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PREFACE

By the Grace and Blessings of Allah the Almighty, we would like to present, with great pleasure, the Volume 03 number 01 of *Food ScienTech Journal* (FSJ). This journal is part of the Universitas Sultan Ageng Tirtaya series of journal.

This journal was envisioned and founded to represent the growing needs of food technology as an emerging and increasingly vital field, now widely recognized as an integral part of agriculture and human living. Its mission is to become a voice of the food technology and science community, addressing researchers and practitioners in areas ranging from chemistry to management, from microbiology to industry, presenting verifiable methods, findings, and solutions.

The journal is intended as a forum for practitioners and researchers to share their research, idea, and solutions in the area of food science and technology. We would like to request for the reader to participate on writing the articles in this journal.

Thank you for your kind attention and support, hopefully this journal will provide lots of benefits for you and society.

Serang, July 2021

Editorial Team

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CONSUMPTION OF EDIBLE-INSECTS: THE CHALLENGES AND THE PROSPECTS

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ABSTRACT

Alternative sources of proteins are necessary to tackle the foreseeing challenge of protein scarcity. Insects were among the foods consumed by early man and they are still vital components in the diets of Asia, Africa, and Latin America. Social barriers are limiting their global acceptance, their consumption is intimately attached to location and culture, and their nutritional values are not known to many. Their consumption is associated with taboos and pessimisms, and are seen as something filthy, not something decent to be consumed. The aim of this review was to provide an overview on the challenges and prospect of edible-insects, and provide highlights on their global position in human nutrition. Literature used was gathered through an online search on Google Scholar and Science Direct databases. Disgust, food neophobia, lack of awareness, unavailability, and personality traits are the major barriers to edible-insect acceptance among consumers. Accepting edible-insects as food depends greatly on location, eating habit, prior experience, age, gender, and religion of a consumer. Entomophagy advocate should intensify their efforts and attract more consumers in the West and other parts of the globe. Research collaborations between applied and social sciences are necessary to win the affection of new consumers and convinced their psych and emotion during the first introduction. Creating awareness on the nutritional, health, and environmental benefits of using insects as a novel protein, processing to completely mask insect presence, and producing products with a close resemblance with meat will certainly promote global insect consumption.

Keywords: entomophagy, alternative protein, consumer perception, insect consumption, unconventional protein.

INTRODUCTION

Entomophagy is a global practice, except in developed countries, mainly Europe and North America (Megido *et al.*, 2014; Testa *et al.*, 2016). Over 2 billion people from over 3000 ethical groups in 130 countries (Ramos-Elorduy, 2009), mostly in Asia, Africa, and South America (Rumpold & Schlüter, 2015; Poelaert *et al.*, 2018), consumed from over 2000 identified insect species (Niassy and Ekesi, 2016; Tang *et al.*, 2019). The edible insects account for only 0.2% of over one million insect species described by science (Akhtar and Isman, 2018; Cartay *et al.*, 2020). Indigenous edible insects are readily available in Asia, Africa, and South America (Gahukar, 2011). Africans consume approximately 500 species (Kelemu *et al.*, 2015) while in India alone about 255 species are considered edible (Chakravorty, 2014). Commonly consumed insects are grasshoppers, termites, large moth caterpillars (Chung, 2008), beetles, bees, wasps, ants, locusts, crickets, cicadas, leafhoppers, planthoppers, true bugs, dragonflies, and flies (van Huis *et al.*, 2013). The biodiversity in the insect species leads to great variation in chemical composition and microbiology of insects (Fernandez-Cassi *et al.*, 2019).

About 4 billion people in the world rejected insects as food (Ruby, Rozin & Chan, 2015) and they may continue to be rejected in many parts of the World (Williams *et al.*, 2016). Legal barriers, safety concern and lack of consumer acceptance are among the leading obstacles in promoting entomophagy (Rumpold & Schlüter, 2015). Interest in consuming new foods and environmental advantages of entomophagy will continue to promote insect consumption in the future (Sogari, 2015). Understanding the environmental impacts of insects and factors affecting the safety and quality of their proteins will play important roles in eliminating barriers to their universal acceptance (Payne *et al.*, 2016). Information regarding insect acceptability by other societies, their nutritional qualities, and their low environmental impacts can make consumers change their perception of entomophagy (Hunts *et al.*, 2020).

