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2. To support academicians and teachers in creating work beneficial to the academic community
3. To stimulate and support education at the university level

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Editorial Note

The Interdisciplinary Research Review (IRR) was established with academic cooperation by the Nakhon Pathom Rajabhat University, The Royal Society of Thailand Committee of Interdisciplinary Research and Development, Rajabhat University (Western Group), and Rajamangala University of Technology Rattanakosin. This Issue, Volume 15 Number 4 (July – August 2020). This issue contains of six interesting articles in multidisciplinary fields: (1) Barriers in the employment of persons with disabilities, (2) An evaluation of rural electrification in Nigeria: A study of Ibogun community, Ogun state, (3) The relationship between Mitragnine blood concentrations and death in Thailand, (4) Factors influencing adoption of vertical forced-air sulfur dioxide fumigation technology of fresh longan exporters in Thailand, (5) Effects of sugar and coconut milk addition on freeze-thaw stability of starches: comparison of slow and fast frozen methods, and (6) Early lockdown policy for COVID-19 in China during first quarter of 2020.

The Editorial Board of the IRR encourages anyone to submit articles for evaluation and review. The processes of submission, review and publication of articles are described on the journal's website, <https://www.tci-thaijo.org/index.php/jtir>. The Editorial Board and Committees of the IRR sincerely thank all peer reviewers who have sacrificed their time to help us produce a better journal, and also wish to thank all teachers, researchers and other academicians for submitting their valuable research to this journal. Finally, we thank readers of our journal who help to spread the knowledge and benefits gained to others. With your feedback and suggestions, we will strive to improve the quality and relevance of the IRR.

Yongyudh Vajradul
Editor
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Barriers in the employment of persons with disabilities

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Abstract

This article aimed to investigate the barriers in employment of persons with disabilities. The article is framed by reviewing the literature from all sources relating to the barriers in employment. The article has the following aims: 1) To define disability and the types of disabilities; 2) To summarize the barriers in employment of persons with disabilities; 3) To overcome these barriers through adopting appropriate recommended strategies. The article summarized with the need of interventions and co-operations at various levels, global, international and national level to bring awareness through research, education and innovative program to remove the negative attitude towards the disabled persons and other barriers in the work environment. Thus, it can be concluded that when only the barriers are surpassed, then programs for inclusion of disabled persons in employment can achieve a positive result.

Keywords: barriers, employment, disabilities

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1. Introduction

According to the latest report of the World Bank approximately one billion or 15% of the world's population experienced some form of disability [39, 40]. However, persons with disabilities face many challenges throughout history when they look for a job for employment in the labor market because disability is often associated with social stigma or social disapproval. Usually, the family and community have a prejudice for disabled persons and so consider them as incompetent or incapable to perform a job. The society usually has demarcation in their attitude and behavior, labeling, or rating their disabilities as abnormal or deviant. As a result, persons with disabilities are considered as the leading inferior groups of society due to these limitations, both physically and socially even though they constitute a major portion of the world's population. Even though the United Nations and governments of many countries have passed inclusive legislation to improve the status of disabled people, still there is prevalent of many problems for people with disabilities in terms of equal rights to employment or status. This has been supported by studies that stated that employers have lacked confidence in people with

disabilities in terms of performance [10, 21, 29]. As a result, a person with a disability has less demand in the employment market. Consequently, persons with disabilities are an underemployed group of the workforce in the labor market [6]. This causes persons with disabilities to have higher poverty rates than the normal persons on a world-wide basis [40]. So, there are many causal effects due to disability, including increasing poverty, through lack of employment and education opportunities, lower wages, and increased cost of living. So, the issue of disability and employment has gained importance on the global stage because it is one of the high-ranking goals of the United Nations Sustainable Development Goals [35, p.5].

Due to the efforts of the United Nations, global awareness of disability-inclusive development is increasing. The 2030 Agenda for Sustainable Development clearly states that disability cannot be a reason or criteria for lack of access to development programming and highlighted the realization of human rights. The Sustainable Development Goals (SDGs) framework includes seven targets, including persons with disabilities, and six other targets on persons in vulnerable situations. The SDGs address essential development domains such as education, employment, and decent work, social protection, resilience to and mitigation of disasters, sanitation, transport, and non-

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discrimination, including persons with disabilities-all of which are important areas of work for the World Bank. The New Urban Agenda specifically focuses on promoting measures to facilitate equal access to public spaces, facilities, technology, systems, and services for persons with disabilities in urban and rural areas. The United Nations Convention on the Rights of Persons with Disabilities (CRPD) promotes the full integration of persons with disabilities in societies. The CRPD specifically mentions the importance of international development in addressing the rights of persons with disabilities. In recent years, an increasing number of organizations have also developed disability policies to provide international aid. Similarly, at the national level, the number of disability discrimination laws and constitutional provisions have increased significantly.

The article is framed by reviewing the literature from all sources, both internet and printed, relating to the barriers of employment of persons with disabilities. The article is organized as introduction, definitions of disability, review of literature, barriers in the employment of people with disabilities, recommended strategies to overcome the barriers, and lastly conclusion. The article has the following objectives:

1. To discuss the meaning, and the types of disabilities
2. To summarize the barriers in employment of persons with disabilities
3. To overcome these barriers through adopting appropriate strategies and recommendations

Definition of disability Disability is defined in various ways, depending on various factors, both environmentally as well as physically, in different countries. It is “the umbrella term for impairments, activity limitations and participation restrictions, referring to the negative aspects of the interaction between an individual (with a health condition) and that individual’s contextual factors (environmental and personal factors)” [40, p.4].

Disability is defined as a health condition or problem that has a degree of permanence and impairs one’s ability to carry out day-to-day activities. Disability is created when this impairment comes up against a disabling environment. A disability is also shaped by physical, institutional, and social barriers, including attitudes and assumptions about differences and impairments [9]. So, disability is synonymous to impairment, causing an impaired or disabled person limitation in social participation and is generally a phenomenon that refers to the loss of any physical function of an individual

According to the UN Convention of the Rights of People with Disability [34], ‘Persons with disabilities include those who have long-term physical, mental, intellectual, or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with

others’.

Disability is a state of decreased functioning associated with a disease, disorder, injury, or other health conditions, which in the context of one’s environment is experienced as an impairment, activity limitation, or participation restriction. Understanding both the health and the environmental aspects of disability allows for the examination of health interventions that improve functioning as well as interventions to change the environment to improve the participation of people with disabilities [3].

‘Disability can be a physical deprivation or deficiency, but it can also be social, cultural, economic, or psychological’ [1]. To identify the barriers faced by people with disabilities, it is important to identify the types of disabilities available in the literature.

It is useful to examine the categories and types of disability to identify the difficulties that individuals with disabilities may encounter in their educational lives and to identify their needs. Disability can be classified into impairment, disability, and handicap [1]. Impairment refers to a psychological or anatomical abnormality, loss, or deficit in terms of structure or functions such as cognitive deficits, psychological deficits, speech deficits, hearing deficits, visual deficits, and so on. Disability on the other hand refers to situations that prevent or reduce functioning normally, which can be behavioral, communication, movement, skills, or inability to perform personal care. Handicap, on the other hand, refers to a lack of social, age, or gender-defined roles due to disability. When we look closely at the disability categories as well as the types of disability, it is clear that the obstacles about the participation of people with disabilities in social life, in professional life and education in addition to the physical, cognitive or psychological limitations of the disabled individuals, also includes a complex structure that includes the perspective of the society, the individuals to be educated together and their families. For this reason, it should be carefully studied and taken into consideration while framing welfare policies and this has to be designed and implemented in a way to create social awareness for the successful employment of the disabled.

2. Literature Review

Even though employment is an income-generating activity for all people including people with disabilities, to date only a few kinds of research have been conducted about the disabled employee, barriers in employment of persons with disabilities, the factors causing the barriers, and the impact and strategies to intervene the barriers. So, [5] analyses factors that act as barriers in employing disabled people in Thailand by conducting qualitative research of 20 physically disabled Thai women. The result of the research found the following barriers as (i) passing of disability

laws and related regulations without sufficient study; (ii) social stigma, prejudice and attitude of people in society; and (iii) overprotection of family members for the disabled members. Some of the recommendations include introduction and interventions by the government of Thailand, NGOs, and disability organizations.

Another previous article by [4] critically reviews the disability and rehabilitation issues in Thailand and pointed out that disability rehabilitation policy in Thailand has predominantly been under a medical model since the government agencies view people with disabilities as ones who are helpless and waiting only to be cared for. According to him, generally in Thailand, the voices of disabled people are persistently ignored in policymaking and implementation and concluded with the government's failure to understand the magnitude of disabled people's rights in terms of many issues, including rehabilitation, education or employment.

Governmental and non-governmental organizations (NGOs) programs in rural and urban areas in Thailand along with the vocational training component included in the school curricula was examined by [23]. The study focused on different training provided, including admission to the course completion, and its outcomes, particularly in terms of employment and self-employment. The detailed study findings and recommendations were presented in annexes report. Annex 2 describes the Thai Government policy on training and employment of people with disabilities and outlines the measures taken to promote employment. There is a growing importance of increasing research on disability employment due to the decline in the working-age population, especially in European countries along with the complexity of defining disability [36]. This study accepts the WHO definition of disability, recognizing that disability barriers arise from the interaction of a person with the environment and concluded with the need for more concrete research agenda on disability and employment to provide recommendations for practice through in-depth research.

The study on the workforce participation barriers for people with disabilities in Australia confirmed the findings of previous studies that people with disabilities are less likely to be employed and if employed are likely to be under-employed and underpaid [15]. The study also discussed the strategies for enhancing employment outcomes of people with disabilities.

The impact of disability on employment varies depending on the requirements of the occupation and the type of disability was discussed by [18]. The article aims to identify key themes and issues in the literature relating to the impact of disability on the labor market. The low work participation issue of people with disabilities has received growing attention from policymakers and a range of legislative and other reforms aimed at securing employment of persons with disabilities and to improve their social status.

Research on barriers and enablers associated with hiring people with disabilities at work was discussed by [36]. Some of the barriers include employer's and coworkers' attitudes towards hiring people with disabilities, while the enablers are policies to protect employees with disabilities against unfair dismissal. Several studies have investigated the attitudes of people with disabilities and reported a high degree of prejudice and social distance towards people with disabilities [6, 14, 19].

Many people have stereotypes about people with disabilities while predicting their job performance even though some of them were highly qualified [7]. Commonly, people seem to rely on stereotypes they have about people with disabilities when predicting future work performance regardless of their qualification [7, 8]. Some research has the hypothesis that employer's attitudes towards hiring people with disabilities may depend on the size of their organization. For instance, employers of smaller organizations perceived individuals with disabilities as less qualified and less capable in performance as compared to employers of large organizations [12, 17].

Meanwhile, employers appreciate being informed or disclosed about the disability and how far it affects performance at the time of applying for a job rather than concealing it [33]. So, the main factors in employing individuals with disabilities are the employer's attitude, openness, experiences, and limitations due to the type of disabilities.

The facilitators and barriers of employment of people with disabilities were examined qualitatively by interviewing 10 participants from various organizations as reasonable work conditions, adjustments, and accommodations. Employment offers disabled people the chance of social participation and social recognition. Among the factors leading to barriers in disabilities employment includes prejudice, unequal opportunities in job position, underpayment, low level of education, etc. The study concluded with the need for an innovative policy promoting inclusion of people with disabilities in work participation. Implementing accurate government policy would enable these people to work participation, improve social status, and providing their rights as citizens.

Many attempts of both governmental and organizational, the proportion of disabled professionals in full-time employment are rather small due to the prevalence of many barriers that disabled people face in seeking and qualifying a job for full-time employment, especially in the top-ranking job [38]. The study data was collected using qualitative interviews and it was found that many people with disabilities faced problems associated with inadequate opportunity, resources, and support.

The reasons for the barriers faced by disabled people in accessing employment was discussed by [30]. The result found many reasons as to why the barriers

ers exist and the strategies to amend the barriers as well as the limitations of analysis that exclude impairment type and severity, social welfare, welfare policy implementations, and underestimations by the cultural system and wider social and economic system.

Social policy issues to amend the social exclusion of disabled people from the British labor market were discussed by [2]. The study made a critical examination of sociological theories of work, unemployment, and under-employment of disabled people and concluded that as the analysis of work and disability have failed to address the various social and environmental barriers met by disabled people at work, it has been suggested to re-consider disabled people's perspectives including the philosophy of independent living in work policymaking.

The employment situation of people with disabilities by doing in-depth case studies investigation from three countries, that is, the US, Japan, and Malaysia were analyzed [13]. The first case study examines the United States regulation for the promotion of disabled persons' employment - Americans with Disabilities Act (ADA) of 1990. The introduction of ADA can be considered an important milestone in the history of employment of persons with disabilities. However, the unemployment rate among the disabled person does not seem to decrease after the implementation of the ADA. The second case study analyses Japan's quota system for the employment of disabled persons. After the introduction of the quota system, the employment of disabled persons, especially people with intellectual disabilities, in Japan has gradually increased. The third case study examines a Malaysian welfare non-governmental organization (NGO) named the "Asia Community Service (ACS)" and its effort to promote the disabled persons' employment. In 2000, the ACS established a workplace named the "Stepping Stone Work Centre" to provide job opportunities to people with intellectual disabilities.

The key challenges faced by persons with disabilities in the Indian labor market along with an overview and strategies adopted by the major organizations and institutions for employing persons with disabilities in India. Among the challenges include poor education, training, inadequate financial resources to apply for employment has summarized by [31]. Also, there are other challenges such as the nature of the workplace or occupation, perceptions of employers, and co-workers leading to a negative attitude towards people with disabilities. Many disabled people leave their job or are asked to quit due to these negative attitudes, resulting in job discrimination without rational analysis of their contribution to the labor market. Besides, many qualified disabled people were discriminated against in terms of payment and promotion. Employers too are influenced by society or social attitude about the hiring of people with disabilities.

So, generally, they underestimate or do not have

confidence in their performance or competence at the time of recruitment. This resulted in people with disabilities to lose self-confidence and skip from applying for certain jobs, fearing social stigma, and adverse reaction from potential co-workers. Along with it, disabled people have fear and insecurity due to their disabilities. For instance, a crippled bank employee in a wheelchair has worries whether the office has an elevator or staircase. Similarly, a hearing retarded employee has worries about whether she will be able to note down the details from the important meeting or group discussions.

There is a report of a study undertaken to identify facilitators and barriers in employment and employability for persons with disabilities in Hyderabad city of Andhra Pradesh. The study aims to the inclusion of persons with disabilities in the Indian employment market. The specific objectives of the study are: 1) identify employers' barriers in employing persons with disabilities; 2) employee barriers comprising of physical access, information and communication access; 3) identify enabling factor among specific industrial sectors; 4) discuss the perspectives of the employers as well as a disabled employee concerning the Indian Persons Disability Act (1995). The result of the study found some barriers as physical access to and within the work site for an orthopedically disabled employee, communication barrier for speech, and hearing retarded employee. About the benefits, around 50% of the respondents were provided medical allowance and sick leave. Concerning the employers' views, all employers adjusted to help persons with disabilities to pursue and perform the job.

The differences in employment and wages between males with and without disabilities, using data from the Village Disability Survey conducted in Tamil Nadu, India was examined by [22]. The study shows that the employment rate of persons with disabilities is relatively low compared to that of the all-India working-age population, with great variations across gender, the urban/rural sectors, and states. The result of the study concludes that the employment gap between individuals with and without a disability is not due to differences in human capital and productivity, but may result from differential returns to characteristics and discrimination in access to employment.

Factors associated with the employment of persons with disability in India based on census data was analyzed by [24]. The study result found different factors affecting the employment of persons with disabilities in rural and urban areas. In rural areas, having mental disability decreased the likelihood of employment while being female and having movement, or sight impairment (compared to other disabilities) increased the likelihood of employment. In urban areas, being female and illiterate decreased the likelihood of employment but having sight, mental and movement impairment (compared to other disabilities) increased the

Table 1. Factors causing barriers in the employment of persons with disabilities.

Factors	Cause
Personal	Lack of education, professional skills, and knowledge, or low social esteem due to the subjective perception of the disabilities including stigmatization. Even when employers are willing to hire and accommodate people with disabilities, a disabled person may find other challenges in the practical process of integrating into the organization due to low social esteem was provided by [16].
Physical	Difficulties to access the office of the organization, barriers in traveling for those on a wheelchair or blind or communication barriers for the hearing impaired [43]
Institutional	Inadequate knowledge, a negative attitude about people with disabilities, inequality in job placement, salary, and promotion of job status [20, 44]
Social	Social factors as “aesthetic anxiety” that refers to the phenomenon of a negative perception of an employer in hiring the disabled employee [6]. But, it is significant to note that an employer has an important role in recruiting and integrating a disabled person for employment. Even though the legislators in many countries passed various laws to provide quota for employment of people with disabilities, still many employers are hesitant in hiring workers with disabilities due to many reasons, such as lack of knowledge concerning disabilities in general, unawareness as how to accommodate disabled worker, along with concerns for the cost for accommodation and training time to employees with disabilities. Moreover, an important barrier that a person with disabilities usually faces when joining an organization for the first time are co-workers’ and supervisors’ negative attitudes and stereotypes. Studies that investigated the attitudes of the general population towards people with disabilities report that people often feel a high degree of social distance towards people with disabilities [26, 37].
Psychological	Psychological factors causing hindrance to the integration of people with disabilities into the organization, which can be seen in different ways, including within the disabled person and the environment. This has been reported by [27] who found evidence that applicants disclosing their disability in their application documents, were invited less frequently to job interviews than applicants with a similar profile but without a disability.

likelihood of employment. The study concluded with the need for introducing and implementing poverty alleviation programs, designed for persons with disabilities in India. These programs should account for differences in employment by disability types and should be spatially targeted. Since persons with disabilities in rural and urban areas have different factors contributing to their employment, government planners need to account for these differences when creating programs aimed at underprivileged development.

Factors causing barriers in the employment of people with disabilities Some of the barriers in the employment of persons with disabilities can be categorized as in Table 1.

3. Recommended Strategies to Overcome Barriers in Employment of People with Disabilities

Some of the recommended strategies to overcome barriers in employment of people with disabilities are listed in Table 2.

4. Conclusion

The above review of the literature leads to various kinds of barriers faced by persons with disabilities in the work environment or while hunting for a job in terms of employers’ and coworkers’ prejudice, institutional, social, personal, and psychological barriers. When persons with disabilities want to join the employment market, they face many challenges more

than abled people. Persons with disabilities are liable to face discriminative attitudes from many angles in the employment market, in terms of education, vocational training, physical access, recruitment process, allocation of job position, promotion, salary and participation in decision-making processes and sometimes leading some of them to untimely dismissal. Besides, even though the right to work, including the right to choose decent work and a safe working environment, is the fundamental human right of the United Nations, there are many problems associated with disabled persons while exercising this right to work, such as inaccessible workplaces, lack of transport, financial and employment assistance, discriminatory policies, and negative attitude or prejudice of the work environmental community. This resulted in psychological frustration and loss of social esteem for these disabled people around the world, compelling them to live in poorer health conditions, deprived them of higher education or status, and ultimately leading to lower economic participation with a higher rate of poverty.

