.20
5.7	Selection of the principal component based on the Eigen values for sensory evaluation of bread fortified with <i>Euryale ferox</i> seed shell extract	5.22
6.1	<i>Euryale ferox</i> kernel starch- <i>Euryale ferox</i> seed shell extract complex incorporated gluten free bread	6.5
6.2	Starch hydrolysis of gluten free bread incorporated with <i>Euryale ferox</i> kernel starch- <i>Euryale ferox</i> seed shell extract complex	6.10
6.3	DPPH radical scavenging activity of gluten free bread incorporated with <i>Euryale ferox</i> kernel starch- <i>Euryale ferox</i> seed shell extract complex	6.13
6.4	Radar plot of sensory scores of gluters free bread incorporated with <i>Euryale ferox</i> kernel starch- <i>Euryale ferox</i> seed shell extract complex	6.14

List of abbreviations

2-NBDG	2-[N-(7-nitrobenz-2-oxa-1,3-diazol-4-yl) amino]-2-deoxy-D-glucose
AUC	Area under the hydrolysis curve
ABTS	2,2'-azino-bis 3-ethylbenzothiazoline-6-sulphonic acid
ANN	Artificial Neural Network
AOAC	Association of Official Analytical Chemists
ATCC	American type culture collection
AUC	Area under curve
DC	Decoction
DMSO	Dimethyl sulfoxide
DPPH	2,2-diphenyl-1-picrylhydrazyl
DPPIV	Dipeptidyl Peptidase-IV
EFKS	<i>Euryale ferox</i> kernel starch
EFSSE	<i>Euryale ferox</i> seed shell extract
FBS	Fetal Bovine Serum
FCR	Folin-Ciocalteau reagent
FRAP	Ferric reducing antioxidant power assay
FTIR	Fourier transform infrared spectroscopy
GAE	Gallic acid equivalent
HI	Hydrolysis index
HRLCMS	Higher Resolution Liquid Chromatography
IR	Infrared
k	Kinetic constant
MAE	Microwave assisted extraction
MC	Maceration
MFI	Mean fluorescence intensity
MS	Mass spectroscopy
MSE	Mean square error
MTT	3-(4, 5-dimethylthiazolyl-2)-2, 5-diphenyltetrazolium bromide)
NCCS	National Centre for Cell Science
NMR	Nuclear magnetic resonance

PCA	Principal component analysis
pGI	Predicted glycemic index
POM	Proportional Odd Modelling
PS	Pregelatinized <i>Euryale ferox</i> kernel starch
PSO	Particle Swarm Optimization
QE	Quercetin equivalent
RDS	Rapidly digestible starch
RMSE	Root means square error
RP-HPLC	Reverse Phase High Performance Liquid Chromatography
rpm	Rotation per minute
RS	Resistant starch
RPMI	Roswell Park Memorial Institute
RT	Retention time
RVA	Rapid Visco Analyzer
SD	Standard Deviation
SDS	Slowly digestible starch
SEM	Scanning Electron Microscopy
SISNN	Swarm Intelligence Supervised Neural Network
SSE	Sum of Square Error
t	Time
T2-DM	Type 2 Diabetes Mellitus
TFC	Total flavonoid content
TOF	TOF Time of flight
TPC	Total Phenolic Content
TPTZ	2,4,6-Tripyridyl-S-triazine
TS	Total starch
UAE	Ultrasound assisted extraction
UHPLC-PDA	UHPLC-PDA- Ultra-performance liquid chromatography coupled to photodiode array detection
UV-VIS	Ultraviolet-visible
XRD	X-ray diffraction

List of symbols

%	Percentage
/	Per
<	Lesser than
>	Greater than
°C	Degree celcius
µg	Microgram
µL	Microlitre
µm	Micrometre
µmol	Micromolar
A _B	Absorbance of the blank sample
AlCl ₃	Aluminum chloride
a*	Redness
A _E	Absorbance of the plant extract
b*	Yellowness
cm	Centimetre
FeCl	Ferric chloride
FeSO ₄	Ferrous sulfater
g	Gram
h	Hour
H	Hydrogen atom
IC ₅₀	Half maximal inhibitory concentration
L*	Lightness
m	Minute
m/z	Mass by charge
mAU	Milli absorbance unit
mg	Milligram
mm	Millimeter
mM	Millimolar
Nm	Nanometer
p	p-value
R ²	Correlation coefficient
s	Second

U	Unit
v	Volume
W	Watt
w	Weight
w/v	Weight by volume
w/w	Weight by weight
α	α Alpha
β	Beta
∞	Infinity
λ	Lambda
Δ	Delta
π	pi
δ	Delta
Σ	Sigma
θ	Theta
H ₂ O	Water
HCOOH	Formic acid
Na ₂ CO ₃	Sodium carbonate
