CHAPTER - I
INTRODUCTION

The origin and dispersal of tea continue to be as baffling as ever. Indeed, there is still considerable speculation about the place and origin of tea. It is generally believed that it originated somewhere in South-East Asia. In China, for example, tea as a beverage was known for about 3000 years, though wild tea was not been found in China. The wild types recorded from time to time in Southern China are possibly relics from cultivation in the unrecorded past [1]. However, current distribution patterns of tea types or varieties suggest that tea possibly originated somewhere in the vicinity of the Irrawaddy basin from where it dispersed to South-East China, Indonesia, and Assam [2].

Tea in India

The saga of commercial development of tea in India is both awe-inspiring and fascinating. The search for tea in Assam was started by the East India Company as an alternate source of supply to the U.K. which till then was mainly dependent on China. It was generally thought by the tea committee established by the Governor General in 1834 that the tea plant was indeed indigenous to Assam, especially in its upper reaches. The investigations of Dr. Nathaneil Wallich at the Botanical Garden, Calcutta, for identifying tea plants from different parts of India are fairly well documented [3]. Equally interesting was the observation of Sir Joseph Banks, the English Botanist, who thought that tea might exist indigenously in the Dooars, proximal to Bhutan, were comparable to those of China where tea was grown. Geographical contiguity suggests that tea would have grown wild in the areas bordering India, Burma and China, though even in 1824, tea was said to have been growing well in the Kumaon Hills. However, the most authentic source of information on existence of tea came from Major Robert Bruce who discovered tea plants in upper Assam; this discovery virtually laid the foundation of the tea industry in India. It is of interest that Dewan Maniram Dutta Barua, who was a minister to the last Raj of Assam, was aware of the existence of tea plants, which grew in the territories inhabited by the Sungpho tribes in Assam, though it was not clear if these plants primarily originated there. Even after this discovery, tea seeds continued to be imported from China and following germination at the Botanical Garden, Calcutta, they were despatched to Assam and the Western Himalayas. The original seeds succeeded only in the Kangra Valley but not in Assam and elsewhere, where attention was paid to cultivate tea from indigenous stock [2].
With the emphasis on indigenous tea in Assam, the first commercial effort in organized tea growing was started by the Assam Tea Company in 1839. The pioneering efforts to manufacture tea were made by George Williamson, who literally gave the first direction in the development of tea technology in India, as opposed to the traditional method of manufacturing practiced in China then; this apart, superiority of the Assam plants over the China plants was also firmly established by George Williamson [4]. From the modest beginning in 1839, tea today has come to occupy a leading role in the economic life of India. Corporate tea companies are organized to operate in places of Eastern India like Assam, Darjeeling, Dooars and Terai regions. In South India, rapid growth has been noticed in the Nilgiris, Travancore-Wynaad and the Annamalais.

**Tea in Indian Economy**

A fact often overlooked is that tea provides direct employment to about one million people, and unlike other agricultural crops, tea provides the highest employment per unit of arable land. It provides the largest quantum of jobs to rural people, people in weaker sections of society and women. Many more are employed by sectors like tea machinery and packing, agricultural chemicals, in services like warehouse facilities, road and river transport related to tea and in tea trade in general throughout the country. More than 70 percent of the country’s population comes in contact with tea in one way or another, including tea drinking, thus rendering tea to play a key role in India’s economy and society, both directly and indirectly [2].

Research has always been an integral part of the tea industry, and tea is one of the few organized core sectors to have a sustained and long-term interest in R and D activities. With the current emphasis on increasing productivity and quality, relevant areas of priorities in research have been sorted out and identified. To meet the challenges of the productivity barriers and to make a significant breakthrough in quality development, stress is being laid on applications of biotechnology, tissue culture technique, integrated energy management, computer technologies etc. in overcoming hurdles in increasing productivity [5 - 7]. Currently, for on field productivity improvement, applications of ergonomics are also in practice in tea industry [8].
Plucking of Tea Leaves

Plucking or picking denotes harvesting of tea crop. Plucking of young shoots, the two leaves and buds, is an intricate art consuming about 15 per cent of the total cost of production of tea and much of the quantity and quality of harvested crop depends on the standard of plucking. It involves removal of young growing shoots comprising the apical bud, the internodes and two or three leaves below it, which together constitute the crop. The tender shoots removed are the sinks as they cannot support their normal growth. They are harvested at regular intervals to stimulate successions of a new crop of shoots. The growing shoots in turn are dependent on the assimilates from the mature foliage where they are produced, that is, the source [9 -10]. Consequently, an ideal plucking system must take cognizance of the intricate relationship between the sink and the source. In practical terms, the amount of maintenance foliage to be retained is of prime consideration in determining the system of plucking to be adopted as it is the maintenance foliage that provides the assimilates for the production of shoots [11 -13].

