Introduction

CHAPTER 1

INTRODUCTION

Cocoa (*Theobroma cacao L.*) belongs to the family *Malvaceae* and the genus *Theobroma*. Cocoa tree produces fruits, referred as cocoa pods, along the trunk and branches. The cocoa pods are oval and contains approximately 30–40 seeds, commonly known as cocoa beans, which are embedded in a sweet mucilaginous pulp. The pulp is rich in fermentable sugars and high in acidity (pH 3.0–3.5). In India, area under cultivation of cocoa during 2022-23 was 1.06 lakh hectares with the annual production of 28,426 metric tonnes (MT). In Kerala, area of cultivation of cocoa during 2022-23 was 17,770 ha with the annual production of 10,130 metric tonnes (MT). Cocoa is mainly grown in Kerala, Karnataka, Andhra Pradesh and Tamil Nadu. In India, Kerala stands second position in terms of cocoa production after Andhra Pradesh (DCCD, 2022).

Cocoa is a native of Amazon base of South America. Major production of it is from the tropical areas of the African continent. Average rainfall ranging from 1500 to 2000 mm per annum is preferably needed for cocoa cultivation. Cocoa can be grown at a minimum temperature of 18-21°C and maximum of 30-32°C, but around 25°C is considered to be favourable for its growth. It can't be grown commercially in areas where the minimum temperature fall below 10°C and annual average temperature is less than 21°C (DCCD, 2022).

A diverse range of value-added products can be developed directly from cocoa beans as well as from the by-products generated during primary and secondary processing. Cocoa powder and cocoa butter are produced by pressing or expelling cocoa liquor under high pressure. This process extracts cocoa butter as a liquid, while the remaining solid cake is ground into cocoa powder. Cocoa butter has diverse commercial applications in the food, cosmetic and pharmaceutical industries (Sukha, 2003).

Cocoa by-products, such as husks and bean shells hold immense potential in health, cosmetics, food, agriculture and biofuel production due to their rich composition. Cocoa husks are a valuable source of dietary fiber, protein and bioactive

compounds like theobromine and flavonoids, enabling their use in food processing, pharmaceuticals, cosmetics and agriculture, while offering high economic value as a cost-effective raw material. Cocoa bean shells, rich in pectin, antioxidants and minerals, can improve sustainability in the cocoa (Soares and Oliveira, 2022).

Chocolate is the most popular product made from cocoa and is highly appreciated by consumers, globally (Goya *et al*., 2022). Cocoa and chocolate are among the most widely consumed luxury foods, with an average consumption of about 9 kg per person per year in Western European countries (Beckett, 2008). The consumption of polyphenol-rich cocoa products improves overall health and helps to prevent a variety of chronic diseases. It is reported to lower blood pressure, reduce hyper glycemia, improve insulin resistance and alleviate symptoms associated with diabetes and obesity in humans (Almoosawi *et al*., 2010).

Chocolates are semi-solid mixtures of finely ground sugar and cocoa solids, about 70% of the composition, suspended in a continuous fat phase. Cocoa solids derived from beans harvested from the fruit of *Theobroma cacao*, with the majority of global production being from Forastero varieties, which produce small, flat and purple beans. Criollo, another variety, is now rare in production, while Trinitario, a disease-resistant hybrid of Criollo and Forastero known for its flavour, accounts for approximately 3% of global production (Awua, 2002).

The essential ingredients in chocolate formulation are cocoa liquor, produced by grinding cocoa beans, cocoa butter (CB), which is extracted by pressing the cocoa liquor, sugar, emulsifiers, aroma and milk components (Li *et al*., 2014 ; Afoakwa *et al*., 2007). The proportions of cocoa solids, milk fat and CB distinguish the primary categories of chocolate, namely dark, milk and white (Konar *et al*., 2016).