The world population is expected to reach 9.7 billion by 2050 (Tomberlin *et al.*, 2015; Gallo and Federico, 2018). Therefore, alternative protein sources are necessary to provide the accelerated world population with the required amounts of protein (Megido *et al.*, 2014; Tang *et al.*, 2019). Also, to provide developing nations that are currently suffering from food insecurity and malnutrition with sufficient protein and other essential nutrients (Ramos-Elorduy, 2009; Gahukar, 2011).

BARRIERS TO EDIBLE-INSECTS ACCEPTANCE

Rejection

Many people are ignorant about the nutritional qualities of insects and choose not to pay attention to their nutritional benefits (Jacob *et al.*, 2013). Concerns for using insects as food are also related to their safety, animal right, and consumers' right (Pali-Schöll *et al.*, 2019). Insects can be edible and people may choose not to routinely consumed them (House, 2018) because their consumption in some parts of the world is taboo with strong negative emotion and is normally associated with the poor economic class (Rao, 2016).

Entomophagy is reducing in many societies because is considered by some to be an old dietary style, dirty and unhealthy (Akullo *et al.*, 2017). In Africa, rejection is due to poor awareness and negative thoughts associated with insects in some societies (Niassy *et al.*, 2016). Edible insects are known and consumed more by elderly persons than the new generation in Botswana (Obopile & Seeletso, 2013). Modern upbringing style and changes in culture and religious beliefs also contributed to the decline in entomophagy (Chung, 2008). This is usually common in westernized societies (Yen, 2015a), many young people in these societies have negative views about entomophagy (Chung *et al.*, 2002). Insects such as cockroaches, and alike, that are known to be dwelling in dirty places are rejected by new consumers (Ruby, Rozin & Chan, 2015), and they may continue to be rejected due to their unclean habitant, disgust and safety concern.

Rejection by the West

Eating insects is a taboo among the majority of people in Western countries (Sidali *et al.*, 2019), many avoid the idea of eating insects for several reasons (Ali, 2016).

Except for the Czech Republic where insects are process and market (Bednárová *et al*., 2013), the Western world rejected insects as food predominantly due to cultural reasons (Sogari, 2015). Disgust is the most common reason for rejecting insects among Americans (Ruby, Rozin & Chan, 2015), this is derived by fear of diseases and contamination (Jensen & Lieberoth, 2019). Western people are not familiar with insects as food and some believed that insects are filthy and potentially harmful (Barton, Richardson & McSweeney, 2020). Most of the Western people are regarding insect as a mere pest, not something decent to be considered as food (Glover & Sexton, 2015), therefore, it will be difficult to predict whether insect will be fully accepted as food in the region (Sogari, 2015).

Peculiarity disgust is the most important predictor of edible-insects acceptance, it is superior to environmental and health consciousness (Powell, Jones & Consedine, 2019). Food neophobia and food technology neophobia also contribute to insect rejection in the West (Lammers, Ullmann & Fiebelkorn, 2019). The alleged poor sensory attribute lamented by some Western consumers was the reason for their rejection (Tucker, 2014; Cunha and Ribeiro, 2019). The high cost and unavailability of insects may affect their acceptance (Barton, Richardson & McSweeney, 2020), also lack of interest in trying novel foods by some persons (La Barbera *et al.*, 2020).