Thus, it can be concluded that when only the above barriers are surpassed, then programs for inclusion of disabled persons in employment can achieve positive results. So, the United Nations, the pioneer global organization has made many timely interventions attempts to remove these barriers for inclusive growth and development of the global society, by addressing and uplifting the problems faced by people including disabilities with their innovative policies for development enhancement, poverty reduction and the right to employment. These interventions measure for persons

Table 2. Recommendations to overcome barriers in the employment of people with disabilities.

Strategies
- Availability of provision to provide better education and training for people with disabilities to help them find a decent job in the job market and to increase their status and living conditions [1]. - More intervention research is needed to change the negative attitude of people towards the employment of persons with physical disabilities [20]. - Public government policies should focus to address the barriers in employment of disabled people [25]. UN should create more integration between participating member countries, and other global organizations. Also, UN reports should include the latest statistics and rates, generate disability data periodically and all reports should be shared with the public through publications to bring awareness [35]. - Environmental interventions to improve the participation of people with disabilities should be encouraged [3]. - Policy intervention should aim to change the negative attitudes of co-workers as well as employers such as implementing policy programs that involve direct contact with disabled people; campaigns to provide information, awareness, education, and training about disabilities [11]. - Inequality in job status, wages, and job placement should be addressed by the legislators as well as the hiring agents because most jobs offered to the disabled employee are underpaid, having the characteristics of restrictive communication with others, less opportunity for progress or promotion in the job hierarchy and low social benefits [28]. - Organizational members or co-workers need to be educated to understand disability and the consequences of prejudice for a person with disabilities in a work environment [36]. - There should be assistive technology for the disabled employee (such as adapted telephones, wheelchairs, magnifiers, and adapted computer equipment) or services to perform job functions efficiently and to increase their self-esteem [41]. - There should be equal employment opportunities to everyone irrespective of caste, class, gender, disability for inclusive sustainable development along with providing a better prospect, fair income, equality, and social security in the workplace for persons with disabilities [35]. - 2.2% of Thai people have some form of disabilities and they are considered as incapable to be employed due to low educational attainment. So it is highly recommended to provide educational and job opportunity facilities among the disabled people in Thailand [42] and also access to public transport for easy mobility of disabled Thai people [43]

with disabilities can be successful with the support and cooperation of other organizations, governmental and non- governmental, nationally as well internationally, researchers and psychologists, having the aim to provide income and economic independence, by providing work and to increase self-confidence in being part of the global society. Due to these interventions of UN, national, international, NGO, and local organizations, it can be expected to bring awareness to the society to change the negative attitude or prejudice to overcome the barriers in employment of persons with disabilities.

References

- [1] D. Alca, The importance of education for the persons with disabilities in labour market, *Employment and Social Protection of Adults with Disability: Selected Papers* 37(2009).
- [2] C. Barnes, G. Mercer, Disability, work, and welfare: Challenging the social exclusion of disabled people. *Work, employment and society* 19(3) (2005) 527-545.
- [3] J. E. Bickenbach, S. Chatterji, E. M. Badley, T. B. Ustun, Models of disablement, universalism and the international classification of impairments, disabilities and handicaps, *Social science & medicine* 48(9) (1999) 1173-1187.
- [4] T. Bualar, Disability rehabilitation policy in Thailand: explaining why it has come under fire, *Journal of Asian Public Policy* 3(1) (2010) 111-117.
- [5] T. Bualar, Employer dilemma over disability employment policy in Thailand. *Journal of Public Affairs* 15(3) (2015) 231-236.
- [6] A. Colella, S. Bruyere, Disability and employment. In S. Zedeck (Ed.), *APA handbook of industrial and organizational psychology*, American Psychological Association 1 (2011) 473-504.
- [7] A. Colella, A. Varma, Disability-job fit stereotypes and the evaluation of persons with disabilities at work, *Journal of Occupational Rehabilitation* 9(2) (1999) 79-95.
- [8] A. Colella, A. S. DeNisi, A. Varma, The impact of rater's disability on performance judgments and choice as partner: The role of disability-job fit stereotypes and interdependence of rewards, *Journal of Applied Psychology* 83(1) (1998) 102.
- [9] CUPE, Disability rights: fact sheet on what is a disability? Canadian Union of Public Employees, <https://cupe.ca/disability-rights-fact-sheet-what-disability> (accessed 14 Mar 2020).
- [10] E. Diksa, E. S. Rogers, Employer concerns about hiring persons with psychiatric disability: Results of the employer attitude. *Rehabilitation Counseling Bulletin* 40(1) (1996) 31-44.
- [11] K. R. Fisher, C. Purcal, Policies to change attitudes to people with disabilities, *Scandinavian Journal of Disability Research* 19(2) (2017) 161-74.
- [12] R. Fraser, I. Ajzen, K. Johnson, J. Hebert, F. Chan, Understanding employers' hiring intention in relation to qualified workers with disabilities. *Journal of Vocational Rehabilitation* 35(1) (2011) 1-1.
- [13] F. Furuoka, K. H. Pazim, B. Lim, R. Mahmud, Employment situation of person with disabilities: Case studies of US, Japan and Malaysia. *Researchers World* 2(4) (2011) 1.
- [14] B. Hernandez, C. Keys, F. Balcazar, Employer attitudes toward workers with disabilities and their ADA employment rights: A literature review. *Journal of Rehabilitation-Washington* 66(4) (2000) 4-16.
- [15] A. Hogan, S. M. Kyaw-Myint, D. Harris, H. Denronden, Workforce participation barriers for people with disability. *International Journal of Disability Management* 7 (2012) 1-9.
- [16] Indian Institute of Public Health Hyderabad. Barriers in employment and employability for persons with disabilities in Hyderabad, A.P. India. South Asia Centre for Disability Inclusive Development and Research, (SACDIR), https://phfi.org/wp-content/uploads/2017/03/employmentand_disability2014.pdf (accessed 11 Mar 2020).
- [17] C. R. Jasper, P. Waldhart, Retailer perceptions on hiring prospective employees with disabilities. *Journal of Retailing and Consumer Services* 19(1) (2012) 116-123.
- [18] M. K. Jones, Disability and the labour market: a review of the empirical evidence, *Journal of Economic Studies* (2008).

- [19] H. S. Kaye, L. H. Jans, E. C. Jones, Why don't employers hire and retain workers with disabilities?, *Journal of occupational rehabilitation* 21(4) (2011) 526-36.
- [20] B. Krahe, C. Altwasser, Changing negative attitudes towards persons with physical disabilities: An experimental intervention, *Journal of Community & Applied Social Psychology* 16(1) (2006) 59-69.
- [21] K. McCary, The disability twist in diversity: Best practices for integrating people with disabilities into the workforce, *The Diversity Factor* 13(3) (2005) 16-22.
- [22] S. Mitra, U. Sambamoorthi, Disability and the rural labor market in India: evidence for males in Tamil Nadu, *World Development* 36(5) (2008) 934-952.
- [23] B. Murray, Vocational training of disabled persons in Thailand: a challenge to policymakers (1998).
- [24] R. Naraharisetti, M. C. Castro, Factors associated with persons with disability employment in India: a cross-sectional study, *BMC public health* 16(1) (2016) 1063.
- [25] B. O'Day, Employment barriers for people with visual impairments. *Journal of Visual Impairment & Blindness* 93(10) 627-642.
- [26] H. Ouellette-Kuntz, P. Burge, H. K. Brown, E. Arsenault, Public attitudes towards individuals with intellectual disabilities as measured by the concept of social distance, *Journal of Applied Research in Intellectual Disabilities* 23(2) (2010) 132-142.
- [27] V. Pearson, F. Ip, H. Hui, N. Yip, To tell or not to tell; disability disclosure and job application outcomes, *Journal of Rehabilitation* 69(4) (2003) 35.
- [28] Z. Peker, Employment of Individuals with Disability: An Examination of UN's Decent Work Practices, *Employment and Social Protection of Adults with Disability: Selected Papers* 81.
- [29] D. Rao, R. A. Horton, H. W. Tsang, K. Shi, P. W. Corrigan, Does individualism help explain differences in employers' stigmatizing attitudes toward disability across Chinese and American cities? *Rehabilitation psychology* 55(4) (2010) 351.
- [30] A. Roulstone, Disabled people, work and employment: A global perspective, In *Routledge handbook of disability studies*, pp. 222-235.
- [31] Shenoy M. Persons with disability & the India labour market: Challenges and Opportunities, *ILO* 13(1) (2011).
- [32] R. C. Toldra, M. C. Santos, People with disabilities in the labor market: facilitators and barriers, *Work* 45(4) (2013) 553-563.
- [33] S. Tse, What do employers think about employing people with experience of mental illness in New Zealand workplaces?, *Work* 23(3) (2004) 267-274.
- [34] UNCRPD, United Nations Convention of the Rights of People with Disability, <http://www.un.org/esa/socdev/enable/rights/ahc8adart.htm#art2> (accessed 18 Mar 2020)
- [35] UNDP, Disability Inclusive Development in UNDP, New York: UN Publications, 2018.
- [36] K. Vornholt, P. Villotti, B. Muschalla, J. Bauer, A. Colella, F. Zijlstra, G. Van Ruitenbeek, S. Uitdewilligen, M. Corbiere, Disability and employment-overview and highlights, *European Journal of Work and Organizational Psychology* 27(1) (2018) 40-55.
- [37] M. T. Westbrook, V. Legge, M. Pennay, Attitudes towards disabilities in a multicultural society, *Social science & medicine* 36(5) (1993) 615-623.
- [38] D. Wilson-Kovacs, M. K. Ryan, S. A. Haslam, A. Rabinovich, Just because you can get a wheelchair in the building doesn't necessarily mean that you can still participate: barriers in the career advancement of disabled professionals, *Disability & Society* 23(7) (2008) 705-717.
- [39] World Bank, Disability Inclusion, <https://www.worldbank.org/en/topic/disability> (accessed 17 Mar 2020).
- [40] World Health Organization. *World Report on Disability: Summary*. Geneva, Switzerland, 2011.
- [41] P. Yeager, H. S. Kaye, M. Reed, T. M. Doe, Assistive technology and employment: Experiences of Californians with disabilities, *Work* 27(4) (2006) 333-344.
- [42] B. Nitkhamhan, W. Laohasiriwong, N. Puttanapong, P. Schlattmann, Social Disparities and Incapability to Work Due to Illness or Disability among Working-Age Population in Thailand, *Indian Journal of Public Health Research & Development* 11(7) (2020) 1124-1129.
- [43] L. J. Avery, Mobilisation and the Disability Rights Movement: The Realities of Public Transport in Bangkok, Doctoral dissertation, University of Leeds.
- [44] S. Lindsay, Discrimination and other barriers in employment for teens and young adults with disabilities, *Disability and rehabilitation* 33(15-16) (2011) 1340-1350.



An evaluation of rural electrification in Nigeria: A study of Ibogun community, Ogun state

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Abstract

Rural electrification (RE) has not been effectively pursued especially due to huge financial implications in the RE infrastructure provision. Because of the privatisation of the electricity distribution in Nigeria and the compartmentalization of distributors to regional areas, it is expected that rural communities, which are composite part of the region, should be incorporated in the overall framework for RE. But since the deregulation of the electricity sector, little or no attempt has been made to evaluate the current situation of RE of many Nigerian communities. This study evaluated RE in Nigeria, however, using Ibogun community as its case study. This study adopted a cross-sectional survey approach. Multistage sampling technique was adopted to distribute 122 copies of questionnaire across 10 villages. Findings revealed that Ibogun community is a literate society dominated by the low-income class. 26% of its residents relied on the electricity service provider (ESP) for electricity supply whereas 69.7% received electricity supply from both ESP and alternatives, particularly power-generating sets. Because of the inadequate electricity supply, about 46% of residents used power-generating set between 1 to 4 hours daily to augment shortage. Most residents received estimated electricity bills, which indicate electricity consumption in the community is not metered. 42.6% confirmed electricity infrastructure was in a poor state and 50% rated electricity supply as poor. About 70% of the residents were affected by poor electricity supply but the greatest negative impacts were imposed on residents' businesses and communication. The major problem of electricity supply was the climate impacts on electricity infrastructure. Although residents perceive government role in electricity supply as marginal, nonetheless the residents considered as priority intervention, the upgrade of existing electricity facilities by the government. And to cope with various challenges of electricity supply and its associated impacts, Ibogun community has adopted self-help approaches toward improving electricity supply through the acquisition of electricity transformers and poles and execution of repairs of electricity transformers and poles when necessary. The inferential statistic (Spearman's Rank Correlation) results indicated that there is no significant association between income and variables (source of electricity, alternative source of energy supply, and daily hourly usage of a power-generating set). The study makes recommendations towards solving the challenges of rural electrification.

Keywords: consumption, electricity, Ibogun, rural electrification, supply

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1. Introduction

Access to electricity is usually a subject of concern globally [1]. This may not be unconnected to the importance of electricity to the economic development of a nation. Again, rural electrification is an act of bringing electrical power to rural and remote areas for safety, agriculture and health care purposes for rural development to make rural life comfortable for the dwellers [2]. It is important to state that modern cities were once rural, and therefore, rural development for national development cannot be overem-

phasised. However, development is dependent on adequate and regular energy supply.

Quite many studies have focused on rural electrification [3 – 6]. Jimenez observed that there was an increase in impacts evaluation studies on the effects of electricity on socio-economic development. In his study, [4] attempted to clarify how and to what extent access to electricity and improvement in such infrastructure contribute to economic and social development. He focused on the factors of education, labour and income outcomes and discovered that electrification brought about an increase of about 7% in school enrolment, 25% in employment and 30% in income. [5] examined factors influencing implementation of rural electrification programme in Kieni East

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Sub County in Kenya. They found that funding, electricity cost, alternative sources of power and demand affect the implementation of the Rural Electrification Programme. While charcoal was discovered to be major source amongst the various sources available, authors reported sufficient awareness of the alternative sources of power to electricity and utilisation of these alternatives by households because they are accessible, cheaper and more reliable.

In Nigeria, access to modern energy service in the rural area is worse as only 40% of Nigeria's population have access to electricity [7]. The challenge of rural electrification in Nigeria has been connected to factors such as difficulty in the terrain and low consumption. As such, the rural regions are made to suffer, since their locations are not attractive to small and medium scale industries, and as a result, leading to urban migration [8]. Again "almost 50% of the states in Nigeria have more than 50% of people without access to electricity, which brings to fore the challenge of lack of electricity access in various parts of Nigeria" (Oseni 2011, 2012 cited in 9).

Rural electrification (RE) has not been effectively pursued especially because of the huge financial implications in the provision of RE infrastructure. As the electricity distribution in Nigeria is privatised and the compartmentalization of distributors to regional areas, it is expected that rural communities which are composition part of the region, should be incorporated in the overall framework for RE. But since the privatisation of the electricity, little or no attempt has been made to evaluate the current situation of RE of many Nigerian communities. Hence this study is an attempt to evaluate RE in Nigeria, however, using Ibogun as its case study.

2. Problem Description

Electrification, as a source of energy, is very significant to the survival of the good living. Be it rural or urban, availability of electricity is essential for social, economic and psychological needs of man. In the last three (3) decades, efforts have been made to ensure that everybody irrespective of where they live, work or reside should have access to electricity. To ensure that this is achieved, the Nigerian government deregulate and privatise its energy sector especially electricity. To eliminate conflict of interest among the beneficiaries of the deregulation process, the government further created a geographical coverage for each of the beneficiaries to ensure that problems in terms of provision, operations, management and administration in the process of providing electricity to Nigerians are removed.

As a result of the deregulation and fractionalisation of electricity providers into various geographical coverage, it is expected that the service providers should go all out to ensure that irrespective of the settle-

ment status electricity should be provided. In the last decades, it is obvious that efforts have been made by electricity service providers to ensure that rural electrification is incorporated into their overall regional electrification master plan. This is further necessary as it has been observed that non-availability of electricity supply in many rural areas of Nigeria seems to be responsible for the rural-urban migration syndrome.

Again, it becomes worrisome why electricity service providers have not taken rural electrification programmes seriously. Information available reveal that returns on the investment made by the service providers in the rural areas do not justify the capital intensive nature and maintenance requirements for rural electrification. It is, therefore, important to ask some fundamental questions whether rural electrification in Nigeria is essentially meant for residents in the villages and communities only without cognisance of other economic activities and practices supporting rural economy such as artisanship, processing and packaging, which are also dependent on the availability of electricity. When such activities are considered in the rural electrification programme, will it not serve as a strategy for containing rural-urban migration. Again, what makes electricity supply in the urban areas of greater priority in rural communities, because the major associated problems service providers are faced in the urban environment include overloading as well as non-payment of consumption charges, which is similar with the problems in rural areas because of lack of infrastructure especially transformers, thus leading to overloading as well as non-payment. It is believed that by extending their presence in the rural areas could serve as a pull for people from the urban environment to the rural environment. It will also serve as a major parameter for industrial and manufacturing development thereby raising revenue desirable through rural electrification. It is against this background that this study is attempting an evaluation of rural electrification in Nigeria by focusing on Ibogun community. Ibogun community is located in Ifo local government area (LGA) of Ogun State, Nigeria.

3. Aim and Objectives

The aims of this study were evaluating rural electrification in Nigeria, using Ibogun community of Ogun State as its case study, with a view of addressing the major factors affecting rural electrification dilemma in Nigeria, and how to improve rural electrification programmes in the country and by extension Ibogun community of Ogun State. The specific objectives, therefore;

- i. To highlight rural electrification situation in Ibogun community, with a view of ascertaining the level of rural electrification status.
- ii. To examine the socio-economic characteristics and attributes of residents in the study area with a view

of providing means of appraising in quality and quantity terms of rural electrification infrastructure in the study area.

iii. To reveal the determinants for rural electrification provision.

iv. Based on the findings from i – iii, proffer solutions capable of generating sustainable rural electrification in Nigeria.