Compound chocolates are chocolate like products made from modified vegetable fats, such as palm kernel oil and coconut oil. These vegetable fats are altered to mimic the melting properties of cocoa butter. The main reason for using compound coatings is cost-effectiveness, as vegetable fats are less expensive than cocoa butter. Cocoa butter (CB), derived as a byproduct of cocoa bean processing. It is obtained from the mature beans of the *Theobroma cacao* plant. It serves as a vital ingredient in the

chocolate and confectionery industries. Increasing demand and limited supply of CB, variability in the quality of cocoa harvest, cost advantages and certain technological benefits have driven the development of alternatives known as Cocoa Butter Alternatives (CBA) (Naik and Kumar, 2014).

Cocoa butter alternatives (CBA) are fats that serve to either fully or partially replace the functions of cocoa butter. Depending on their functional roles in chocolate, CBA are classified as cocoa butter replacers (CBR), cocoa butter equivalents (CBE) and cocoa butter substitutes (CBS). These fats are naturally derived from plants such as palm kernel oil (PKO), palm olein (PO), mango seed fat, soybean oil, rapeseed oil, cottonseed oil, groundnut oil and coconut oil. Sources like shea butter, palm oil and others are commonly used to produce CBA for replacing cocoa butter (Hussain *et al*., 2018).

Chocolate is commonly used to coat different food items, such as fresh-cut fruits and vegetables, cookies, nuts, wafers and biscuits, through a process called enrobing. Enrobing involves covering the surface of a product with a layer of chocolate or compound coating. Chocolate coating creates a barrier that helps protect the product from moisture and air, thereby extending its shelf life. It also improves the overall sensory experience of the product (Brown, 2009).

Traditionally, the enrobing process was slow and required manually dipping food items into melted chocolate. As the demand for chocolate-coated products increased, it became impractical to employ enough workers to dip the items by hand and meet the production demands (Sundara *et al*., 2014).

Chocolate coating can be applied to fully cover the food item (full coating), only the bottom (half-coating) or the bottom and lower sides (shoulder dipping) (Bean, 2009). This process is typically carried out using an enrober, it is a machine through which products move under a continuous stream of chocolate (Talbot, 2009). The goal of an enrober is to cover the product completely with chocolate, ensuring it has a smooth, glossy finish without any holes or defects. It also ensures a uniform coating thickness and creates an attractive, eye-catching and distinctive product (Gray, 2017).

Cookies are widely favoured as snacks for several reasons, including their variety in shapes and sizes, ease of digestion, high energy content, relatively low production costs, convenience and long shelf life (Sławińska *et al*., 2024). Products like wafers and cookies can be coated with chocolate or compound coatings. Chocolate enrobing enhances these products by improving their visual appeal and adding a rich, indulgent flavour (Sundara *et al*., 2014). Butter cookies, known for their rich texture, buttery taste and simplicity are particularly well-suited for chocolate enrobing. The enrobing process also contributes to improved product stability by providing a moisture barrier and maintaining the freshness, crunch and overall appeal of the cookies (Brown, 2009).

Chocolate-enrobed products are becoming increasingly popular. However, small-capacity enrobing machines suitable for small and medium scale entrepreneurs are not available. Chocolate enrobing machines are often not commercially viable for small-scale entrepreneurs due to high initial investment, operational costs and space requirements. They require additional equipment, such as tempering units and cooling tunnels, making them expensive to operate and maintain. Since enrobing machines are designed for high-volume production, small-scale operations can lead to inefficiencies, while improper tempering may result in chocolate bloom, compromising product quality. Additionally, skilled labour is necessary for both operation and cleaning, further increasing overall expenses. Therefore, the present study is aimed to develop economically feasible chocolate enrobing machine for cookies that will be beneficial to small and medium-scale entrepreneurs especially Self- Help Groups (SHGs).

The present study entitled “Development of a Chocolate Enrobing Machine for Cookies” was undertaken with the following objectives

1. Development of a chocolate enrobing machine for cookies
2. Optimization of process parameters for chocolate enrobing process
3. Performance evaluation of the developed machine in terms of capacity, energy requirement and efficiency.