The growing bud exerts maximum pulling force for metabolites from the maintenance foliage; the relative sink capacity of a shoot of one leaf and a bud and two leaves and a bud being 75 and 35 per cent, respectively [14]. Therefore, indiscriminate removal of large buds and one leaf and a bud would adversely affect the health of bushes.

Obviously, an ideal plucking system should allow the maximum crop to be harvested with a minimum period of rest to the bud without affecting the health of the bush in the process. The essence of good plucking therefore is to remove only the shoots arising from auxiliary buds following tipping of the primary shoots after they have grown above the tipping level. To harvest standard shoots, plucking has to be done at set intervals based on the growth rate of the shoots [15].

**Plucking System**

A plucking system is ideal only when it is based on growth of shoots. This growth rate varies with plant types or nature of the cultivars, conditions of growing, and general environmental conditions, particularly temperature and humidity. When growth rate is fast ‘janam plucking’ or plucking up to janam is practiced, that is, young shoots consisting of two to three leaves and growing apex are broken back to a horizontal surface (previously fixed by tipping) at the level close to janams or cataphylls. When growth rate is rather slow fish-leaf plucking, that is, removal of all growth on the plucking table over the fish-leaf instead of over janam is followed. There are two other types of plucking which are essentially variance of janam plucking. In
standard plucking, all growth on the plucking table except the janams, buds and the small shoots having one leaf and a bud, is removed, but in black plucking which is a bit drastic, all growth on the plucking table excepting the janams and closed buds is removed [15].

**Plucking Standard**

The standard of plucking is unequivocally important as more than anything else, it determines the quality potential of the processed leaf. It is generally accepted that fine plucking makes the best quality tea as this form of plucking consists picking of only two leaves and a bud and plucking of these flushes is regarded as fine plucking. In a broader sense, fineness of plucking may also involve harvesting all one and a bud, two and a bud, and single banjhis over the janam, part from the fact that fine plucking also calls for plucking at short intervals usually at seven days intervals. If still shorter rounds of plucking are practiced to get leaves with attributes for high quality, then it may cause severe depletion of ‘sinks’ on plucking surface as shoots will not have opportunities for optimal growth so necessary before plucking. Consequently, over a period of time yield may decline but quality of tea will certainly improve.

Indeed, a linear relationship exists between the size of shoots with different combinations of leaves and a bud and their weights. In terms of ‘sink’ capacity of pluckable shoots, shoots with one leaf and a bud have the highest sink capacity (75 per cent)—therefore, their indiscriminate removal along with larger buds may adversely affect the physiological balance causing a decline in the production of subsequent flushes. From this point of view at least standard plucking would appear to be ideal [15].

**Plucking Postures and Possible Physical Problems**

Quantifying working posture and relating variations in posture to the physical demands of a task has long been an area of interest in the field of ergonomics. In more recent times technological advances have led to the proliferation of adjustable workplaces which allow the operator to adjust the workplace to a desired setting, rather than the worker having to adapt to the fixed dimensions of the workplace [16].
The tea-plucking job is absolutely done by manually. The pluckers are to stay at tea garden almost 8 hours a day. Physical workload varies from time to time, but the overall physical load ultimately increased at the end of the day due to the working posture and increasing load on their backpack.

A number of researchers have reported the association of poor body postures (Table 1) with pain or symptoms of musculoskeletal disorders [17–21]. The decrease in lumbar lordosis with change in posture has been well documented [22-23]. Such decrease in lumbar lordosis causes an increase in lumbar intradiscal pressure [24–26]; and may be related to low back pain through disk degeneration [27]. Elevation of the shoulders in occupational tasks has been shown to cause an increase in neck and shoulder pain [28]. Thus, the position of the upper limbs is also important in any analysis of working posture.

