

# Contents

<i>Abstract</i>	<i>i</i>
<i>Declaration by candidate</i>	<i>ii</i>
<i>Certificate from supervisor</i>	<i>iii</i>
<i>Acknowledgements</i>	<i>vi</i>
<i>Contents</i>	<i>v</i>
<i>List of Tables</i>	<i>ix</i>
<i>List of Figures</i>	<i>x</i>
1 Introduction.....	1
1.1 Preamble.....	1
1.2 Inference of wholesomeness .....	2
1.3 Standard based quality inference.....	2
1.4 AI in quality inference .....	5
1.5 Applicability of deep learning models in quality inference .....	8
1.6 Motivation .....	9
1.7 Research gap .....	9
1.8 Objectives.....	10
1.9 Justification .....	10
1.10 Summary of chapter I and arrangement of the thesis.....	10
1.11 References of chapter I.....	11
2 Review of literature.....	15
2.1 Non-destructive quality assessment of agricultural produce.....	15
2.2 AI-ML in quality inference of agricultural produce.....	17
2.2.1 Application of digital image-based ML in quality inference of agricultural produce .....	18
2.2.2 Application of hyper/multi spectral image based ML in quality inference of agricultural produce .....	22
2.2.3 Application of other non-destructive techniques-based ML in quality inference of agricultural produce .....	23
2.3 Deep learning solutions in agri-food systems .....	25

2.3.1	Commonly used deep learning tools .....	25
2.3.2	Image-based deep learning solutions .....	26
2.3.3	Inference of wholesomeness of agricultural produce based on deep learning .....	26
2.3.4	Inference of ripeness stage of agricultural produce based on deep learning .....	29
2.3.5	Inference of chemical composition of agricultural produce based on deep learning .....	30
2.3.6	Inference of shelf-life of agricultural produce based on deep learning.....	31
2.3.7	Deployment of deep learning models in app development .....	32
2.4	Summary of chapter II .....	35
2.5	References of chapter-II.....	36
3	Materials and methods .....	46
3.1	Materials and methodology for deep learning-based classification of tomato as edible or spoilt .....	46
3.1.1	Materials .....	46
3.1.2	Methodology .....	48
3.2	Materials and methodology for classifying tomato as mature green, intermediate and advanced. ....	53
3.2.1	Materials .....	53
3.2.2	Methodology .....	56
3.3	Materials and methodology for estimation of physico-chemical properties of tomato based on their surface characteristics.....	60
3.3.1	Materials .....	60
3.3.2	Methodology .....	61
3.4	Materials and methodology for estimation of shelf-life of tomato based on their surface characteristics.....	64
3.4.1	Materials .....	64
3.4.2	Methodology .....	65
3.5	Materials and methodology for app development.....	70
3.5.1	Materials .....	70
3.5.2	Methodology .....	71

3.6	References of Chapter-III.....	74
4	Results and discussions.....	78
4.1	Results obtained in classifying tomato as edible or spoilt.....	78
4.1.1	Effectiveness of various optimizers during model training.....	78
4.1.2	Results obtained on binary classification of tomatoes into edible and spoilt.....	79
4.1.3	Model evaluation.....	80
4.2	Results obtained in classifying tomato as mature green, intermediate and advanced..	82
4.2.1	Performance of VGG 16 based transfer learning model .....	83
4.2.2	Performance of VGG 19 based transfer learning model .....	83
4.2.3	Performance of inception V3 based transfer learning model .....	84
4.2.4	Performance of ResNet101 based transfer learning model .....	84
4.2.5	Performance of ResNet 152 based transfer learning model .....	84
4.2.6	Evaluation of models based on performance and training time .....	85
4.2.7	Model evaluation.....	85
4.3	Results obtained in predicting physico-chemical properties of tomato from their surface characteristics.....	90
4.3.1	Results of physical analysis.....	90
4.3.2	Results of chemical analysis .....	93
4.3.3	Principal Component Analysis.....	96
4.3.4	Statistical Validation .....	96
4.3.5	Mapping of physico-chemical properties.....	99
4.3.6	Model Evaluation using confusion matrix .....	101
4.3.7	Model Evaluation using Pearson correlation .....	104
4.4	Results obtained from prediction of shelf-life of tomatoes based on its surface characteristics.....	105
4.4.1	Effect of temperature on quality of tomato upon storage.....	105
4.4.2	Effect of temperature on Decay Rate .....	111
4.4.3	Effect of temperature on Disease Damage Incidence .....	111
4.4.4	Effect of temperature on Maturity Index.....	112
4.4.5	Kinetics of changes in quality parameter of tomato during storage.....	112

4.4.6	Predictability of the shelf life of tomatoes at different temperatures.....	115
4.4.7	Relationship between shelf life and storage temperature.....	117
4.4.8	Application of Deep Learning to estimate the shelf life of tomatoes at different temperature .....	118
4.5	Results obtained in developing the app for quality inference of tomatoes .....	119
4.5.1	Performance comparison of developed models for deployment as mobile app.....	119
4.5.2	Evaluation of computational capability of the developed app .....	121
4.5.3	Validation of results predicted by developed app against measurement in real sample .....	122
4.5.4	Challenges faced during deployment of app onto Smartphone.....	123
4.6	References of Chapter IV .....	124
5	Summary and Conclusion .....	128
5.1	Summary .....	128
5.2	Conclusion .....	130
5.3	Future scope of the thesis.....	131

*Appendices*