4. Literature Review

It has been estimated that 1.3 billion people in the world do not have access to electricity which represent 18% of the global population of which the majority are resident in Africa and South Asia [5]. [1] observed that the most rural area dwellers in Nigeria relied on fuelwood for energy need. Although, fuelwood is put to use by over 70% of Nigerians. However, it is on record that Nigeria had the second highest number of people without electricity access in 2016, estimated at about 74 million or 39% of the solution [IEA 2017 cited in 10]. Based on this verdict, the country accommodates the highest number of people without electricity access in Africa [IEA, 2017, World Bank 2017 cited in 10]. The poor access as noted is greatly experienced by the rural areas, especially in the poor countries, thus rural dwellers are at a disadvantage [4, 11]. The poor access has also been linked to factors such as high cost of providing electricity service in low-density area, difficult terrain of remote areas and low consumption by rural communities, which makes the rural electricity schemes more expensive compared to urban schemes and problem of affordability due to low rural income, electricity losses due to long distances as well as more expensive customer support and equipment maintenance [11]. Besides, there is a challenge of air pollution due to utilization of solid fuels for cooking, lighting and heating by the rural communities. The effects of this inefficient way of burning them result in considerable emission of air pollutants, which have implication for human health. For instance, kerosene burning devices can damage lung function, increase cancer risks as well as incidences of infectious illness and asthma. Also, kerosene lamps have been estimated to be responsible for seven per cent of annual global carbon emission.

“Since the privatization of generation and distribution in Nigeria, electricity expansion plans have focused on areas already covered by the grid or close to the grid, based on the business plans of the distribution companies. This makes electricity access to rural areas slow and creates a mix-up as to how to proceed with rural electrification” [ESMAP, 2005 cited in 9], but the plan of the Nigerian Rural Electrification Agency (NREA) was created to bridge the gap [9]. [12] survey revealed that poor electricity supply made residents resort to alternatives such as power-generating set, solar/inverter, fossil fuel and coal, all of which

pose threats to public health and the environment except solar/inverter. [8] analysis showed that the rural areas consume high polluted means of lighting houses in Nigeria, which is as a result of the rural electrification scheme failure to meet the demand for electricity by the rural consumers in Nigeria. This challenge is acute and peculiar because the country has not been able to provide adequate supply to the connected populace let alone the rural areas, and also, it has not been able to extend its service of power transmission to very part of the connected area of the country [8].

[13] in their study of rural energy condition in Oyo State posited that generator and other fuel-powered engines (grinding and welding engines), battery supported flashlights and fire-wood form the core energy sources in rural areas. The rural dwellers depend on fossil fuel generator to charge their phones and lamps, many (such as traders, welders and pepper grinders) also make use of petrol or diesel-powered engines to operate their livelihood-based machines. Households generally make use of flashlights powered by batteries and rechargeable lamps as a form of light for easy navigation at night.

The increases in the demand for electricity have grown faster than the supply and the population; this has led to the rural household to still rely on unhealthy and unsustainable sources of energy to light-up their environment. However, for any meaningful planning work towards rural electrification, reliable data cannot be overemphasised but this is lacking. He then advocated for collection of information as a disaggregate ward/village levels in Nigeria [9].

5. Study Area

Ibogun is situated in Ifo LGA of Ogun State, southwestern Nigeria (Figure 1). Ibogun is one of the eleven political wards recognised by the Independent National Electoral Commission [14]. Ibogun is made up of 32 villages. The villages consist of Olaogun, Adina, Akiode, Sulola, Ekundayo, Akin-side, Olaoparun, Opo, Alasia, Odeyinlo, Alapako Oke, Alapako Isale, Odeyemi, Alapoti, Egbeda, Fasina, Osungboye, Ilugboro, Omitoro, Balogun, Sowunmi, Ibogun, Awe Nla, Awe Kekere, Awe Alapapo, Fayelu, Abudu, Giwa, Olorundada, Ojodu, Abudu Tuntun, and Epoto.

Ibogun community has a moderate population and is not an exemption among communities that urgently needs rural electrification. By its agrarian nature, the community is involved with the cultivation of crops, vegetables and animal farming amongst which are poultry, piggery, etc. The community produces a relatively high yield of cassava every year, which is sufficient for setting up a garri producing factory and could turn out to be a major source of revenue to some residents. This is same for fufu processing that is currently being taken to neighbouring states especially

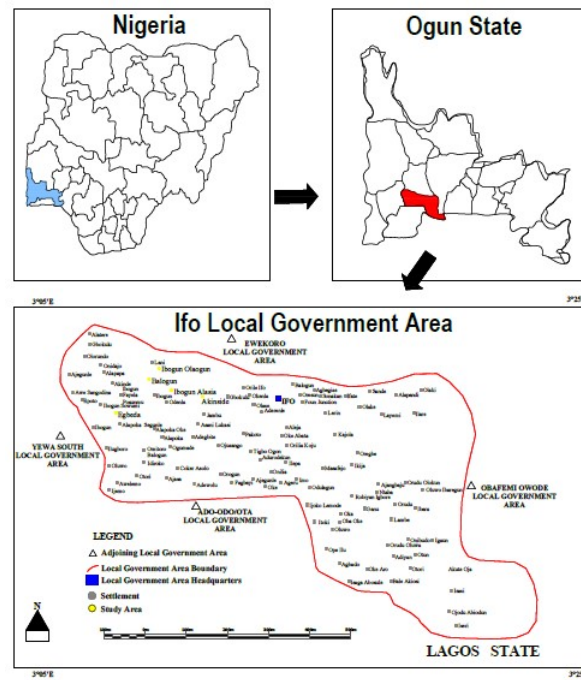


Figure 1: Map of study area.

Lagos State for sale. In terms of development, Ibogun community is predominantly residential and agricultural land uses along with scanty commercial activities. Also, there are institutional developments such as schools, health centres, police post, etc. The processing factories found at the community are small scale in nature and they include block making, sawmills, welding, etc. There are pieces of evidence of trading activities in the community with the domination of building/construction materials. Residential (housing) developments spring up from time to time due to its proximity to Lagos and some medium-sized urban areas in Ifo LGA and Ogun State. Ifo LGA, where Ibogun community is situated, is one of the Development Pressure Area as recognised by the Ogun State Regional Plan [15]. Ibogun is also host to the College of Engineering and Environmental Studies, Olabisi Onabanjo University, Ibogun Campus. The community has an advantage of locating next to border settlements to the western part through which some of the agricultural products from their farms if properly processed and packaged, can be exported for the benefits of the community, Ogun State and the country at large. These border settlements link up with Benin Republic, through which goods are imported into Nigeria.

6. Study Methodology

A cross-sectional approach was adopted for this study. The approach was based on the recommendation of the [16] in a study of rural electrification. The survey approach is believed to offer the merit of providing valid information that can be generalized

to a broader population. According to [17], cross-sectional research design is employed when a study is concerned about the prevalence of phenomenon or situation as well as involving only one contact with the study target population.

The study utilised data from both and secondary sources. The researchers utilised a questionnaire to obtain information from Ibogun community residents. The questionnaire used captures socio-economic profile of the residents, issues regarding sources of electricity supply, electricity consumption, and problems associated with electricity supply and consumption. The collected data were complemented by field observation. The secondary data sources included journal articles, government publications, and technical reports.

The study adopted a multistage sampling technique for sample selection. At the first stage, 10 villages were randomly selected out of the 32 villages making up Ibogun community. The villages selected are Olao-gun, Adina, Akinside, Opo, Alasia, Oderinlo, Egbeda, Fasina, Balogun, and Giwa. At the second stage, in each of the selected village, questionnaires were distributed using a purposive sampling technique. Data collected were analysed using a Statistical Package for Social Sciences (IBM Statistics 25). Also, results from analysis are presented through the use of tables and charts. Inferential statistics were also conducted to determine relationship or association with respondents' monthly income and variables (source of electricity, an alternative source of energy supply, and daily hourly usage of a power-generating set). To achieve the objective, three hypotheses were formulated. They are:

i. H_0 : There is no significant relationship or association between residents' income and source of electricity.

ii. H_0 : There is no significant relationship or association between residents' income and alternative source of energy supply.

iii. H_0 : There is no significant relationship or association between residents' income and daily hourly usage of a power-generating set.

7. Results and Discussions

7.1 Socioeconomic profile of respondents

From Table 1, the respondents' gender consists of 52% females and 48% males, a result which is an almost equal ratio. Results on the marital status of respondents show that a majority (74.6%) are married, singles accounted for 18.9%, and 4.1% are widowed. Also, the age distribution of the respondents indicates about 78% are within the working-age group with the potential to contribute to the economy of the rural community to which they belong. The majority (91.8%) of the respondents have acquired formal education, 0.8% had informal education and 6.6% had no education. The results of occupational status revealed that half (50%) are traders, 18.9% are artisans, farmers (12.3%), 9.8% are civil servants and 2.5% are private employees. The results indicate the rural communities are gradually transforming into township status with over 70% of the respondents working in a paid job and self-employed and less than 13% getting involved in farming. The monthly income of the respondents revealed half (50%) of the respondents earned below ₦18,000 (\$ 50), 31% earned between ₦18,001-₦60,000 (\$ 50 – \$ 166.70) and about 5% earned above ₦60,000 (> \$166.70), which thus implies Ibogun community is dominated by low-income class. The meagre income of the respondents may limit households' access to the required electricity. The study area represents an emerging settlement as results showed that 41.8% migrated to the community in the last three years. Another 20.5% had lived in the study area for 4-6 years, 17.2% lived for 7-10 years and 18.9% had been residents for over 10 years. The influx into the study area indicates an increase in electricity demand by the residents is inevitable.

7.2 Electricity supply

This study captured electricity sources for Ibogun Community as shown in Table 2. 26% of the respondents relied exclusively on the electricity service provider (Ibadan Electricity Distribution Company - IBEDC). A greater percentage (69.7%) received electricity supply from both IBEDC and alternatives whereas about 5% relied exclusively on alternatives. However, 4.1% did not connect to any electricity source. The alternative electricity sources used by the respondents are power-generating set (77%),

firewood (9.8%), solar inverter (0.8%) and coal (0.8%) (Table 2). A greater proportion utilizing power-generating set portend environmental pollution in Ibogun community. This finding is contrary to an earlier study by [12] that reported 48% of the respondents utilised power-generating set and 19% who utilised fossil fuel and coal, as an alternative energy source. The variations recorded may be due to the availability of energy sources and household income. More importantly, the results imply that electrification planning should be location-specific as household characteristics differ across geographical space. From Table 2, results revealed variations in the daily electricity supply by the IBEDC. 58.2% of the respondents confirmed daily electricity supply is between 1-5 hours while 19.7% received electricity supply for 6-10 hours. Another 12.3% received electricity supply for 11-16 hours and above 16 hours (6.6%). The results here demonstrated that in the study area, the majority received electricity supply for less than 5 hours daily. This must have informed the greater proportion that utilised power-generating set to augment the shortfall. The result confirmed [1] findings that the duration of electricity supply in the northern part of Nigeria is better than the southern part, where the study area is located.

7.3 Electricity consumption

The respondents' time of access to electricity varies as results in Table 3 showed that 13.9% of the respondents had access between 6pm and 12 midnight, 9% had their access time between 12 midnight - 6am, 5.7% confirmed 12noon-3pm, 3.3% said between 6-9am and equal proportion (1.6%) had day access time of 9am-12noon and 3-6pm respectively. Although, a greater proportion (62.3%) could not ascertain access time to electricity but there seems to be greater supply between 6pm and 6am. The results validated the stance of [1] who stated rural households have an average of 6 hours of electricity daily, which thus confirms that rural households tend to have shorter hours of electricity supply than urban households. Also, for electricity consumption, the respondents pay for the electricity bills via diverse modes. The largest proportion (73.8%) pay estimated sum as determined by the electricity service provider, 10.7% used prepaid meter, 7.4% through self-assessment and 4.1% used analogue meter serving as the basis for their electricity bills. The results indicated that less than 15% of the respondents have their electricity consumption metered, which is a challenge to ascertain energy demand in Nigeria. The results also implied the problems of overcharging and undercharging are inevitable. 87.7% of the respondents pay their electricity bills monthly, 2.5% pay once in two months and 0.8% pay once in 3 months. Of the proportion that utilised power-generating set, 31.1% used it between 3-4 hours daily, next is between 5-11 hours daily (20.5%), and 14.8%

Table 1. Socioeconomic profile of respondents.

Variable	Frequency	Percent	Variable	Frequency	Percent
Gender			Level of education		
Male	59	48.4	Informal	1	0.8
Female	63	51.6	Primary	21	17.2
<i>Total</i>	<i>122</i>	<i>100.0</i>	Secondary	66	54.1
Marital status			Tertiary	25	20.5
Single	23	18.9	No education	8	6.6
Married	91	74.6	No response	1	0.8
Widow/Widower	5	4.1	<i>Total</i>	<i>122</i>	<i>100.0</i>
No response	3	2.5	Occupational status		
<i>Total</i>	<i>122</i>	<i>100.0</i>	Farmer	15	12.3
Age			Artisan 23 18.9		
Below 20 years	9	7.4	Trader	62	50.8
21-30 years	32	26.2	Public Servant	12	9.8
31-40 years	44	36.1	Private	3	2.5
41-50 years	19	15.6	Retired	1	0.8
Above 50 years	16	13.1	Unemployed	1	0.8
No response	2	1.6	Student	5	4.1
<i>Total</i>	<i>122</i>	<i>100.0</i>	<i>Total</i>	<i>122</i>	<i>100.0</i>
Monthly income			Residency period		
Below ₦18,000	61	50.0	Less than 3 years	51	41.8
₦18,001 - ₦30,000	22	18.0	4-6 years	25	20.5
₦30,001 - ₦60,000	28	23.0	7-10 years	21	17.2
₦60,001 - ₦120,000	4	3.3	Above 10 years	23	18.9
Above ₦120,000	2	1.6	No response	2	1.6
No response	5	4.1	<i>Total</i>	<i>122</i>	<i>100.0</i>
<i>Total</i>	<i>122</i>	<i>100.0</i>			

Table 2. Electricity supply.

Variable	Frequency	Percent
Source of electricity		
IBEDC	26	21.3
Alternative	6	4.9
Both IBEDC & Alternative	85	69.7
Not connected to power	5	4.1
<i>Total</i>	<i>122</i>	<i>100.0</i>
Alternative sources		
Firewood	12	9.8
Solar/Inverter	1	0.8
Generating set	94	77.0
Coal	1	0.8
Others	2	1.6
No response	12	9.8
<i>Total</i>	<i>122</i>	<i>100.0</i>
Length of supply by ESP		
1-5 hours	69	56.6
6-10 hours	24	19.7
11-16 hours	15	12.3
Above 16 hours	8	6.6
No response	6	4.9
<i>Total</i>	<i>122</i>	<i>100.0</i>

that used for 1-2 hours. While 9.8% of the respondents power the set for 12-15 hours, marginal proportion (0.8%) used the set for above 16 hours (Table 3).

7.4 Perception on the state of infrastructure, electricity supply rating and impacts

From Table 4, results revealed respondents perceived state of infrastructure in the study area. 42.6% of the respondents stated that electricity infrastructure was poor, 36.9% claimed they were fair, and 9% said satisfactory. The proportions who stated good and very good were 7.4% and 3.3% respectively. The respondents' perceptions regarding electricity supply revealed half (50%) rated supply as poor, 36.1% thought it was fair, 7.4% stated satisfactory, 5.7% reported that supply was good and marginal proportion (0.8%) affirmed it was very good. About 70% of the respondents were negatively affected, and for those who reported severe impacts, results revealed the proportion of impacts range from businesses (24.1%), communications (24.1%), studies (18.5%), social (14.8%), security (14.8%), to recreation (0.8%).

7.5 Respondents' perception on the challenges of electricity supply

Results presented in Table 5 showed that 62.2% of the respondents strongly agreed or agreed to climate impacts on electricity infrastructure as a challenge whereas about 28% disagreed or strongly agreed. Similarly, over-half (51.7%) of the respondents strongly agreed or agreed to the fact of frequent breakdown of electricity transformer due to overloading as the problem of electricity supply while 36% disagreed or strongly disagreed. Respondents also made

Table 3. Electricity consumption.

Variable	Frequency	Percent
Access Time to Electricity		
12 midnight to 6am	11	9.0
6 - 9am	4	3.3
9am - 12 noon	2	1.6
12 - 3pm	7	5.7
3-6pm	2	1.6
6pm - 12 midnight	17	13.9
Unable to specify	76	62.3
No response	3	2.5
<i>Total</i>	<i>122</i>	<i>100.0</i>
Payment Mode for electricity consumption		
Prepaid Meter	13	10.7
Estimated	90	73.8
Self-Assessment	9	7.4
Analogue Meter	5	4.1
No response	5	4.1
<i>Total</i>	<i>122</i>	<i>100.0</i>
Electricity bills' payment frequency		
Monthly	107	87.7
Once in 2 months	3	2.5
Once in 3 months	1	0.8
No response	11	9.0
<i>Total</i>	<i>122</i>	<i>100.0</i>
Daily hourly usage of generating set		
1-2 hours	18	14.8
3-4 hours	38	31.1
5-11 hours	25	20.5
12 - 15 hours	12	9.8
Above 16 hours	1	0.8
No response	28	23.0
<i>Total</i>	<i>122</i>	<i>100.0</i>

their opinion known concerning non-payment of electricity bills by residents as a challenge to electricity supply, and results indicated that over half (52.4%) disagreed or strongly disagreed while 39.4% strongly agreed or agreed. Regarding the challenge of obsolete electricity infrastructure and billing rate, 51.6% and 65.5% strongly agreed or agreed respectively. Also, almost half (43.5%) agreed to sharp practices as electricity supply problem whereas 27.1% disagreed or strongly disagreed. Again, the majority (50.8%) disagreed or strongly disagreed with the vandalism of electricity infrastructure by miscreants as an electricity supply problem while 25.5% thought otherwise. However, a closer examination of the results revealed that “rate of billing” and “climate impacts on electricity infrastructure” are major problems of electricity supply in the study area. In addition to this, respondents greatly disagreed in respect of non-payment of bills by respondents. Greater proportion of neutrality by the respondents regarding the challenge of electricity was reported in the case of vandalism by miscreants (23.8%).

Table 4. Perception on the state of infrastructure, electricity supply rating and impacts.