Table 1: Examples of poor body postures

<table>
<thead>
<tr>
<th>Source</th>
<th>Poor body postures</th>
</tr>
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<tbody>
<tr>
<td>Van Wely (1970)</td>
<td>Standing</td>
</tr>
<tr>
<td></td>
<td>Upper arm hanging unsupported</td>
</tr>
<tr>
<td></td>
<td>Lifting heavy weights with back bent forwards</td>
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<tr>
<td>Armstrong (1986)</td>
<td>Raised elbows</td>
</tr>
<tr>
<td></td>
<td>Wrist flexion and extreme wrist extension</td>
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<tr>
<td></td>
<td>Radial and ulnar deviation</td>
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Low back disorders (LBDs) represent the most common and most costly musculoskeletal disorder experienced in the workplace. Up to 80% of adults will eventually experience back pain at some time during their life and 4-5% of the population has an acute low back pain episode every year [29], which indicates that in the USA alone an additional 11-13 million people will develop LBDs annually. Much of this LBD is associated with occupational factors [30].

In order to prevent the onset of musculoskeletal disorders, it is probably most effective to try to affect several variables simultaneously. Possible preventive measures can be divided into five categories: (1) engineering modifications (e.g. workstations), (2) organization of work (e.g. work/rest schedules), (3) personal protective equipment (e.g. clothing), (4) training (e.g. work methods) and (5) administrative control (e.g. employee selection). The starting point of an ergonomics intervention, to reduce the risk of musculoskeletal disorders, should always be to strive for a redesign of the workplace [31].

In a modern industry, knowledge of ergonomics plays an immense role in suggesting remedies for such physical discomfort. However, management is also concerned with the cost of ergonomics
intervention. Human factors specialists therefore have to justify ergonomics improvements in the workplace, not just in terms of improved posture and comfort but also in terms of improvements in performance. Thus, interrelationships between posture, comfort and performance need to be made explicit if ergonomics as a discipline is to be explored in various industries [32].

**Concept of Industrial Comfort**

It seemed reasonable to consider "industrial comfort" as a concept, however, with a threshold level below which the operator would not be distracted from his work. The measure of it would be levels of discomfort, judged on a scale or otherwise defined. The overall level of discomfort felt by the operator would be a summation of all the individual sensations via the various sense channels. This would include a contribution from the environment as well as discomforts experienced as a direct result of the man-machine relationship.

This concept (of industrial comfort) was derived from an earlier study of the comfort experienced by passengers in vehicles [33]. This hypothesized that the comfort level experienced would arise as a result of the summation of sensory stimuli experienced via all sensory organs, judged as a totality [34].

**Rating of Perceived Exertion**

Watt and Grove (1993) [35] and Gamberale (1985) [36] identified several techniques of perceived exertion. The rating of perceived exertion (RPE) from 6 to 20 [37] is the most frequently used. RPE values have been compared with a lot of physiological variables such as heart rate [37-39], oxygen uptake [40-42], blood lactate [43-45] or ventilation [40, 46, 47].

**Management Sensitivity Regarding Tea Garden Workers**

Tea industry management readily perceives a direct linkage between the nutrition and productivity of the tea bushes; they exhibit a relative lack of appreciation of the input-output relationship in respect of the industry's major asset – labour. There is a convergence between the health and welfare of workers and the interests of management. Better health leads to higher labour productivity, which in turn justifies viewing health and welfare outlays as investment rather than consumption expenditure. In order to maintain the major
plantation asset at an optimum productivity level, the factors influencing it, such as the worker's life at home, their life in the community and their relationships at the workplace must be kept in good order.

The independent economic status accorded to women tea pluckers and the nearly equal terms under which they operate should form the platform from which management can embark on a forward-looking personnel policy that will bring out the best in the women workers. In fact, the industry's major asset is not labour as such, but female labour. It is therefore important for management to take into account the socio-economic needs of women tea workers. [48]

The Life of The Tea Pluckers

Three countries in South Asia – Bangladesh, India and Sri Lanka- account for 52 per cent of global black tea production, 42 per cent of exports and 36 per cent of consumption. The tea industry in the region also provides year-round employment to about 1.5 million workers – mostly women – and an equal number depend on tea-related ancillary activities for their livelihood. Yet South Asia's predominance in the tea world is on the decline, with many of the old fields in need of replanting, processing facilities requiring modernization and welfare structures calling for upgrading. At global level, the tea industry is finding it increasingly difficult to make ends meet, caught between rising costs on the one hand and stagnant or declining prices on the other.

As the most costly and yet measurable operation in the tea industry; plucking has been the focus of a productivity-linked approach in respect of wages and incentives. However, several field-level prerequisites, such as improved soil conditions, modifications to the micro-climate, appropriate choice of planting material, optimization of pluckable shoots, adoption of a management approach of pruning, skilful manipulation of the plucking surface, and integration of plucker intake with field responsiveness, have to be met before embarking on that approach [48].