Variable	Frequency	Percent
State of electricity infrastructure		
Very Good	4	3.3
Good	9	7.4
Satisfactory	11	9.0
Fair	45	36.9
Poor	52	42.6
No response	1	0.8
<i>Total</i>	<i>122</i>	<i>100.0</i>
Electricity supply rating		
Very Good	1	0.8
Good	7	5.7
Satisfactory	9	7.4
Fair	44	36.1
Poor	61	50.0
<i>Total</i>	<i>122</i>	<i>100.0</i>
Impact of state of electricity supply		
Strongly Affected	54	44.2
Mildly Affected	31	25.4
Not Affected	36	29.5
No response	1	0.8
<i>Total</i>	<i>122</i>	<i>100.0</i>
Impacts		
Business	13	24.1
Studies	10	18.5
Social	8	14.8
Recreation	2	3.7
Security	8	14.8
Communication	13	24.1
<i>Total</i>	<i>54</i>	<i>100.0</i>

7.6 Respondents' perception of expected government intervention

The respondents' perceptions on their expectation of government intervention towards rural electrification were examined in this study and results indicated that greater proportion agreed to upgrade of existing facilities (85.5%), expansion of electricity infrastructure (80.3%), safety and security (72.2%), improved billing system (68.9%), and checking sharp practices (58.2%). However, greater disagreements were recorded concerning “checking sharp practices” while respondents' least disagreements were recorded for the item “upgrade existing facilities”. But the respondents' neutrality regarding government intervention was highest for “checking sharp practices” and lowest for “upgrade existing facilities.” The results implied that residents identified obsolete electricity infrastructure as the major problem facing rural electrification.

7.7 Presence of government intervention on rural electrification

Residents' perception regarding if their community witnessed government intervention in electrification were sought and analysis was presented in Figure 2. 77% of the respondents opined there has not been government intervention in their community, 14% said

Table 5. Respondents' perception on the challenges of electricity supply.

Challenges	SA*	A*	U*	D*	SD*	Total
Climate impact on electricity infrastructures	27.0	35.2	9.8	16.4	11.5	100.0
Frequent breakdown of electricity transformer due to overloading	23.8	27.9	12.3	22.1	13.9	100.0
Non-payment of bills by residents	11.5	27.9	8.2	35.2	17.2	100.0
Obsolete electricity infrastructures	13.1	38.5	14.7	19.7	9.0	100.0
Rate of Billing	27.0	38.5	7.4	18.9	8.2	100.0
Sharp practices	22.1	26.2	17.2	18.9	15.6	100.0
Vandalisation by miscreants	6.6	18.9	23.8	20.5	30.3	100.0

*(SA – Strongly Agree; A – Agree; U – Undecided; D – Disagree; SD – Strongly Disagree)

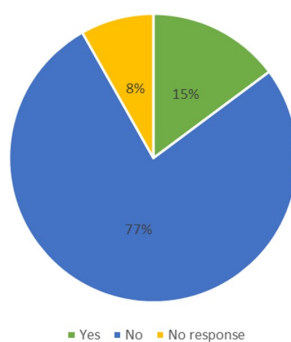
Please note that values presented in the table are in percent

Table 6. Respondents' perception of expected government intervention.

Intervention	SA*	A*	U*	D*	SD*	Total
Upgrade existing facilities	55.7	32.8	3.3	4.1	4.1	100.0
Improve the billing system	27.9	41.0	7.4	18.9	4.9	100.0
Expansion of electricity infrastructure	47.5	32.8	6.6	9.0	4.1	100.0
Safety and security	36.1	36.1	7.3	13.9	6.6	100.0
Check sharp practices	29.5	28.7	13.1	16.4	12.3	100.0

*(SA – Strongly Agree; A – Agree; U – Undecided; D – Disagree; SD – Strongly Disagree)

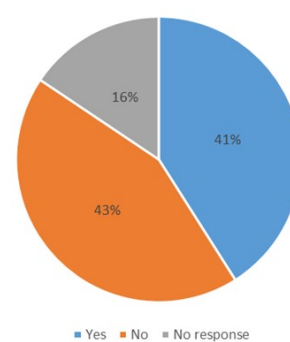
Please note that values presented in table are in percent

**Figure 2:** Presence of government intervention on rural electrification.

there was government intervention, and the remaining 8.2% were indifferent. The interventions witnessed according to some of the residents have been in the form of provision of the transformer and electric poles as well as stable electricity distribution. One of the respondents stated that they received the “promise of community electrification.”

7.8 Presence of electricity self-help projects

As presented in Figure 3, 41% of the respondents reported the community adopted a self-help approach towards electricity provision whereas 43.4% stated there was nothing of sort. The self-help projects embarked upon by the community include the purchase of electricity transformers and poles to replace faulty transformers and damaged poles; repair of faulty electricity transformers; reconnection to the alternative power line and purchase of 30kva generator.

**Figure 3:** Presence of electricity self-help projects.

7.9 Hypotheses testing

Further analyses were conducted to determine if significant relationship or association exists between respondents' income and three other variables - source of electricity, alternative source of energy supply, and daily hourly usage of a power-generating set.

7.9.1 Test 1

H_0 : There is no significant relationship between the residents' income and source of electricity

Decision Rule: Reject the H_0 if p value is less than alpha level of significance ($\alpha = 0.05$) otherwise accept the H_0 .

Since p value (0.629) is greater than 0.05 level of significance as shown in Table 7.

Decision: Accept the H_0 hypothesis

Conclusion: The Spearman's rank correlation is - 0.045 (Table 7) and this means that there is little or no correlation between resident's income and source of electricity. This suggests that residents' income does

Table 7. Correlation between residents' income and source of electricity.

		Monthly Income	Source of Electricity
Spearman's rho	Monthly Income	Correlation Coefficient	1.000
		Sig. (2-tailed)	.629
		N	117
	Source of Electricity	Correlation Coefficient	-.045
		Sig. (2-tailed)	.629
		N	122

Table 8. Correlation between residents' income and alternative source of energy supply.

		Monthly Income	Alternative source of energy supply
Spearman's rho	Monthly Income	Correlation Coefficient	1.000
		Sig. (2-tailed)	.107
		N	117
	Alternative source of energy supply	Correlation Coefficient	.107
		Sig. (2-tailed)	.277
		N	105

not have a relationship or association with the source of electricity.

7.9.2 Test 2

H_0 : There is no significant relationship between residents' income and alternative source of energy supply

Decision Rule: Reject the H_0 if p value is less than alpha level of significance ($\alpha = 0.05$) otherwise accept the H_0 .

Since p value (0.277) is greater than 0.05 level of significance as presented in Table 8.

Decision: Accept the H_0 hypothesis

Conclusion: The Spearman's rank correlation is 0.107 (Table 8) and this means that there is little or no correlation between resident's income and alternative source of energy supply. This suggests that residents' income does not have a relationship or association with alternative source of energy supply.

7.9.3 Test 3

H_0 : There is no significant relationship between residents' income and daily hourly usage of power-generating set

Decision Rule: Reject the H_0 if p value is less than alpha level of significance ($\alpha = 0.05$) otherwise accept the H_0 . Since p value (0.323) is greater than 0.05 level of significance as shown in Table 9.

Decision: Accept the H_0 hypothesis

Conclusion: The Spearman's rank correlation is 0.106 (Table 9) and this means that there is little or no correlation between resident's income and daily hourly usage of power-generating set. This suggests that residents' income does not have relationship with daily hourly usage of power-generating set.

8. Conclusion and Recommendations

This study evaluated rural electrification in Ibogun Community in Ifo LGA, Ogun State, Nigeria. The

study was initiated based on the dearth of study to examine rural electrification since the privatisation of electricity supply in Nigeria. Findings indicated that the majority of residents belong to the working-age group who possess the potential to contribute to community development. Ibogun community is a literate society dominated by the low-income class. The community witnessed an influx of migrants which suggest an increase in electricity demand. 26% of the Ibogun residents relied on electricity service provider (ESP) for electricity supply whereas 69.7% received supply from both ESP and alternatives especially power-generating sets. The majority of residents received less than 5 hours of electricity supply daily. A greater proportion of residents could not specify time of access to electricity although results suggest electricity supply was greater between 6pm and 6am. Most of the residents received estimated bills, thus indicating electricity consumption not metered. Because of the limited electricity supply, about 46% could use power generating set for between 1-4 hours daily to augment shortage. 42.6% conformed electricity infrastructure was in a poor state and 50% rated electricity supply as poor. About 70% of the residents were strongly affected by the poor electricity supply, and consequently, greater impacts were felt on residents' businesses and communication. Other areas of impacts were education, social and security. The major problem of electricity supply was the climate impact on electricity infrastructure while least of the problems identified was vandalism by miscreants. The upgrade of existing electricity facilities was the most desired intervention by the residents though residents considered government role in electricity supply to be marginal hitherto. Ibogun community has since been adopting self-help approach towards electricity supply through the acquisition of electricity transformers and poles as well as carrying out of repairs when nec-

Table 9. Correlation between residents' income and daily hourly usage of power-generating set.

		Monthly Income	Generating set and Hours of usage
Spearman's rho	Correlation Coefficient	1.000	.106
	Sig. (2-tailed)	.	.323
	N	117	89
	Correlation Coefficient	.106	1.000
	Sig. (2-tailed)	.323	.
	N	89	94

essary. Spearman's Rank Correlation results showed that there is no significant association between income and the variables such as the source of electricity, alternative source of energy supply, and daily hourly usage of a power-generating set.

Based on the findings, this study recommends for an improvement in the electricity supply by the ESP to the Ibogun Community. This is because the shortage of electricity supply would undermine the available potentials of both human and natural resources. Increase in electricity supply to the community would translate in mitigating the use of power-generating sets, which has been identified a major source of environmental pollution in Ibogun Community. The ESP should further install prepaid meters so that the issue of overcharging, undercharging and non-payment (default) can be addressed, and more importantly, electricity consumption rate can be monitored for effectiveness and efficient planning. There is a need to upgrade the existing electricity infrastructure especially damaged poles and transformers that breakdown too often. To extend the average life span of transformers and address overloading problems, ESP should see to proper monitoring of electricity consumption and shed load where necessary. It is desirable for the ESP to further liaise with the Physical Planning Authority both at the Local Government and State levels to keep track of physical development in and around Ibogun Community.

References

- [1] S. O. Oyedepo, Energy and sustainable development in Nigeria: The way forward, *Energy, Sustainability and Society* 2(15) (2012) 1-17.
- [2] O. G. Olanakanmi, O.A. Roleola, P.O. Alao, O. Oyedepo, F. Onaifo, Hybridization energy systems for a rural area in Nigeria, *IOP Conf. Ser.: Earth Environ. Sci.*, 2019, 331 012007.
- [3] B. Ngwenya, Stakeholders perception of socio-economic benefits of rural electrification programme in Zimbabwe: A case of Umzingwane district, *American Journal of Rural Development* 1(3) (2013) 33-39.
- [4] R. Jimenez, Development effects of rural electrification, (IDB Policy Brief; 261) Infrastructure and Energy Sector Energy Division, Policy Brief N° IDB-PB-261, <https://publications.iadb.org/publications/english/document/Development-Effects-of-Rural-Electrification.pdf>
- [5] R. Kareithi, G. Muhua, Factors influencing implementation of rural electrification programme in Kenya: A case of Kieni East sub county, Nyeri county, *European Scientific Journal* 14(21) (2018) 236-247.
- [6] A. Groth, Socio-economic impacts of rural electrification in Tanzania, *International Journal of Sustainable Energy Planning and Management*, 21 (2019) 76-92.
- [7] [C. C. Uzoma, K. C. Amadi, Energy access: A key to rural development in Nigeria, *Journal of Social Science* 5(1) (2019) 452-456.
- [8] F. O. Akpojedje, M. E. Onogbostere, E. C. Mormah, P. E. Onogbostere, A comprehensive review of Nigeria electric power transmission issues and rural electrification challenges, *International Journal of Engineering Trends and Technology* 31(1) (2016) 1-9.
- [9] S. Ohiare, Expanding electricity access to all in Nigeria: a spatial planning and cost analysis, *Energy, Sustainability and Society* 5(8) (2015) 1-18.
- [10] K. Olaniyan, B. C. McLellan, S. Ogata, T. Tezuka, Estimating residential electricity consumption in Nigeria to support energy transitions, *Sustainability* 10 (2018) 1440.
- [11] M. Torero, The impact of rural electrification: challenges and ways forward, *Revue D'economie du Developpement* 23 (2015) 49-75.
- [12] B. Badejo, O. Olanakanmi, N. Ogunseye, Investigating electricity consumption in Ogun state, Nigeria, *Journal of Engineering Studies and Research* 26(1) (2020) 7-16.
- [13] A. A. Popoola, H. H. Magidimisha, Rural energy conditions in Oyo state: present and future perspectives on the untapped resources, *International Journal of Energy Economics and Policy* 9(5) (2019) 419-432.
- [14] Ogun - INEC Nigeria, <http://www.inecnigeria.org>
- [15] Ogun State Government, Ogun state regional plan (2005-2025) final report, Lagos: CPMS Limited, 2008.
- [16] World Bank, Monitoring and evaluation in rural electrification projects: A demand-oriented approach. Washington DC: The World Bank, 2003.
- [17] R. Kumar, Research methodology: A step-by-step guide for beginners. London: SAGE Publications Ltd., 2011.



The relationship between Mitragynine blood concentrations and death in Thailand

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Abstract

Kratom (*Mitragyna speciosa* Korth) is a plant that is indigenous to Thailand and leads to addiction. In Thailand, every part of the Kratom plant is classified as a Penal Drug in a Category-5 Narcotic under the Narcotics Act B.E. 2522 (1979). Mitragynine and its derivatives are a type of alkaloids from the Kratom plant that have pharmacotoxicological effects. Blood samples of the deceased whose urine screening with ToxtyperTM was positive for Mitragynine ($N = 34$) and blood samples of persons suspected of Kratom abuse ($N = 7$) were obtained from the Institute of Forensic Medicine under the Royal Thai Police Headquarters from January 2017 to December 2017. The purpose of this research is to study the Mitragynine blood levels in Thai people. The average blood Mitragynine concentration of all 41 samples (categorized into 7 groups) was 197.71 ± 338.16 ng/ml (ranged 2.98 - 1,554.23). Group A ($N = 15$), a group of people whose the autopsy results were not able to determine the exact cause of death, indicated the average blood Mitragynine concentrations of 332.96 ± 495.27 ng/ml, while the average blood Mitragynine concentration of Group B ($N = 12$), fatal accident victims, was 114.99 ± 145.19 ng/ml. Moreover, Group C ($N = 2$) with homicidal cases reported the blood Mitragynine concentration at 347.84 ± 205.47 ng/ml, Group D ($N = 1$) with a suicide case reported at 60.40 ng/ml, Group E ($N = 1$) in which a person died from cancer reported at 2.98 ng/ml, Group F ($N = 3$) in which people died from cardiovascular disorders reported at 232.60 ± 333.10 ng/ml, and Group G ($N = 7$) who were suspected of Kratom abuse reported at 39.29 ± 32.29 ng/ml. High blood Mitragynine concentrations can also cause death. This is the first study in Thailand investigating the level of Mitragynine in blood samples of the deceased and the accused.

Keywords: Mitragynine, Kratom, blood, deceased

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1. Introduction

Kratom (*Mitragyna speciosa* Korth) is a plant that is indigenous to Thailand and leads to addiction. In Thailand, all parts of the Kratom plant are classified as a Penal Drug in a Category-5 Narcotic under the Narcotics Act B.E. 2522 (1979); therefore, consuming any parts of Kratom is still prohibited in Thailand.

Historically, Thai people used Kratom in two ways: chewing the leaves for their stimulating effects on the nerves to work harder, and consuming the '4 × 100' (pronounced: sii koon roi) considered as a type of addiction as entertainment. The '4 × 100' is a boiled Kratom juice cocktail containing antihistamines and sleeping pills or psychotropic drugs, and the narcotic drug is often added. However, this 4 × 100 cocktail puts the addicts at risk of death easily owing to the overdose of poly-drugs.

Mitragynine and its derivatives are types of alkaloids from the Kratom plant that have pharmacotoxicological effects. To elaborate, any persons who

consume any parts of the Kratom plant can be found positive for Mitragynine or its derivatives in human biological specimens such as blood or urine.

In the past, most of the Thai Kratom users, who died unnaturally and were sent to the autopsy at the Institute of Forensic Medicine under the Police General Hospital, were involved in '4 × 100' abuse. The first publication concerning the fatal 4 × 100 was reported by Tungtanuwat and Lawanprasert, demonstrating that Mitragynine and many substances (i.e. Caffeine, Diphenhydramine, Alprazolam, Nortriptyline, Methadone, Tramadol and Methamphetamine) were found in the biological specimens of the deceased but no quantitative analysis data of Mitragynine content was reported [1]. The possible explanation may be due to the lack of reference standards, thus making the toxicological data of Mitragynine affecting the death of this case disappear.

In addition, Kronstrand et al. conducted a pilot research study on quantitative analysis of Mitragynine in the deceased [2]. In their study, nine cases of unintentional fatal intoxications with Mitragynine and

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O-desmethyltramadol from the herbal blend Krypton, whose blood Mitragynine concentration postmortem ranging from 200 – 1,800 ng/mg. They concluded that the synergistic effect of the potent mu-receptor agonist of O-desmethyltramadol and Mitragynine contributed to the unintentional death of the nine cases presented. Subsequently, research on the content of Mitragynine has continuously been published. No previous studies, however, have been conducted among Thai people who consume a lot of the Kratom plant; consequently, the quantitative information of Mitragynine among Thai drug abusers is scant. To fill the gap, therefore, this study has been established.

2. Materials and Methods

Blood samples from the deceased whose urine screening with ToxtyperTM was positive for Mitragynine ($N = 34$) and blood samples of persons suspected of Kratom abuse ($N = 7$) were obtained from the Institute of Forensic Medicine, Police General Hospital under the Royal Thai Police Headquarters from January 2017 to December 2017. Standard Mitragynine solution (100 $\mu\text{g/mL}$ in methanol) was purchased from Cerilliant[®]. After blood was processed with SPE (Solid-Phase Extraction) extraction, the eluent will be sent to measure with LC-MS/MS (LC: Ultimate3000TM, MS: TSQ QuantivaTM) from Thermo Scientific[®]. The study was approved by the Ethics Committee on Human Experimentation of Police General Hospital. Also, the SPSS version 17 was used for statistical analysis.

3. Results

When classified by autopsy reports, 34 blood samples of the deceased can be divided into 6 groups. The first group (Group A) is a group in which the autopsy report cannot be clearly identified, because no significant pathology has been found to cause death. After checking with the police, body indicated that he died without knowing the cause. There are 15 cases in this group with all males and the average age of 36.00 ± 14.31 (aged 18 - 59 years old). The second group (Group B) include those who died from traffic accidents. There are 12 cases in this group with all males and the average age of 20.75 ± 4.55 (aged 15 - 29 years old). The most common pathology reports include skull rupture, brain trauma, lung injury, laceration, bruising, spleen and renal laceration, as a result of the impact of significant force. The deceased in the third group (Group C) died from the assault or a homicide case. This group consisted of 2 cases with all males and the average age of 25.00 ± 8.49 (aged 19 - 31 years old). One was stabbed with a knife, and the other was attacked with firearms. The deceased in the fourth group (Group D) died from suffocation. The rope marks were found on the neck of the deceased, their

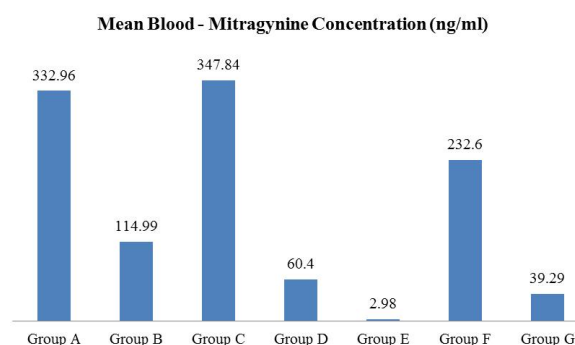


Figure 1: Mean Blood-Mitragynine Concentration (ng/ml).

death was considered as suicide by hanging. There is 1 male aged 21 years old. The deceased in the fifth group (Group E) died from cancer. This group consisted of 1 case, an 83-year-old female whose blood was found positive for Mitragynine and THC-COOH from the Kratom and Marijuana plants. The deceased in the sixth group (Group F) died from cardiovascular disorders. This group comprised 3 cases with all males and the average age of 30.67 ± 14.50 (aged 16, 31 and 45 years old). The last group (Group G) is a group of persons suspected of Kratom abuse. This group comprised 7 cases with all males.

The results of the Mitragynine blood concentrations in the blood specimens showed that all 41 samples (Table 1, Figure 1) had the average concentration of Mitragynine in the blood at 197.71 ± 338.16 ng/ml (ranged 2.98-1,554.23). The groups were sorted in descending order as follows: Group C > Group A > Group F > Group B > Group D > Group G > Group E.

Moreover, Group A, a group in which the autopsy report cannot be clearly identified the cause of death was a large population of this study ($N = 15$) and yielded a high average blood-Mitragynine value (332.96 ± 495.27 ng/ml) with the lowest value of 12.42 and the highest value of 1,554.23 ng/ml. On the contrary, it revealed that one case was detected low blood-Mitragynine level (72.63 ng/ml) but detected narcotic drugs and other drugs up to six items, i.e. Methamphetamine, Morphine, Codeine, Diphenhydramine, Tramadol and Fluoxetine.

In Group B, the group in which the deceased died from a traffic accident, it found that 10 out of 12 cases were using Kratom as recreational cocktail called the '4 × 100', antihistamines such as Diphenhydramine, Cetirizine and Chlorpheniramine, opioid derivatives such as Dextromethorphan and Tramadol, and drugs such as Ketamine, Methamphetamine and Marijuana were found in their blood tests.

In Group C, there were two Homicide cases. First, the 19-year-old man who was found to have died of stabbing was found that his blood-Mitragynine level was 202.55 ng/ml, and Ketamine and Clonazepam

Table 1. Blood-Mitragynine concentration in the Thai deceased.

Group		A	B	C	D	E	F	G	Total
N		15	12	2	1	1	3	7	41
Mitragynine Concentration (ng/ml)	Mean	332.96	114.99	347.84	60.40	2.98	232.60	39.29	197.71
	SD	495.27	145.19	205.47	-	-	333.10	32.29	338.16
	Min	12.42	7.34	202.55	-	-	38.55	5.69	2.98
	Max	1,554.23	453.71	493.13	-	-	617.22	94.57	1,554.23

were detected in his blood specimen. The second man who died from being shot was found that his blood - Mitragynine level was 493.13 ng/ml with Methamphetamine detected in blood.

In Group D, a 21 years old male died from suicide by hanging was detected Mitragynine only, indicating that he used the Kratom plant for the sake of increasing work efficiency.

In Group E, an elderly woman who died from stage IV cancer was found that her blood indicated low concentrations of Mitragynine and THC-COOH, an active ingredient of the Kratom and marijuana.

In group F, there was one interesting case, a 31-year-old man whose autopsy report stated that he died of a severe myocardial infarction. The toxicology report showed that his blood indicated the low level of blood-Mitragynine (38.55 ng/ml) but detected two narcotic drugs (Methamphetamine and Methadone) and five other drugs (i.e. Hydroxyzine, Chlorpheniramine, Tramadol, Diphenhydramine and Clonazepam) that were commonly used to add in the 4 × 100 Kratom cocktails.

4. Discussion

From the overall results, it was found that Mitragynine concentrations in the blood of Kratom abusers range from 2.98 to 1,554.23 ng/ml with the mean of 200 ng/ml which is probably the normal value in the regular addicts. This result is consistent with the clinical study in Thailand of Trakulsrichai et al., the researchers conducted a study on the pharmacokinetics of Mitragynine in 10 male subjects using Kratom tea, demonstrating that the highest C_{max} 105 ng/ml were found in the subjects taking the highest loading dose of 23 mg and the lowest C_{max} 18.5 ng/ml were found in the subjects taking the lowest loading dose of 6.25 mg [3]. In their study, they explained that the dose used in their study was 9 times lower than it was actually used in Malaysia.

Group A and Group F have similar characteristics. Since the average age of the deceased is similar and the deceased died without traces of bruise wounds or severe injury, both groups have a wide range of Mitragynine concentrations (see Table 1) and many samples have a higher level of concentrations. For some cases that took in poly-drug use, when compared with other data, it is compatible with fatal accidental drug overdose. The results are in accordance

with the studies by Holler et al. and Neerman et al., Holler et al. reported one case of death involving Propylhexedrine and Mitragynine intake and his blood-Mitragynine was 390 ng/ml [4]. From their study, the authors suggested that the cause of death was ruled propylhexedrine toxicity and Mitragynine may have contributed as well but no published data for drug concentrations was reported. Neerman et al. published an autopsy report of a 17 year old white man who had a recorded history of heroin abuse and chronic back pain and reportedly self medicated with Kratom [5]. His toxicological analysis reported Mitragynine (600 ng/ml) and four drugs (i.e. Dextromethorphan, Diphenhydramine, Temazepam and 7-Aminoclonazepam) were found in his blood sample. Given the facts of the case, the Medical Examiner certified the cause of death as “possible Kratom toxicity”.

When considering the data from Group A, it showed that there were 3 cases having blood-Mitragynine values at a very high concentration (992.85, 1235.72 and 1554.23 ng/ml). In line with the study by Karinen et al., they reported one fatal case with high blood-Mitragynine (1,060 ng/ml) and concluded that the cause of death was intoxication with mitragynine [6]. Moreover, the study by McIntyre et al. found that the blood-Mitragynine corroborates this study. McIntyre et al. published one case report of a 24-year-old man whose medical history was significant for alcohol abuse and depression [7]. The postmortem blood analysis found Mitragynine in peripheral blood (230 ng/ml) and central blood (190 ng/ml) with the addition of Venlafaxine, Diphenhydramine, and Mirtazapine (in therapeutic range).

If only Mitragynine was detected in Group D, it may be concluded that they used Kratom for the sake of increasing work efficiency. In the case of detecting Mitragynine with THC-COOH in the elderly or cancer patients in Group E), it is possible that they used herbal medicines to reduce suffering and unbearable conditions from terminal cancer. In the last three years, the addictive plant law has become more lenient and Thai people are paying much attention to the use of these two medicinal addictive plants to improve the quality of life in terminal cancer patients. The fact that the suspected persons (Group G) had lower blood-Mitragynine concentration than Groups B and C may be explained that this group of the alive person has a less risky and sensational lifestyle compared with both death groups that held a higher Mitragynine concen-

tration.

5. Conclusion

On account of scant research, this study is the first study on the level of Mitragynine in blood samples of the deceased and the accused in Thailand. Mitragynine contents in each group are different. The deceased from traffic accidents or murder often had a high amount of Mitragynine in the blood when compared to the group that consumed herbal medicine to treat illnesses. The deceased from the group of people who died without knowing the cause and of those that died but found pathological conditions on the heart tended to experience a high amount of Mitragynine and might die from an overdose. Moreover, high concentrations of Mitragynine in the blood can also cause death.

References

- [1] W. Tungtanuwat, S. Lawanprasert, Fatal 4×100 ; Home-Made Kratom Juice Cocktail, *Journal of Health Research* 24(1) (2010) 43-47.
- [2] R. Kronstrand, M. Roman, G. Thelander, A. Eriksson, Unintentional fatal intoxications with Mitragynine and O-desmethyltramadol from the herbal blend Krypton, *Journal of Analytical Toxicology* 35 (2011) 242-247.
- [3] S. Trakulrichai, A. Tongpo, C. Sriapha, S. Wongvisawakorn, P. Rittilert, S. Kaojarern, Kratom abuse in Ramathibodi Poison Center, Thailand: a five-year experience, *Journal of Psychoactive Drugs* 45(5) (2013) 404-408.
- [4] J. M. Holler, S. P. Vorce, P. C. McDonough-Bender, J. Magluilo, C. J. Solomon, B. Levine, A drug toxicity death involving propylhexedrine and Mitragynine, *Journal of Analytical Toxicology* 35(1) (2011) 54-59.
- [5] M. F. Neerman, R. E. Frost, J. Deking, A drug fatality involving Kratom, *Journal of Forensic Sciences* 58 (Suppl.1) (2013) 278-279.
- [6] R. Karinen, J. T. Fosen, S. Rogde, V. Vindenes, An accidental poisoning with Mitragynine, *Forensic Science International* 245 (2014) e29-32.
- [7] I. M. McIntyre, A. Trochta, S. Stolberg, S. C. Campman, Mitragynine 'Kratom' related fatality: a case report with post-mortem concentrations, *Journal of Analytical Toxicology* 39(2) (2015) 152-5.



Factors influencing adoption of vertical forced-air sulfur dioxide fumigation technology of fresh longan exporters in Thailand

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Abstract

The research aimed to study the factors influencing an adoption of vertical forced-air SO₂ fumigation technology of longan exporters of Thailand. A questionnaire was applied as a tool of data collection, from 101 representative samples in the northern and eastern regions of Thailand which are two main plantation areas of fresh longan. Statistical analysis was applied by factor analysis from the in-depth interviews with 36 variables. The result indicates that there were 28 factors in 6 components which influenced the exporters' decision in adopting the technology with the sum of variance of 53.958%. These components were worthiness, competitiveness, organization goals, operations, management, and technological hindrance. Our findings are useful for further development of the strategic plan and policy, especially for the fresh longan exporters of Thailand, to enhance an adoption of SO₂ fumigation with vertical forced-air technology for safer operation and better food safety.

Keywords: sulfur dioxide fumigation, fresh longan, vertical forced-air technology, factor analysis

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1. Introduction

Longan is considered an economically important fruit generating income with relatively high value crop to Thailand. Consequently, Thailand becomes the world-top longan producer of which a majority of 90% to be exported as agricultural produces [1]. Longan can be exported as fresh produces or processed as dried and frozen products. China, Viet Nam, Indonesia and Hong Kong are major competitive business partners. Based on the export statistic during 2015-2019, the exported fresh longan and its relative products have been significantly growing.

An economic document reports that longan fruit is mainly produced in the northern and eastern regions of Thailand with production capacities of 1,051,552 tons in 2018 and 1,006,913 tons in 2019. Among these, 50% of the longan production was accounted as fresh longan produces. In 2019, the longan was exported in the amount of 743,024 tons with the export value of 28,904 million baht. This figure is 0.51% higher than that of 2018 export value and tended to increase over

the years [2]. Two main crucial postharvest losses affecting fresh-longan exporting value are 1) microbes or fungus spoilage, and 2) pericarp browning of longan. Several techniques are currently studied to solve the problems of postharvest losses in longan such as fungicide dip, wax and chitosan coatings, microbial antagonists, heat treatments, and irradiation [3-5]. At present, sulphur dioxide (SO₂) fumigation is only a commercially accepted method to preserve the fresh longan for export. There are two types of SO₂ fumigation that are available in for commercial use, namely, traditional SO₂ fumigation and vertical forced-air SO₂ fumigation. The traditional SO₂ fumigation has been developed and using for more than 30 years, but it is still the most popular method to preserve the longan for export. In traditional SO₂ fumigation, the powder of sulfur is burnt into SO₂, associated with ventilation fan in fumigation chamber. This technique needs low capital of investment and operation. However, the staff must be skillful in sulfur burning process. The disadvantage is that the risk of sulphur explosion due to lack of enough experience and proficient skill of the operator in combustion process. Also, inexperienced operator may cause an incomplete sulfur burning, re-

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sulting inconsistent SO₂ concentration in fumigation process, longer period per treatment and overdosed SO₂ concentration of longan products [6]. The second method of SO₂ fumigation is to apply the vertical forced-air technology. This technology has been researched since 2011 [6]. In this technique, the SO₂ is released directly from SO₂ gas cylinder which can deliver the consistent residues of SO₂ for exported fresh longan. As a result, it gives advantages in providing the uniform quality of SO₂ longan, and easy control of SO₂ residue. However, the disadvantage is its high capital investment and operation expenditures in fumigation [3, 4, 6-8]. According to the registered list of longan enterprise from Department of Agriculture in 2016 [9], the ratio of enterprise's usage on vertical forced-air per traditional SO₂ fumigations were 1: 16, thus it is less widely recognized than the traditional SO₂ fumigation.

In 2013, the General Administration of Quality Supervision, Inspection, and Quarantine of the P.R.China have notified the overdosed residues of SO₂ of imported fresh longan from Thailand. Later in 2014, suspension of 10 Thai longan exporters was taken place by P.R. China due to overdosed residues of SO₂ in longan flesh over Chinese's standard. That Chinese's restricted import measure made a significant impact to image and accountability of exported longan produces of Thailand [10]. If residues of SO₂ on imported longan is greater than 50 mg/kg, that lot of import longan will be destroyed or rejected to enter the P.R.China [11]. As the priority and awareness of the problem affected Chinese consumers, the sanitary and phytosanitary of Thai longan must be determined. For instance, sources of longan production and packing house must be approved and credited by Good Agricultural Practices (GAP) and Good Manufacturing Practice (GMP) standards. The exported fresh longan must be randomized and verified for SO₂ residue with laboratory analysis certification attached [10]. If overdosed residues of SO₂ in exported fresh longan of Thailand exists, several measures and random inspection will be reckoned with the consequences. Since the vertical forced-air SO₂ fumigation technology can play important role to maintain the good standard of SO₂ residue in longan flesh, it is important to expand the usage with more technology acceptance from the longan exporters. The strong point of the vertical forced-air SO₂ fumigation technology is its assurance of SO₂ penetration with quality consistency and residues controlled under the limit of P.R. China's standards (less than 50 ppm in longan flesh) [6]. Therefore, it is of our interest to study the factors influencing attitude towards the adoption of vertical force-air SO₂ fumigation for the longan packing enterprises. Thus, the objective of this research was to investigate the factors influencing the decision to adopt the vertical forced-air SO₂ technology of packing house exporters of Thai fresh longan. It is expected that result of this work can identify the

crucial factors which will be beneficial to the government sector to further elaborate the strategy to expand the boarder usage of vertical forced-air SO₂ technology with better operator's safety and consumer's food safety than the traditional SO₂ fumigation.

2. Materials and Methods

2.1 Materials

The study was a survey research with purposive sampling. The target framework is the owners and managers of SO₂ fumigation enterprise in the northern and eastern regions of Thailand who registered to Registration Company of Agricultural Product Factory in 2016, with a total of 103 fumigation enterprises [9]. Questionnaire was distributed into the target areas; 128 sets for the northern entrepreneurs and 68 sets for the eastern entrepreneurs, with a total of 196 sets from 98 fumigation enterprises (2 questionnaires per enterprise). The returned questionnaires were 101 sets which were further processed for the statistical data analysis.

2.2 Methods and data analysis

The statistical tool for data collection was questionnaire in this research. The questionnaire was designed into 5 parts. Parts 1-3 involved the personal data of the respondents, general data of the company, production pattern and business goals. Parts 4-5 was designed for the factor analysis regarding the topic of "Influencing Attitude towards the Adoption of Agricultural Innovations: A Case Study on Vertical Forced-air Sulfur Dioxide Fumigation Technology". The open-ended questions related to factors influencing production of exported fresh longan and tool verification content were verified and approved by experts in the technical and management fields of longan fumigation and fruit export. The experiment was tried out with 34 staff of fresh longan exporters in the northern region who were not research sampling group. Analysis was proceeded for reliability and alpha coefficient according to Cronbach Technique. Reliability of tool verification was found at 0.92 level, indicating that all variables were related and usable for the factor analysis.

Data analysis was accomplished by descriptive statistics to indicate the general characteristics of workplace for SO₂ fumigation and target of fresh longan business. Factor analysis on influencing attitudes towards the adoption SO₂ fumigation by vertical forced-air technology was applied to analyze the latter part of the data. To consider the suitability of the data for factor analysis, the strength of inter-correlations among the variables using Kaiser-Meyer-Olkin (KMO) was applied. A measure of sampling adequacy of KMO higher than 0.6 was a criterion as the minimum value for a good factor analysis [12]. To determine the numbers of factors or components to be extracted, the eigenvalues that retained the factors

greater than 1 and scree plot were used as the references. Finally, the rotation factor was applied using orthogonal (Varimax) method to obtain the group of factors which later were renamed as the factor components, accordingly.

3. Results

3.1 General information of respondents

The general information of respondents (owners or managers of SO₂ fumigation enterprise) was found to be mostly male of 55.4%, with ages between 24-40 years old of 54.5% and 41-63 years old of 39.6%. The education of respondents was mainly below bachelor's degree of 48.5%, and with bachelor's degree of 45.5%. Most of them worked in business of SO₂ fumigation of fresh longan between 1-10 years of 82.2% and 62.4% of which had not yet known the vertical forced-air SO₂ fumigation technology which researched and developed by Maejo University.

Most companies have been running the business for 1-10 years of 73.3%, and for 11-20 years of 22.7%. Most enterprises used the traditional SO₂ fumigation technology of 94.1%. Some enterprises applied both the traditional and vertical forced-air SO₂ fumigations of 4% and minor enterprises of 2% used SO₂ vertical forced-air fumigation solely.

Type of business ownership was as an individual or owner of 60.4%, and as a joint limited company between Thai and foreigner of 30.7%. The findings agreed with report from Office of Agricultural Economics in 2018 whose the business pattern of longan packing house enterprises was mostly by foreign shareholders for export [13]. Most of longan produces was exported by 89.1%. The business modelling was in small size with less than 50 workers by 81.2% and in medium size with less than 200 workers of 69.5%. The production capacity was 10,001 - 50,000 kg/day. Since the longan can be produced off season, 58.4% most of entrepreneurs operated the longan fumigation all year-long both in-season and off-season, while 23.8% of respondents operated the longan fumigation only off-season due to pricing competition, and 17.8% of respondents operated the longan fumigation only in-season.