The typical day at a tea estate in India starts with the morning whistle signifying that the workday will start in 30 minutes. All the pluckers gather at the location where they know the harvesting will start that day. They carry large wicker baskets that strap across their foreheads with the baskets hanging down their backs. The women often carry umbrellas for protection against the rain and intense sun.

The pluckers have a goal each day – and they are awarded a bonus if they exceed it – so there is a benefit to efficient work. Three or four times a day they take their basket to an area where the leaves are looked at for quality (no poorly harvested leaves are accepted), weighed and recorded. At lunch, after the second weighing, the pluckers congregate together outside if the weather is nice, or inside a nearby
building. Those with children not yet in school, always harvest in the region nearest their home so that they can go home at lunch to be with their children. Those who are nursing can visit the day care center or their home to nurse during weighing times and lunch [49].

**Occupational Noise**

Noise is one of the most pervasive problems in today's occupational environment, affecting workers in manufacturing, construction, transportation, agriculture, and military [50]. Development of modern automated machines in industries has considerably decreased the physical burden of work on workers in addition to increasing the productivity of the industrial enterprises. But one of the most undesirable and unavoidable byproduct of these operations and machines is noise pollution. Industrial workers thus are exposed to these high noise levels because of their occupation. High level noise, not only hinders communication between workers, but, depending upon the level, quality, and exposure duration of noise, it may also result in different type of physical, physiological, and psychological effects on the workers [51].

Noise is any unwarranted disturbance within a useful frequency band [52]. Noise can be described in terms of intensity (perceived as loudness) and frequency (perceived as pitch). Both the intensity and duration of noise exposure determine the potential for damage to the hair cells of the inner ear [53].

Sound intensity is measured as sound pressure level (SPL) in a logarithmic decibel (dB) scale. Noise exposure measurements are often expressed as dB(A) scale, a scale weighted toward sounds at higher frequencies, to which the human ear is more sensitive [53]. Noise is present in every human activity, and when assessing its impact on human well-being it is usually classified either as occupational noise (i.e. noise in the workplace), or as environmental noise, which includes noise in all other settings, whether at the community, residential, or domestic level (e.g. traffic, playground, sports, music). High levels of occupational noise remain a problem in all regions of the world. The average noise levels in developing countries may be increasing because industrialization is not always accompanied by protection [54].

There are therefore several reasons to assess the burden of disease from occupational noise at country or subnational levels. Occupational noise is a widespread risk factor, with a strong evidence base linking it to an important health outcome (hearing loss). It is also distinct from environmental noise, in that it is by definition associated with the workplace, and is therefore the responsibility of employers as well as individuals. An assessment of the burden of disease associated with occupational noise can help guide policy and focus research on this problem. This is particularly important in light of the fact that policy and practical measures can be used to reduce exposure to occupational noise [55].
Noise Induced Hearing Loss (NIHL)

Hearing impairment or hearing loss is defined as the amount by which an individual's hearing threshold level changes for the worse as result of some adverse influence. It implies some disorder of the structure or function of the hearing apparatus and is usually measured in decibels (dB) [56].

Noise induced hearing loss is due to loss of hair cells in the cochlear portion of the inner ear. These hair cells vibrate when sounds pass into the cochlea, and thereby send electrical signals to the brain, which are perceived as sound. Excessive noise selectively damages some of these hair cells, causing hearing loss and sometimes tinnitus (noise in the ears) [57].

Damage to hearing from noise depends on a number of factors. These include the character of the noise, its frequency spectrum, its intensity and its duration. Other important aspects include the interval between the exposure and an individual's susceptibility. Noise may be continuous or intermittent. Very short interval intermittent noise which may occur in industries such as drop forging or pile driving is described as impact noise. Impulse noise is noise of short duration and high intensity with a characteristic wave form, such as follows gunfire. If impulse or impact noise is repeated very rapidly, as may occur in a piston engine, its characteristics merge with those of continuous noise [57, 58].