3.2 Factor analysis of technology adoption

Based on factor analysis, data of Part 4 from questionnaire with 36 variables were analyzed. Derived value of KMO variables on investigation of factors influencing attitudes towards the adoption SO₂ fumigation technology was 0.763, of which the acceptance level lied above the threshold level of 0.50. On the other hand, all variables in the scale were relatively correlated and appropriated for principal factor analysis. According to Bartlett's Test of Sphericity, the finding was found that KMO was equal to 0.763. In

Table 1. The KMO and Bartlett's Test of Sphericity of data obtained from questionnaires.

KMO	Bartlett's test of sphericity	
	χ^2	p-value**
0.763	2,761.136	0.0009

**p-value < 0.05

conclusion, all variables were correlated at P - Value < 0.0009 as presented in Table 1.

After considering the KMO value, the principal components approached by the Total Initial Eigenvalues of greater than 1 were further analyzed and rearranged discerningly as shown in Table 2. We found that the first 10 components were accounted for the sum of 77.275% of the variation. The statistical values of the major principal components were tabulated in Table 2.

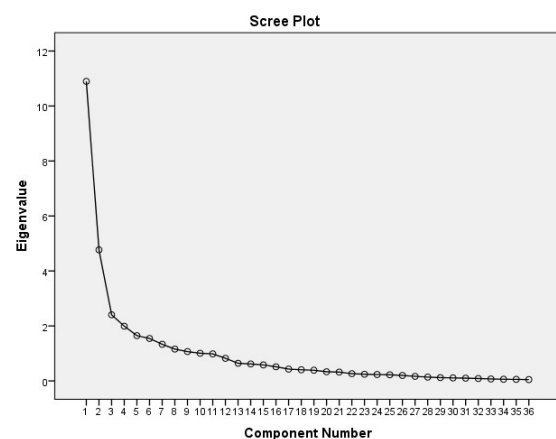


Figure 1: Scree plot Eigenvalue.

Figure 1 shows the scree plot of Eigenvalue sorted in descending order. To consider component analysis of adoption of SO₂ fumigation technology based on decreased Eigenvalue, the principal components with value greater than 1 were found only 10 components. It means that the variables were to be extracted up to 10 components, accordingly.

Based on the variables of each component, the orthogonal rotation approached by Varimax criterion was applied and found that 36 variables were re-ordered into 10 principal components following the weighing factors. The variables of each component were regrouped and renamed as followings:

Component 1 was composed of 9 variables: Q6, Q7, Q5, Q3, Q4, Q9, Q8, Q2 and Q32, named as **Work-thiness**.

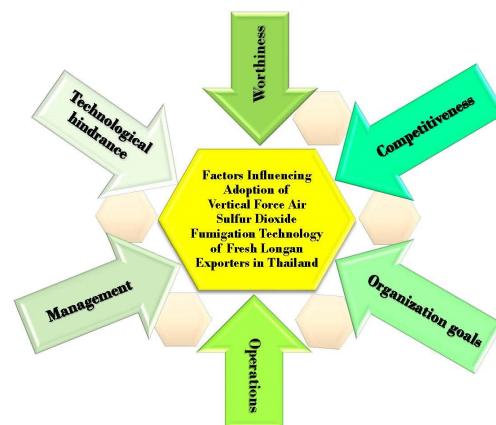
Component 2 was composed of 5 variables: Q28, Q34, Q30, Q33 and Q12, named as **Competitiveness**.

Component 3 was composed of 5 variables: Q36, Q21, Q22, Q29 and Q31, named as **Organization goals**.

Component 4 was composed of 2 variables: Q24

Table 2. Statistical values of major components before and after extracting the factors.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.895	30.265	30.265	10.895	30.265	30.265	5.475	15.208	15.208
2	4.768	13.244	43.509	4.768	13.244	43.509	4.317	11.992	27.200
3	2.405	6.680	50.190	2.405	6.680	50.190	3.297	9.157	36.357
4	1.993	5.535	55.724	1.993	5.535	55.724	2.544	7.065	43.423
5	1.648	4.577	60.302	1.648	4.577	60.302	2.424	6.732	50.155
6	1.545	4.291	64.593	1.545	4.291	64.593	2.284	6.344	56.500
7	1.333	3.703	68.296	1.333	3.703	68.296	2.173	6.035	62.534
8	1.158	3.218	71.514	1.158	3.218	71.514	1.945	5.403	67.937
9	1.067	2.964	74.478	1.067	2.964	74.478	1.733	4.813	72.750
10	1.007	2.797	77.275	1.007	2.797	77.275	1.629	4.525	77.275
11	.985	2.735	80.010						
...	...	...	...						
...	...	...	...						
36	0.049	0.135	100.000						

**Figure 2:** Factors influencing adoption of the vertical forced-air SO₂ technology of Thai longan exporters.

and Q23, named as **Production standards**.

Component 5 was composed of 3 variables: Q14, Q13 and Q27, named as **Operations**.

Component 6 was composed of 3 variables: Q17, Q16 and Q18, named as **Management**.

Component 7 was composed of 2 variables: Q11 and Q10, named as **Potentiality**.

Component 8 was composed of 2 variables: Q26 and Q25, named as **External constraints**.

Component 9 was composed of 2 variables: Q20 and Q19, named as **CEO attitude**.

Component 10 was composed of 3 variables: Q35, Q1 and Q15, named as **Technological hindrance**.

The 10 principal components consisted of detailed questions and weighing factors after rotation as shown in Table 3.

To maximize Varimax criterion after rotation of components, it was found that there were 3 factors decreasing less than loading data with 4 components e.g., Components 4, 7, 8, and 9. These 4 components showed the least correlation in the matrix in the range of 0-0.5 with only 2 variables. Thus they were considered as the non-significant factors and were to be eliminated from factor analysis. This resulted in

the remaining of 6 principal components, which were accounted for the sum of variance of 53.958% with graphically presentation in Figure 2.

When compared to the adoption of innovative technology with other businesses, we found some similarities of the factors affecting the decision of technology adoption. The previous work by Thong and Yap [14] who studied the main factors of adoption of the IT innovation in small businesses showed that management innovativeness, attitude towards new IT technology, business size and competitiveness were the main determinants of IT technology adoption. These influential factors were similar to the determinants found in our study where the adoption of SO₂ fumigation using vertical forced-air technology for fresh longan exporters was partially dominated by the factors involving the management visionary and size of business.

4. Conclusion

In this work, the factor analysis was conducted to analyze the 36 variables that could influence the attitude of longan exporters to adopt the vertical forced-air SO₂ fumigation technology. These variables were

Table 3. The weighing factors of each variable after the Varimax orthogonal rotation.

Variable adoption of SO ₂ fumigation technology with experience of exporters in Thailand	Component									
	1	2	3	4	5	6	7	8	9	10
Q6 Technology design must be easy to use and maintain in operation	.866									
Q7 New technology must efficiently perform to control and reduce pollution i.e. sulfur pungent smell surrounding areas and communities	.817									
Q5 Chosen technology must not too complicated. There must be regularly training session for new staff and knowhow transfer as well as proper manuals for workers	.778									
Q3 Reduction of operating costs/ expenses i.e. sulfur dioxide cost in order to maximize profit	.702									
Q4 There must be unsophisticated and user friendly design in new technology. Easy to operate to reduce product defects and machine malfunction in operation	.693									
Q9 Controllability of contaminants and residues i.e. SO ₂ upon fumigating process	.671									
Q8 Reduce maintenance costs. Longevity of equipment and structure by controlling use of sulfur. The corrosive	.631									
Q2 Feasible in investment with shortest payback period from structure and system installation	.578									
Q32 Strict in product quality control and importing rules from import country	.484									
Q28 Trends and future of export fresh longan industry		.827								
Q34 Perception of consumers towards fumigated fresh longan in terms of quality and safety		.825								
Q30 With variety of substitute longan products (dried, canned etc.), which sourcing the same raw material (fresh longan) affects market shares. This would be constraint in opting high investment technology		.772								
Q33 Attitudes and perceptions of business partners or stakeholders (Foreign joint venture, exporters, and importers) towards investment policy affecting the choice of technology		.718								
Q12 Operator must be high alert on dynamics upon product improvement and technology changes in competitive fresh longan export business		.585								
Q36 Issue of uncontrollable consistency of fresh longan yields in season and off-season impacted by climate changes to supply the operation. As a result, poor quality of input fails to comply with import client's orders			.732							
Q21 Policy on increasing market share as well as productivity capability to penetrate new markets			.724							
Q22 Policy on productivity (both quality and quantity optimization) improvement			.689							
Q29 Dependence on Fresh longan export competition in market			.543							
Q31 Government supports in financials, operational extension, export facilities and industrial information to accelerate export fresh longan industry			.376							
Q24 Commitments to improve production standards				.845						
Q23 Aims to improve product quality according to market demands				.821						
Q14 Operator's Human Resource Development plan readiness to cope with adoption in new technology					.846					
Q13 Operator's readiness to recruit qualified personnel (specialist) to cope with new technology					.785					
Q27 High operating costs i.e. chemicals and high wage specialists would reducing competitive advantages in fierce markets					.487					
Q17 Organization structure (in small, medium and large scales) to handle funds for opting in new technology						.733				
Q16 Ultimate goals and objectives in market positioning are varied upon organization structure differences reflects in choosing technology						.721				
Q18 Management styles upon organization structure (likely operators in Thailand are SME scales with limitations in vision in market forecast for long-terms)						.546				
Q11 Potency in efficiently increase productivity upon demands and business needs							.705			
Q10 New technology must have operating capability to maintain consistently product upon market needs i.e. size, color and freshness							.628			
Q26 Fund raising and sourcing difficulties to set up fumigation plant with new technology								.914		
Q25 Since sulfur dioxide being controlled chemical by government regulations. It is difficult to apply in industry								.541		
Q20 Decision in opting new technology depends upon operator management's experiences in competitive fresh longan export business									.864	
Q19 Operator's decision maker and management must keep update on technology improvement information									.663	
Q35 Chosen technology must be controlled in coping with environment impacts on community ecosystem in long-term										.786
Q1 Technology under patent and copyright would be barrier to opt by operator, commercially										.559
Q15 Existing operating staff is difficult to learn and train especially, cheap waged workers										.515

to be grouped into 10 components and there were 4 components to be eliminated due to non-significant weighing factor for their correlations. The 6 remaining components were then used for Varimax ortho-

nal rotation analysis. The major factors influencing attitude towards the adoption of vertical forced-air SO₂ fumigation technology for fresh longan exporters in Thailand were found to be 6 components involving

worthiness, competitiveness, organization goals, operations, management, and technological hindrance. Since the vertical forced-air SO₂ fumigation technology seems to be a long-term solution in reducing high sulfur residues into a safety consumption limit while maintaining the product quality and appearances, it is important to expand the adoption of the technology for wider usage by longan exporters. Thus these factors are useful to further develop the strategic plan and policy for enhancement of vertical forced-air SO₂ fumigation technology applicable to the fresh longan exporters of Thailand.

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References

- [1] Office of Agricultural Economics, Situation and trend of agricultural commodities in 2020, <http://www.oae.go.th/assets/portals/1/files/trend2563-Final-Download.pdf>.
- [2] Regional Commercial Affairs Division, Longan commodities the 3rd week of September 2019 (16 - 20 September 2019), http://kbp.ops.moc.go.th/ewt_dl.link.php?nid=2343.
- [3] J. Phimphimol, Postharvest management of commercial fresh longan 2012, Chiang Mai, Thailand: Chiang Mai Documentary Design, 174.
- [4] Y. Jiang, et al., Review: Postharvest biology and handling of longan fruit (*Dimocarpus longan* Lour.), *Postharvest Biology and Technology* 26 (2002) 241-252.
- [5] L. Hetong, et al., Technologies of post-harvest handling and storage for longan fruits, in 2011 International Conference on New Technology of Agricultural Engineering (ICAE 2011), pp. 758-763.
- [6] J. Varith, S. Jaturonglumlert, C. Nitatwichit, P. Supapunt, T. Awirothananon, R. Kongtanajaruanun, P. Intanoo, P. Klinkajorn, Policy proposals to push the Vertical Force-air fumigation technology to perform commercial and enhance the export of fresh longan fruits vol. 1, Chiang Mai, Thailand: Wanida printing.
- [7] National Bureau of Agricultural Commodity and Food Standards, Code of practice for sulphur dioxide fumigation of fresh fruits, Government gazette, Announcement and general editions, 2015.
- [8] J. Pimpimol, et al., Improved Sulfur Dioxide Fumigation of Fresh Longan Using a Vertical Forced-Air Technique, *Acta horticulturae* 880 (2010) 415-422.
- [9] Department of Agriculture, List of the firms to be recognized, 2016.
- [10] Department of Trade Negotiations. Barriers to export longan fruit to China, http://www.thaifta.com/thaifta/portals/0/logan_cnsep57.pdf
- [11] The Office Agricultural Affairs, P.R.C. Thailand fruit market situation in China in 2018 and trends, <https://www.opsmoac.go.th/guangzhou-news-files-412991791854>
- [12] A. L. Asnawi, A. M. Gravell, G. B. Wills, Factor analysis: Investigating important aspects for agile adoption in Malaysia, in 2012 Agile India.
- [13] Office of Agricultural Economics, Annual report in 2018.
- [14] J. Y. L. Thong, C. S. Yap, CEO characteristics, organizational characteristics and information technology adoption in small businesses, *Omega* 23(4) (1995) 429-442.



Effects of sugar and coconut milk addition on freeze-thaw stability of starches: comparison of slow and fast frozen methods

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Abstract

This research aimed to evaluate the effect of water, sucrose and coconut milk on starches processed by fast and slow frozen methods and subjected to repeat freezing and thawing. The rice, tapioca and blend starch gels contain water, 45°Bx of sucrose and coconut milk were treated to 5 freeze-thaw cycles. The result showed that the fast freezing inhibited syneresis better than slow freezing. The repeated freezing and thawing found the liquid was separated from starch gel. The percentage of syneresis was lower in sucrose (7.04 – 22.73%) and coconut milk (12.9 – 36.00%) addition to starch gel samples than non-addition (26.18 – 53.50%). Starch gels which were subjected to 5 cycles freeze-thaw stability found to have small porous and some fissure structure in sucrose and coconut milk added. These results suggest that retrogradation induced by freeze-thaw treatment was retarded by sucrose, coconut milk and added tapioca starch to rice starch.

Keywords: frozen starch, freeze thaw, starch gel, sugar, coconut milk

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1. Introduction

ASEAN countries, including Thailand, prefer their meals made from native starch as main course and dessert. Most native starches such as rice and tapioca starch are used as material for dessert cooking by mixing them with sugar and/or coconut milk [1]. These desserts and foods have short shelf-life. In order to extend their shelf-life, there are some approaches chemical treatment, thermal processing or cooling and frozen processing. The freezing approach to preserve food by reducing temperature to below freezing point, leading to lower a_w value of food and to delay microbial growth in food. This is the most favorite method for ready-to-eat food production, as it extends the shelf-life and consumers could prepare, cook and eat conveniently [2]. However, the freezing method can induce changes in physical and chemical properties of foods. Starchy food is known to be affected by retrogradation when frozen or stored under low temperature. The rate of freezing such as slow freezing induces the association of starch chain resulting in harder texture and more syneresis value to starch gel [3, 4]. Those phenomena can be prevented by using rapid freezing to retard nuclei formation during the

nucleation and propagation stages of starch chain association [5].

Numerous studies reported about the freeze-thaw stability could effect to modify starch and some hydrocolloids on starch gel properties. Some studies reported that ingredients might improve or retard the change in starch quality, for instance, inulin, xanthan gum or starch blending [6 – 14]. However, few studies were investigated about the effect of native starch and some major ingredients such as sugar and coconut milk. Sugar has been shown to retard or accelerate the retrogradation and gelatinization temperature of the gel. [15 – 19] reported that sugar reduced the crystallinity of starch molecules on the retrogradation but increased the gelatinization temperature.[16, 20]. found that adding sugar lead to varying results or increase the re-crystallization of amylose complex. Coconut milk is often added in the food to increase flavor and taste. During food processing, the formation of lipid and amylose complex, especially short chain and medium chains fatty acid that contain in coconut milk, could reduce retrogradation and make starch gel rigid [21, 22]. The ready to eat chilled and frozen Thai desserts, that contained starch with high moisture, sugar and coconut milk, are popular among consumers. This process could extend shelf life and make it more commercially available. In order to understand

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and maintain the dessert or food product quality in general, user of starch gel should understand physical changes during the freezing and thawing process. Repeated freezing and thawing increase phase separation and ice crystal growth, inducing syneresis and porous structure which in turn causes unacceptable sensorial qualities after thawing [4, 2, 23, 15]. This study investigated changes in syneresis and morphology of starch when subjected to freeze-thaw stability of sucrose and coconut milk added to common rice starch, tapioca starch and blend of this starch gels. The correlation of results could serve as knowledge base for extending shelf life of ASEAN or Thai ready to eat desserts which produced at commercial scale.

2. Materials and Methods

2.1 Material

Rice starch (33.8% amylose content) and tapioca starch (31.4% amylose content) were purchased from Choheng Rice Vermicelli Co., Ltd. (Nakhon Pathom, Thailand) and Thai Tham Factory (Chonburi, Thailand), respectively. Food grade sucrose (Mitr Phol Sugar Co.Ltd., Supanburi, Thailand) was used at 45 °Brix of sucrose solution preparation. Coconut milk (Thai Agri Food Co., Ltd. (Nakhon Pathom, Thailand) was purchased from local supermarket.

2.2 Starch gel preparation

Starch gels were classified as rice starch gel (RS), tapioca starch gel (TS) and rice starch/tapioca starch blend gel (RS/TS) in ratio of 1:0.85. The starch suspensions (15%, w/w of starch on a dry basis) were prepared by mixing with water or 45 °Bx sucrose solution or coconut milk and stirred continuously at 250 rpm for 5 minutes. Then the suspension was stirred continually at 200 rpm at 80°C for 20 min.

2.3 Freezing and thawing

Forty grams of starch gel were loaded into cylindrical tubes and then frozen. The slow frozen method was done in a chest freezer (Sanyo, SF-C1497, Thailand). While air blast frozen (March cool, 2009 model, Thailand) at -25 °C for 3 hours was remarked as fast frozen. The storage temperature of gel was recorded as the core temperature of gel reached approximately -18 °C for 24 hours. Starch gels were stored continuously for 7 days. After that the gels underwent the thawing process at 30±3 °C in water bath for 2 hours. Six cylindrical tubes from each thawing condition were selected for syneresis and determination of microstructure. The remaining 6 cylindrical tubes were then put back into the freezer for repeated tests up to 5 freeze-thaw cycles.

2.4 Syneresis

The syneresis measurement method was modified from [4]. Forty grams of hot starch pastes were transferred into 150 ml centrifuge tubes and stored at 4 °C for 21 days. The storage tubes then warm up to 30±3 °C and centrifuged at 8000 rpm for 15 min. The percentage of syneresis was calculated as ratio of liquids separated (ml) to total weight of the gel before centrifugation as follow:

$$\% \text{syneresis} = (\text{liquid separated (ml)}) / (\text{total weight of the gel (g)}) \times 100$$

2.5 Microstructure

The starch gel sample was freeze-dried using vacuum freeze dryer (Scanvac cool safe55, Denmark). Freeze dried sample was cut and mounted on aluminium stubs, coated with gold. The scanning of image was observed at 50x with the accelerated voltage of 15 kv.

2.6 Statistical analysis

All experiments were performed in triplicates using completely randomized design. Differences between the mean values were established using Duncan's new multiple range tests at a confidence level of 95%. All statistical analyses were performed using SPSS version 25.

3. Results and Discussion

3.1 Percentage of syneresis

When starchy product is frozen, the formation of ice crystals and starch aggregation region take place that leads to phase separation within food matrix [11]. These created undesirable qualities such as becoming harder, drier and unacceptable (rejected) by consumers. The syneresis percentage for starchy products in different systems was monitored for the ability of starch to impede the undesirable physical changes during freezing and thawing. The syneresis in a frozen gel is a useful indicator of starch retrogradation tendency. It is measured by an increase in molecular association or aggregation between starch chain-amylose (with short term retrogradation) and amylopectin with long term retrogradation [24,25].which results in the releasing of water from the gel structure. However, the addition of sugar, fat and some hydrocolloids could interact with water molecules and reduces the syneresis [7, 10, 2, 4].

The effect of rice starch, tapioca starch and blend gel on the % syneresis presented in Table 1 and 2. Freeze-thawed rice starch gel with water, sugar or coconut milk had significant higher syneresis value after the first and second cycle and slightly changed through cycle 3-5. The freeze-thaw rice starch gel with

Table 1. Syneresis value of rice (RS), tapioca (TS) and blend (RS/TS) starch gels (15%w/w) addition sugar and coconut milk in each cycle using slow frozen method.

sample	Syneresis (%)				
	Cycle1	Cycle2	Cycle3	Cycle4	Cycle5
water					
RS	38.31 ^{aB} ±4.42	47.88 ^{aA} ±3.76	51.88 ^{aA} ±1.58	53.50 ^{aA} ±2.67	52.51 ^{aA} ±3.21
TS	0.0 ^{cC}	26.18 ^{cB} ±2.54	32.68 ^{cA} ±3.23	30.02 ^{cA} ±5.50	30.89 ^{cA} ±5.91
RS/TS	22.38 ^{bC} ±3.05	31.04 ^{bB} ±1.96	48.66 ^{bA} ±0.82	47.38 ^{bA} ±1.09	45.98 ^{bA} ±5.81
sugar					
RS	11.80 ^{aC} ±1.08	15.68 ^{aC} ±3.57	18.81 ^{aAB} ±2.42	19.99 ^{aAB} ±3.49	22.73 ^{aA} ±1.26
TS	0.00 ^{bNS}	0.00 ^{bNS}	0.00 ^{cNS}	0.00 ^{cNS}	0.00 ^{cNS}
RS/TS	0.00 ^{bB}	0.00 ^{bB}	0.82 ^{bB} ±0.72	7.04 ^{bA} ±1.27	7.47 ^{bA} ±4.10
coconut					
RS	27.00 ^{aC} ±2.69	29.93 ^{aBC} ±2.21	31.36 ^{aABC} ±1.68	34.64 ^{aAB} ±3.98	36.00 ^{aA} ±1.63
TS	0.00 ^{cC}	0.00 ^{cC}	20.11 ^{bB} ±1.35	24.77 ^{cAB} ±2.09	27.67 ^{cA} ±6.79
RS/TS	12.9 ^{bC} ±3.09	18.70 ^{bB} ±1.97	28.96 ^{bA} ±1.83	28.58 ^{bA} ±1.81	31.20 ^{bA} ±2.51

^{a-c} Mean values in each column in the each system with different superscripts are significantly different ($p \leq 0.05$)

^{A-C} Mean values in each row with different superscripts are significantly different ($p \leq 0.05$)

^{NS} mean values in each row are non-significantly different ($p > 0.05$)

Table 2. Syneresis value of rice (RS), tapioca (TS) and blend (RS/TS) starch gels (15%w/w) addition sugar and coconut milk in each cycle using fast frozen method.

sample	Syneresis (%)				
	Cycle1	Cycle2	Cycle3	Cycle4	Cycle5
water					
RS	29.52 ^{aC} ±4.42	40.16 ^{aB} ±3.76	40.53 ^{aA} ±1.58	40.62 ^{aA} ±2.67	40.65 ^{aA} ±3.21
TS	0 ^{cD}	13.98 ^{cc} ±2.54	26.98 ^{cB} ±4.23	38.40 ^{cA} ±4.50	41.21 ^{bA} ±1.91
RS/TS	13.85 ^{bC} ±3.05	28.81 ^{bB} ±1.96	29.69 ^{bA} ±0.82	35.54 ^{bA} ±1.09	36.88 ^{cA} ±1.81
sugar					
RS	0 ^{aE}	0 ^{aD}	11.11 ^{aB} ±1.42	11.48 ^{aA} ±1.49	11.72 ^{aA} ±1.26
TS	0 ^{bNS}	0 ^{bNS}	0 ^{bNS}	0 ^{cNS}	0 ^{cNS}
RS/TS	0 ^{bC}	0 ^{bC}	0 ^{bB}	0 ^{bA}	1.39 ^{bA}
coconut					
RS	10.85 ^{aC} ±1.69	22.11 ^{aB} ±1.21	23.66 ^{aAB} ±1.68	24.02 ^{aAB} ±1.98	25.43 ^{bA} ±1.63
TS	0 ^{bC}	0 ^{cC}	0 ^{cC}	7.25 ^{cB} ±1.09	15.18 ^{bA} ±2.79
RS/TS	0 ^{bD}	14.04 ^{bC} ±1.97	19.94 ^{bB} ±1.83	24.26 ^{bA} ±0.81	24.61 ^{aA} ±1.51

^{a-c} Mean values in each column in the each system with different superscripts are significantly different ($p \leq 0.05$)

^{A-C} Mean values in each row with different superscripts are significantly different ($p \leq 0.05$)

^{NS} mean values in each row are non-significantly different ($p > 0.05$)

Table 3. Percent of syneresis of rice starch at different freezing rate. The samples were subjected to one and five freeze-thaw cycle.

	water		sugar		coconut milk	
	Cycle1	Cycle5	Cycle1	Cycle5	Cycle1	Cycle5
Fast freezing	28.29 ^b ±2.24	38.70 ^b ±3.10	0.0 ^b	12.62 ^b ±1.09	11.15 ^b ±1.76	26.64 ^b ±2.13
slow freezing	37.91 ^a ±3.65	50.23 ^a ±5.22	10.10 ^a ±1.08	20.38 ^a ±1.38	26.67 ^a ±3.21	37.10 ^a ±2.46

^{a-c} Mean values in each column with different superscripts are significantly different ($p \leq 0.05$)

blending of tapioca starch displayed a lower syneresis value when compare with rice starch, meanwhile, the freeze thaw tapioca starch gel had zero syneresis value in the first cycle and begun releasing liquid from the gel at the second cycle of thawing. The percentage of syneresis could be explained with the amylose/amylopectin ratio in the starch. High syneresis value in rice starch resulted from high amylose content (33.75%) which could induce linear amylose molecules more re-associated and greater the retrogradation tendency [2]. while high amylopectin (low amylose content) resulted in low syneresis [4]. Previ-

ous studies showed that high amylose content starch (32.50% in [7] and 37.50% in [2]. had a significant higher syneresis than medium and low amylose content (17.6%). It was suggested that amylose play an important role in the retrogradation during the freezing and thawing. However the effect of the addition of different starch on the syneresis value of the freeze thaw cycle has not many been reported. Some reported blending rice starch gel with waxy starch and cassava starch on the reduction of syneresis significantly [2]. The effect of some hydrocolloids on the reduction of syneresis in starch have been widely reported by rea-

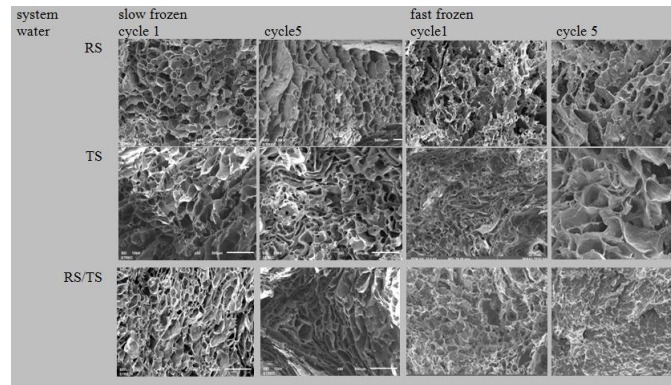


Figure 1: Microstructure images of rice (RS), tapioca (TS) and blend (RS/TS) starch gels (15%w/w) addition water after freeze and thaw for 1 and 5 cycles (50x, Bar = 500 μ m) with slow and fast frozen methods.

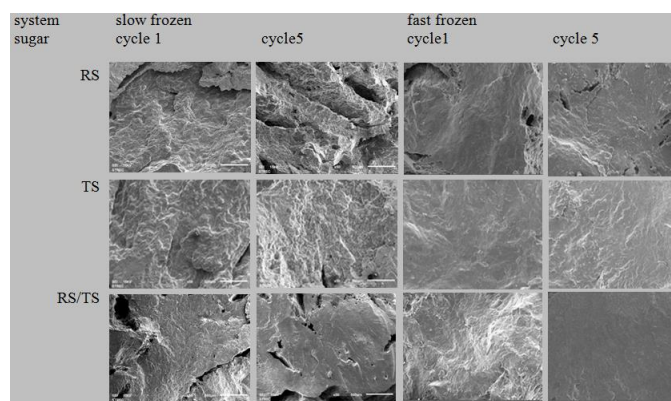


Figure 2: Microstructure images of rice (RS), tapioca (TS) and blend (RS/TS) starch gels (15%w/w) addition sugar after freeze and thaw for 1 and 5 cycles (50x, Bar = 500 μ m) with slow and fast frozen methods.

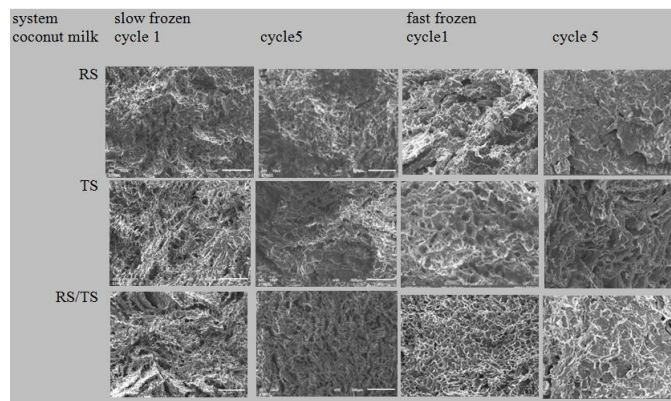


Figure 3: Microstructure images of rice (RS), tapioca (TS) and blend (RS/TS) starch gels (15%w/w) addition coconut milk after freeze and thaw for 1 and 5 cycles (50x, Bar = 500 μ m) with slow and fast frozen methods.

son of the increasing of the viscosity of the starch paste and retardation of amylose re-association [26, 27, 23, 13, 14]. The freeze-thaw starch gel with addition of sugar and coconut milk showed less liquid separated from the starch polymer when compared with just adding water. Especially tapioca had zero syneresis value which was the same results with [4]. and blended starch gels exhibited liquid separation after

the third cycle repetition. The adding of sugar led to the lowest liquid separation while adding coconut milk led to more liquid separation, respectively. It could be explained that sugar molecules can interact with starch molecular structure by intermolecular hydrogen bond and hydrated water molecules with the starch granule [19]. leading to lower amount of frozen water. High solid concentration in the gel facilitated

the starch chains to be associated when kept at low temperature for a long time. Previous studies showed that freeze-thaw rice starch gel with sucrose added at the levels of 10 to 20% showed significantly lower syneresis percentage from the gel [15]. The adding of coconut milk in the starch gel had less liquid separation than addition of water. It might be due to the formation of lipid and amylose complex especially short chain and medium chain fatty acid in coconut milk that led to the reduction of retrogradation, syneresis and make starch gel more rigid [21, 22].

The effect of the frozen resulted that the fast frozen method in Table 3 had significant lowest liquid separation from the gel than in the slow frozen method. Several studies had been reported that fast freezing showed the results of lower syneresis or lower retrogradation on the frozen starch gel than slow freezing method [5, 7, 26]. The fast freezing method could be useful to prevent the ice nuclei formation and propagation state in the starch than occurred in slow methods. In this study, it was also found the same trend that the fast frozen method of the starch gel had significant lower liquid separated from the gel than in slow frozen method.

3.2 Microstructure

The SEM images of freeze thaw starch gels are shown in Figure 1-3. Ice crystals were observed as holes or pores in the gel matrix except with sugar adding. The slow frozen gel with chest freezer at -20 °C produced more porous and less homogeneous structure than fast frozen gel with air blast. It is clear that structure attributes are impacted by ice crystal formation and amylose retrogradation in starch during frozen after many repeated freeze-thaw cycles [10, 26]. The microstructure in the first freeze thaw cycle exhibits large pores in the gel and the morphology of the structure were the same in the previous research [23]. After the fifth freeze-thaw cycle, the surrounding starch gel become thicker matrix and less homogeneous like small pore surrounded with thick and some crack matrices. The probable cause is water from thawing process was trapped in the thick area of gel.

The freeze-thaw starch gel with addition sugar and coconut milk had less percentage of syneresis. The adding of coconut milk had the small porous structure meanwhile the adding sugar had rigid texture and microstructure gave no porous. This structure finding the correlated with the lower in the syneresis value also, and cause from the high solid concentration in the region facilitated the starch chains to associate forming thick filament and more condensed. It was in accordance with the research of [15]. who reported the SEM structure of rice starch were less porous and more condense when mixing starch gel from 10 up to 20% sucrose.

4. Conclusion

The addition of sucrose coconut milk and tapioca starch in the blending gel (RS/TS ratio 1:0.85) was found to be an effective agent for reduction of liquid separated from gel when undergoing repeated freeze-thaw cycles. Sucrose, coconut milk and tapioca starch are effective agents to enhance the freeze-thaw stability especially for ASEAN food and Thai dessert for fast frozen method than slow frozen method.

References

- [1] K. Chumkaew, C. Punfuujinda, Effect of Tiliacora triandra leaf juice on qualities of Thai layered dessert, *Sciences Engineers Health Studied* 13(3) (2019) 133-142.
- [2] S. Charoenrein, S. Preechathamwong, Effect of waxy rice flour and cassava starch on freeze-thaw stability of rice starch gels, *Carbohydrate Polymers* 90(1) (2012) 1032-1037.
- [3] S. Varavinit, S. Shobsngob, W. Varayanond, P. Chinachoti, O. Naivikul, Freezing and thawing conditions affect the gel stability of different varieties of rice flour, *Starch/Stärke* 54 (2002) 31-36.
- [4] L. Y. Teng, M.L. Chin, Y. A. Yusof, Rheological and textural studies of fresh and freeze-thawed native sago starch-sugar gels. II. Comparisons with other starch sources and reheating effects, *Food Hydrocolloids* 31(2013) 156-165.
- [5] S. Charoenrein, N. Preechathamwong, Undercooling associated with slow freezing and its influence on the microstructure and properties of rice starch gels, *Journal of Food Engineering* 100 (2010) 310-314.
- [6] P. Deetae, S. Shobsngob, W. Varayanond, P. Chinachoti, O. Naivikul, S. Varavinit, Preparation, pasting properties and freeze-thaw stability of dual modified crosslink-phosphorylated rice starch, *Carbohydrate Polymers* 73 (2008) 351-358.
- [7] J. Muadklay, S. Charoenrein, Effect of hydrocolloids and freezing rated on freeze-thaw stability of tapioca starch gels, *Food Hydrocolloids* 22(7) (2008) 1268-1272.
- [8] R. Pongsawantmanit, S. Srijunthongsiri, Influence of xanthan gum on rheological properties and freeze-thaw stability of tapioca starch, *Journal of food Engineering* 88(1) (2008) 137-143.
- [9] A. Arocas, T. Sanz, S. M. Fiszman, Improving effect of xanthan and locust bean gums on the freeze-thaw stability of white sauces made with different native starches, *Food Hydrocolloids* 23(8) (2009) 2478-2484.
- [10] S. Charoenrein, O. Tatirat, K. Rengsutti, M. Thongngam, Effect of Konjac glucomannan on syneresis, textural properties and the microstructure of frozen rice starch gels, *Carbohydrate Polymer* 83 (2011) 291-296.
- [11] Y. C. Meng, M. H. Sun, S. Fang, J. Chen, Y. C. Li, Effect of sucrose fatty acid esters on pasting, rheological properties and freeze-thaw stability of rice flour, *Food Hydrocolloids* 40 (2014) 64-70.
- [12] J. M. Schwartz, K.L.B. Bail, C. Garnier, G. Lamas, D. Queveau, B. Pontoire, G. Srzednicki, P. L. Bail, Available water in Konjac glucomannan-starch mixture. Influence on the gelatinization, retrogradation and complex properties of two starches, *Food Hydrocolloids* 41 (2014) 71-78.
- [13] C. Zhang, J.A. Han, S.T. Lim, Characteristic of some physically modified starches using mild heating and freeze-thawing, *Food Hydrocolloids* (2017).
- [14] J. Ye, R. Yang, C. Liu, S. Luo, J. Chen, X. Hu, J. Wu, Improvement in freeze-thaw stability of rice starch gel by inulin and its mechanism, *Food Chemistry* 268 (2018) 324-333.
- [15] T. Arunyanart, S. Charoenrein, Effect of sucrose on the freeze-thaw stability of rice starch gels: Correlation with microstructure and freezable water, *Carbohydrate Polymers* 74 (2008) 514-518.
- [16] S. M. Chang, L. C. Liu, Retrogradation of rice starch studies by differential scanning calorimetry and influence of sugar,

- NACL and lipids, *Journal of Food Science* 56 (1991) 564-566, 570.
- [17] C. Y. Lii, M. F. Lai, K. F. Liu, Factors influencing the retrogradation of two rice starches in low-molecular-weight saccharide solutions, *Journal of Cereal Sciences* 28 (1998) 175-185.
- [18] P. Perry, A. Donald, The effect of sugars on the gelatinization of starch, *Carbohydrate Polymers* 67(4) (2002) 511-529.
- [19] M. C. Allan, B. Rajwa, L. Mauer, Effect of sugars and sugar alcohols on the gelatinization temperature of wheat starch, *Food Hydrocolloids* 84 (2018) 593-607.
- [20] L. A. Baker, P. Rayeas-Duarte, Freeze-thaw stability of amaranth starch and the effect of salt and sugars, *Cereal Chemistry* 75 (1998) 301-307.
- [21] S. Wang, J. Wang, J. Yu, S. Wang, Effect of fatty acids on functional properties of normal wheat and waxy wheat starches: A structural basis, *Food Chemistry* 190 (2016) 285-292.
- [22] C. M. Tang, L. Copeland, Analysis of complexes between lipids and wheat starch, *Carbohydrate Polymers* 67 (2007) 80-85.
- [23] N. Seetapan, N. Limpanyoon, C. Gamonpilar, P. Methacanon, A. Fuongfuchat, Effect of cryogenic freezing on textural properties and microstructure of rice flour/tapioca starch blend gel, *Journal of Food Engineering* 151 (2015) 51-59.
- [24] V. J. Morris, Starch gelation and retrogradation, *Trend in Food Science and Technology* 1 (1990) 2-6.
- [25] A. C. Eliasson, M. Gudmundsson, Starch: Physicochemical and functional aspects In *Carbohydrate in food*, Abingdon, UK: Taylor&Francis, 2006.
- [26] C. Ferrero, M.N. Martino, N.E. Zaritzky, Corn starch-xanthan gum interaction and its effect on the stability during storage of frozen gelatinized suspensions, *Starch/Starke* 46 (1994) 300-308.
- [27] M. H. Lee, M. H. Baek, D. S. Cha, H. J. Park, S. T. Lim, Freeze-thaw stability of sweet potato gel by polysaccharide gums, *Food Hydrocolloids* 16 (2002) 345-352.