Sound above a certain intensity level may cause damage to the ear. The criteria to describe the likely damage from noise are based on a concept of equivalent amounts of acoustic energy. This concept is known as the Equal Energy Concept and assumes that equal amounts of energy produce equal amounts of hearing loss [59]. Acoustic energy may be defined as the product of noise intensity and duration. As sound intensity is measured on a logarithmic scale, an increase of 3dB equates with the doubling of energy. Accordingly exposure time should be halved for equal risk, if the intensity of the sound increases by 3dB. Noise emission levels have been computed to calculate the exposure and risk to individuals in noisy working environments. Noise in excess of 85dB(A) for 40 hour week is considered to be hazardous and will cause hearing loss in 5% of the population. At 90dB(A) for a 40 hour per week, 15% of the population will develop hearing loss due to cochlear damage [60–61]. Excessive noise may cause a temporary or permanent hearing loss known as a temporary or permanent threshold shift. The relationship between noise induced permanent threshold shift and noise induced temporary threshold shift is not clear-cut. A temporary threshold shift may blend imperceptibly into a permanent threshold shift with continued exposure to noise. Noise induced permanent threshold shift usually occurs first around 4 Kilo Hertz (kHz) and then progresses to involve adjacent frequencies. The hearing loss at 4 kHz progresses over the first ten years of noise...
exposure and then tends to stabilize. It may take 30 years of ongoing noise exposure to involve the frequencies of 1 kHz and below [57]. NIHL has a recognizable audiometric pattern with the maximum damage usually occurring at 4 kHz, but occasionally it may occur at 3 kHz or 6 kHz. There is a great deal of variation in hearing loss due to individual susceptibility. It is impossible to predict in any one individual the likelihood of further progression of the hearing loss or the rate of progression with continuing exposure to noise above the accepted limits. Noise induced hearing loss tends to occur equally in both ears unless there is a particular reason why one ear is exposed more than the other. This may occur for example, while shooting a rifle in which a right handed individual would have his left ear closer to the muzzle of the gun [56].

Threshold shift is the best precursor of NIHL, the main outcome of occupational noise. It corresponds to a permanent increase in the threshold of hearing that may be accompanied by tinnitus. Because hearing impairment is usually gradual, the affected worker will not notice changes in hearing ability until a large threshold shift has occurred. Noise-induced hearing impairment occurs predominantly at higher frequencies (3-6 kHz), with the largest effect at 4 kHz. It is irreversible and increases in severity with continued exposure.

The consequences of NIHL include:
- social isolation;
- impaired communication with coworkers and family;
- decreased ability to monitor the work environment (warning signals, equipment sounds);
- increased injuries from impaired communication and isolation;
- anxiety, irritability, decreased self esteem;
- lost productivity;
- expenses for workers' compensation and hearing aids [54].

Non Auditory Health Effects of Noise

According to American Speech Language Hearing Association (ASHA, 1981) [62], hearing impairment or hearing loss usually denotes a change for the worse in auditory structure or auditory function, outside the range of normal hearing. Hearing handicap is usually denoted as an average hearing threshold level (HTL) of greater than 25.0 dB(A) for both ears at selected frequencies [63]. According to an earlier report [64], continual exposure to high noise levels damage and destroy hair cells within the ear, making noise-induced hearing loss an irreversible impairment. Additionally, there is evidence that the noise damage
is induced in the affected tissues at molecular level by the elevation of substances (for example, free radicals), which, together, have been called reactive oxygen species (ROS) [65–68]. Although ROS are normal byproducts of cellular aerobic metabolism, these unstable molecules can impair cellular lipids, proteins and nucleic acids in DNA if the balance of corresponding antioxidants is disrupted [68]. Reports also indicate that health effects of noise are substantial and studies clearly have established a relation between exposure to noise and stress responses [69]. Several studies have reported about adverse effects of industrial noise on metabolic processes and psychological status [70–72]. Further, elevation of cellular levels of ROS following stress and injury has been reported not only in the cochlea but also in other tissues, including the brain and heart [73]. Literature survey also has revealed that, in addition to cochlea, noise-induced oxidative DNA and lipid damage was found in liver that has high metabolic functions [68]. Moreover, there is both direct and indirect biochemical and histological evidence of cochlear oxidative stress [68].

In view of the above cited literature survey, following were the aims of this study:

(a) to examine the interrelationship between posture, comfort and productivity of tea pluckers;

(b) to determine an optimum stature-bush height ratio (SBHr) which may be applicable in Indian context; and to observe the relation of this optimum SBHr with Total Yield (TY) and other physiological variables like heart rate, energy consumption and body part discomfort frequency severity (BPDFS);

(c) to examine the influence of off-field dependent (nutrition, health and welfare) variables on the productivity of tea pluckers.

(d) to examine the deleterious effects of industrial noise on the different physiological parameters of workers of tea processing factory.
References


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