Early lockdown policy for COVID-19 in China during first quarter of 2020

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Abstract

Threat posed by COVID-19, infectious disease that spread globally on 2019-20, is characterized to pandemic level as announced on 11 March 2020 from World Health Organization (WHO), director himself. As spread of disease overload to medical department resources, self-isolation becomes necessary to balance out between increasing infected patient and available medical officer. And to ensure such policy, forced isolated strategy from government, may refer as “the lockdown” or “national quarantine”, starts to put an act over the world. Objective was to examine the effect of “lockdown” occurring in Wuhan as related to the reducing of overall new cases and deaths related to COVID-19 compare to other countries. Dataset used in this paper received from European Centre for Disease Prevention and Control (ECDC) from December 31, 2019, through March 31, 2020. The purpose was to determine whether country to country variation increasing new case associated with the timing, duration of the lockdown interventions. On 31 December 2019, WHO received an official report about cluster of mystery infected patients, later known as COVID-19. As a result, China became center of this pandemic and had been staying number one in total infected case compared to other country since then. The first lockdown took place in Wuhan on 21 January 2020 which put massively forced isolation to citizen. The result proof success as number of daily infected from peak 15000 to around hundreds. As 29 March 2020, the total confirmed case in China also dropped down from number one ranking.

Keywords: 2019-nCoV, Covid-19, Wuhan, outbreak, lockdown, pandemic.

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1. Introduction

Without pharmaceutical way to deal with the spread of disease during pandemic, burden on health care services and critical infrastructure goes up significantly. So there is no pharmaceutical, such as forced isolated strategy or lockdown, that potentially provide a valuable time for vaccine and antiviral medication production and distribution, also known as Flattening the pandemic curve [1, 2]. Optimally, appropriate implementation of non-pharmaceutical interventions would decrease the infected cases but there are differences in performance and outcome that carry from performing the “lockdown” on each country that worth discussion.

In practical, to carry on the “lockdown”, it obviously causes an instant impact negatively on overall economy [3]. This results in quality, strictness and timing on “lockdown” put a heavy burden on decision-making from government since stake on both economy and save life are both high. As during the 1918-1919 influenza pandemic, research on mortality data in US urban area have proven forced isolated strategy from government, or the lockdown, is necessary

in saving life in pandemic situation by Markel [4]. For standard “lockdown”, things are school closer, public gathering ban, isolation, quarantine. In addition, there are also less strict policies such as business hours restricted, streetcars’ capacity limited, staggered business hours, signs with cover coughs, staggered business hours, warning signs posted in theaters, schoolchildren given information to take home, warned not to gather in groups. Though it is hard to defer effect on each policy used, data leans more to the timing on initiate the “lockdown”. This is due to state of emergency help alert citizens and increase their awareness, to extend that even cities that never officially closed their schools reported a student absenteeism rate over 45% at the peak of its epidemic. Overall, cities that implemented “lockdown” earlier experienced associated delays in the time to peak mortality, reductions in the magnitude of the peak mortality, and decreases in the total mortality burden.

On 11 March 2020, World Health Organization (WHO) officially announced an infectious disease outbreak that spread globally on 2019-20, initially named as 2019-nCoV [5] and later changed to COVID-19 [6], to be characterized as pandemic level [7]. As it is not something that occurs frequently, however, it is nec-

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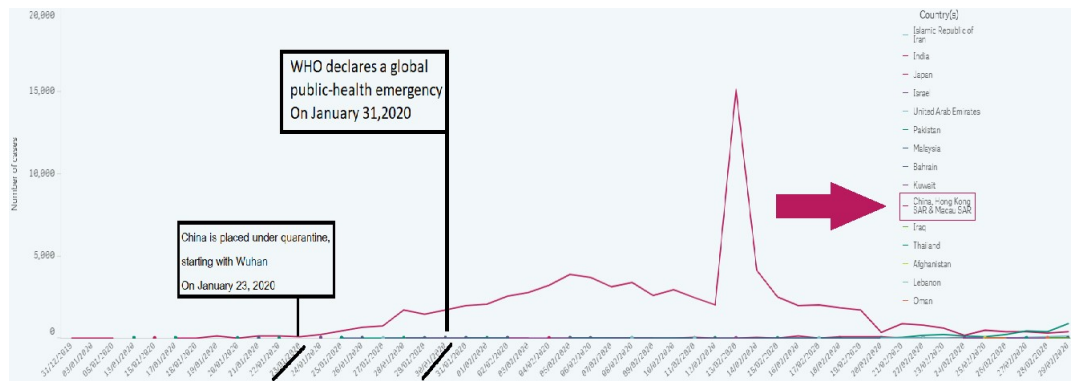


Figure 1: Distribution of the daily report of new infected cases from all Asian countries up until February 2020.

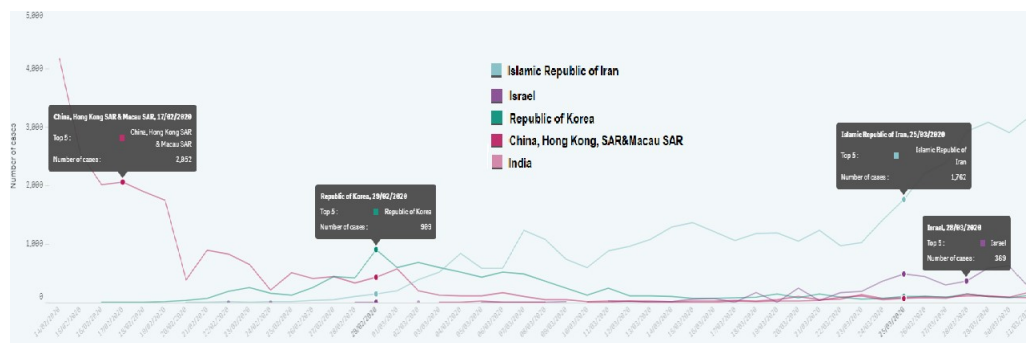


Figure 2: Distribution of the daily report of new infected cases on Top 5 in Asian countries after peak February until March 2020.

Table 1. Characteristics of COVID-19 on case study countries in Asia (during first quarter 2020).

Country	First reported cases date	Date of the first lockdown	14-Cumulative reported case per 100,000		
			On 29/02/20	On 31/03/20	's first peak date
China	12/31/19	22/01/20	0.9	0.08	15/02/20
S. Korea	20/01/20	20/02/20	5.67	2.86	09/03/20
Israel	21/02/20	11/03/20	0.08	50.27	31/03/20
Iran	19/02/20	-	0.47	32.40	31/03/20
Italy	31/01/20	08/03/20	1.46	121.95	31/03/20
Spain	31/01/20	07/03/20	0.07	162.89	31/03/20
France	24/01/20	16/03/20	0.07	56.66	31/03/20
Germany	23/01/20	-	0.05	67.52	31/03/20
USA	20/01/20	21/03/20	0.02	48.90	31/03/20

essary to define state of pandemic which led to life and dead on massive population [8]. WHO is also aware of this and getting better at notify state of emergency quicker in every new occur pandemic as shown in comparison to event on outbreak on severe acute respiratory syndrome (SARS) during 2002-03 [9]. At that time, it took around 3 month to issue the notification compare to the current COVID-19 which took only one month from the first patient found. This notification plays a big part on encourage each government to start the lockdown on their country at ease. As to help contribute on how important of the early lock down, in this paper, we study its effect related to COVID-19 during first quarter of 2020.

2. Experiment Design

In this section, we will discuss about data source, reason behind area of focus. Dataset used in this paper was offered by European Centre for Disease Prevention and Control (ECDC) from December 31, 2019, through March 28, 2020 [10]. On 15 April 2020, coronavirus COVID-19 is now affecting 210 countries [11]. To observe an impact outcome, it is required to consider the choices on case study countries. Figure 1 shows distribution of the daily report of new infected cases from all Asian countries. The data represent the new COVID-19 infected case on each date. It showed that China is the only country that actively found new case in Asia during first two months by far during January-February 2020. However, at the end of

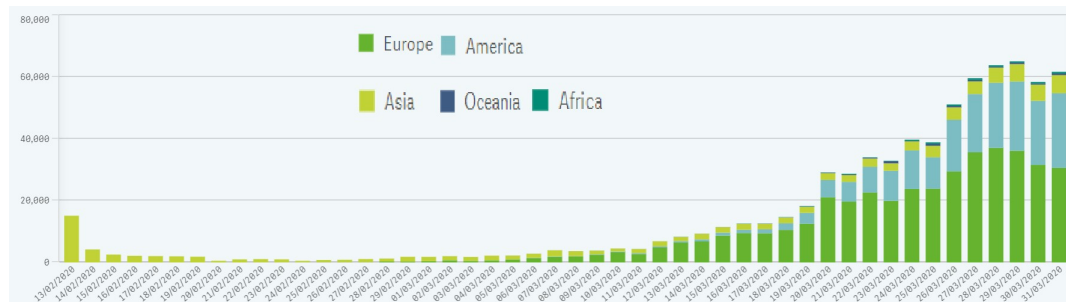


Figure 3: Distribution of the daily report of new infected cases on globally after peak February until March 2020.

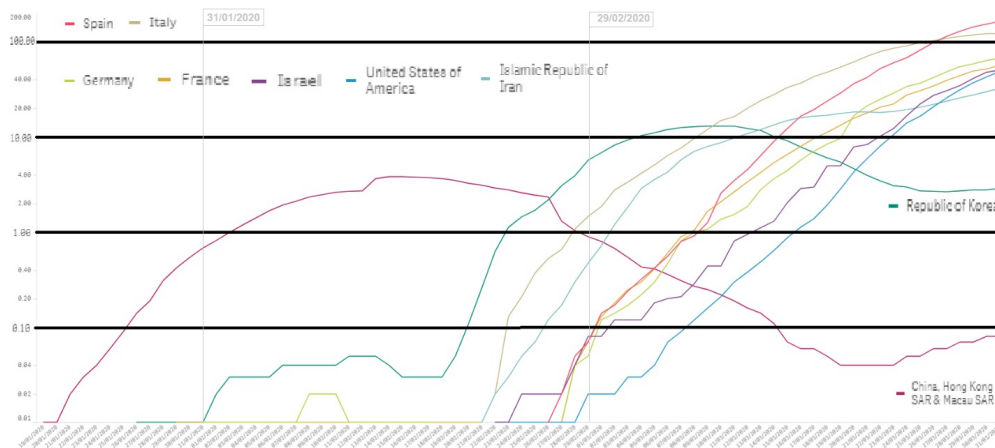


Figure 4: Distribution of the report of 14-day cumulative number of reported cases per 100,000 population using Logarithmic scale (First quarter 2020).

February, there was a sign of increasing numbers from other countries.

This emphasizes in Figure 2 which shows notable 5 countries that have new infected reach out. These are India, Israel, Islamic Republic of Iran, Republic of Korea (or South Korea) and China. However, India statistics, including other non-top 5, appears to have less new cases compared to those top 4 countries. As a result, we will focus on these 4 countries as representatives of Asia.

However, as the pandemic reaches out globally, there are reported infected cases outside Asia. During March 2020, both Europe and America showed a significant increase in new infected cases, which overcame those in Asia. Based on data, I picked the top 5 countries excluding Asia, using the same selection criteria used in Figure 2. Those countries are Italy, France, Spain, Germany and the United States of America as represented in Figure 3. As data shown in Figure 2 and 3, these emphasize the threatening worldwide crisis, caused by COVID-19.

Next, I discuss about method used in this paper. In Figure 4, 14-cumulative number of reported cases per 100,000 population of selected group country is shown. “14 days” is the standard quantity of days for a quarantine using this COVID-19 [12]. The Logarithmic scale is here to make data more compact to view.

As Markel [4] purposed the parameter call “public health response time (PHRT)” as the time in days (either positive or negative) between the dates when weekly excess death rate (EDR) first exceeds twice the baseline pneumonia. But due to COVID19 has low fatality rate [13], I decide to emphasize variation around new infected case.

Table1 contains the first reported cases date, along with the first lockdown policy in each country. Due to difficulty to identify wording of “lockdown” from each government, therefore in this paper, any act to forced mass isolation on citizen such as national quarantine, curfew or etc, could refer as “lockdown” as to list in this table [5, 7, 14 – 16]. 14-Cumulative reported cases per 100,000’s first peak date is mentioned as to define the effect of lockdown policy

3. Discussion

On 13 February 2020, China reached peak of 15,000 new cases. But in overall, it is later shown as a good sign that China have proven to be the first country that was able to sustain new cases over the pass value from date 15 February 2020 as shown in Table1. The second country is Republic of Korea. This country did not announce the form of lockdown to citizen but did put a massive lockdown to 9000 of military

force on 21 February 2020 [15]. Similar to China, Republic of Korea also passed the peak of 14-Cumulative reported cases on 9 March 2020.

On the other hand, other countries were slow to react to the first reported infected case in their countries well enough, compared with China and Korea as shown in Figure 4. This results in no sign of decreasing in terms of daily new infected cases during March 2020. Up until now, COVID-19 has killed more people than SARS and MERS combined [13] due to its spread nature.

Nevertheless, there was a proposed theory proving increase in fatality rate by economic failure caused by lockdown [17] which has the potential to harm more than the spread COVID-19. It could be an arguable statement in the sense of fatality comparison which could lead to the next research topic. However, despite not undergoing lockdown, individual responsibility, such as wearing a mask [18] or hand hygiene [19], is strongly recommended and has become a common practice globally.

4. Conclusion

The first lockdown took place in Wuhan on 21 January 2020 which put massively forced isolation on citizens. The result proof success as the number of daily infected from peak 15000 to around hundreds. As of 28 March 2020, the total confirmed cases in China also drop down from number one ranking.

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References

- [1] P. R. Saunders-Hastings, S. Krewski, Reviewing the history of pandemic influenza: Understanding patterns of emergence and transmission, *Pathogens* 5(4) (2016) 66.
- [2] P. Gourinchas, Flattening the pandemic and recession curves, Mitigating the COVID Economic Crisis: Act Fast and Do Whatever (2020): 31.
- [3] A. Fernando, A. David, L. Francesco, A simple planning problem for COVID-19 lockdown (April 6, 2020), University of Chicago, Becker Friedman Institute for Economics Working Paper No. 2020-34.
- [4] H. Markel, H. B. Lipman, J. A. Navarro, et al., Nonpharmaceutical interventions implemented by US cities during the 1918-1919 influenza Pandemic, *JAMA*. 298(6) (2007) 644-654.
- [5] World Health Organization, Novel Coronavirus(2019-nCoV) Situation Report, pp. 1-5, 21 Jan 2020.
- [6] World Health Organization, Novel Coronavirus(2019-nCoV) Situation Report - 22, pp. 1-7, 11 Feb 2020.
- [7] World Health Organization, Novel Coronavirus(2019-nCoV) Situation Report - 51, pp. 1-9, 11 Mar 2020.
- [8] World Health Organization, Avian influenza: assessing the pandemic threat, January 2005. WHO/CDS/2005.29.
- [9] C. Ewen, C. David, M. Smriti, S. Emma, T. Jeff, The coronavirus pandemic in five powerful charts, *Nature* 579 (2020).
- [10] European Centre for Disease Prevention and Control, <https://www.ecdc.europa.eu/en>, (accessed 15 April 2020).
- [11] Countries where COVID-19 has spread, <https://www.worldometers.info/coronavirus/countries-wherecoronavirus-has-spread/>, (accessed 15 April 2020).
- [12] World Health Organization, Considerations for quarantine of individuals in the context of containment for coronavirus disease (COVID-19): interim guidance, 19 March 2020, No. WHO/2019- nCoV/IHR Quarantine/2020.2. World Health Organization, 2020.
- [13] Mahase, Elisabeth, Coronavirus: covid-19 has killed more people than SARS and MERS combined, despite lower case fatality rate, (2020).
- [14] Holly Secon, Aylin Woodward and Dave Mosher, A comprehensive timeline of the new coronavirus pandemic from China's first COVID19 case to the present, <https://www.businessinsider.com/coronaviruspandemic-timeline-history-major-events-2020-3>, (accessed 9 April 2020).
- [15] Coronavirus: South Korea emergency measures as infections increase, <https://www.bbc.com/news/world-Asia-51582186>, 21 February 2020, (accessed: 15 April 2020).
- [16] Rothe, Camilla et al., Transmission of 2019-nCoV infection from an asymptomatic contact in Germany, *The New England Journal of Medicine* 382(10) (2020): 970-971.
- [17] L. Hirschhorn, Principal Emeritus, Pandemic lockdown must fail: Save lives without crippling the economy, (accessed: 15 April 2020).
- [18] Considerations for wearing masks help slow the spread of COVID-19, U.S. Centers for Disease Control and Prevention, 16 July 2020, (accessed 6 August 2020).
- [19] Hand hygiene recommendations guidance for healthcare providers about hand hygiene and COVID-19, U.S. Centers for Disease Control and Prevention, 17 May 2020, (accessed 6 August 2020).