Shelomi (2015) opined that entomophagy was rejected by Western people due to the wrong strategies adopted during the first introduction, entomophagy advocates and researchers focused on education and trialability to promote the acceptance of the edible insects, forgotten that changes in value are supply-driven, and there were no follow-up studies that will justify any rejection. Also, ethical issues were given less attention to promoting entomophagy (Waltner-Toews & Houle, 2017). In the current approach, justifications were mostly given based on the nutritional, economic, and environmental benefits of entomophagy. This is putting new consumers in a dilemma, the psychology of the consumers' needs to be changed first since disgust is deeply associated with the individual psyche (Deroy, Reade & Spence, 2015). Shelomi (2015) also argued that using scientific evidence alone will not ensure total adoption of entomophagy by the Western population, according to him entomophagy will only be accepted by Western when attention given to production and marketing strategies were changed to focused more on supply-side innovations. This may be true; as Western consumers keep on rejecting insects despite the long-term campaign regarding their environmental, nutritional, sensory, food safety, and environmental benefits (van Huis, 2015). Sidali *et al.* (2019) opined that adopting rural tropical culture can improve insect acceptance in the West. Also, Issues related to emotion and psychology must be addressed for entomophagy to be accepted by the Western countries (van Huis, 2015).

Disregarding insects as food by Western countries leads to avoiding insects in food production research in the region (van Huis *et al.*, 2013). Entomophagy is still a strange field of study in Europe, this accounts for it is slow development and less commitment to marketing and business analyses (Pippinato *et al.*, 2020). Solutions to the present problems in entomophagy required multidisciplinary collaboration and cooperation between technical and social sciences (van Huis, 2017). Efforts should be double on public awareness of the importance of using insects as food since exposure to entomophagy is among the leading factor that influences willingness to accept insects as food (Woolf *et al.*, 2019). Better solutions can be postulated when the reasons behind the rejection were fully understood (Santeramo *et al.*, 2018). More researches are needed in the areas of safety, mass production, improved technology for harvest and postharvest products development, acceptance, and marketing (Rumpold and Schlüter, 2013; Liu and Zhao, 2019; Schlüter and Rumpold, 2019). These can improve acceptance and lower rejections caused by eating habit, cultural norms and safety worries.

Safety Concern

Insects can be a vector of disease, can sting and bite, can also accumulate pesticides, and passed it to the food chain (Rao, 2016). They harbor a wide range of both pathogenic and spoilage microorganisms (Grabowski & Klein, 2017). Their safety concerns are related to microbial contaminants, allergens, and chemical contaminants such as toxins and heavy metals (Cappelli *et al.*, 2020). Edible insects were rejected by many because of the claimed pathogenicity and allergenicity (Patel, Suleria & Rauf, 2019). Consuming raw insects can be dangerous (Grabowski & Klein, 2017) as many species produced for food and feed can cause disease from the several microorganisms they harbor (Eilenberg *et al.*, 2015). Insects are associated with some risks even when grown under controlled conditions, the risk depends on the species, rearing, and processing conditions (Mézes & Erdélyi, 2020). There is hazy information regarding edible-insects safety (Alrifai and Marcone, 2019; Murefu *et al.*, 2019). Some insect species that are traditionally considered safe may turn unhealthy when subjected to laboratory scrutiny, some species can contain allergens and others can feed on contaminated plants (Mézes & Erdélyi, 2020). Safety regarding pesticide residues, mycotoxins, and human pathogens must be considered (Rumpold & Schlüter, 2015) as insects are regarded as unhygienic and disease vectors by Western people (Lensvelt & Steenbekkers, 2014). Researches should be intensified in the area of safety to protect consumers from any possible health risks associated with insects (Fernandez-Cassi *et al.*, 2019). The nutrients quality, bioavailability, and digestibility need to be assessed for all the edible species (Rumpold & Schlüter, 2015). Safety measures including control of hazardous chemicals, allergens, pesticide residues, pathogens, all forms of toxins, etc., must be pondered during farming, harvesting, processing, and distribution of insects and insect products (Liceaga, 2019). Substantial research needs to be conducted in the area of safety including allergy reactions, anti-nutritional factors, and all forms of contaminants (Testa *et al.*, 2016). Cappelli *et al.* (2020a) come up with strategies that will ensure the safety of edible-insect during processing. Consuming raw insects can be dangerous (Grabowski & Klein, 2017) as many species produced for food and feed can cause disease from the several microorganisms they harbor (Eilenberg *et al.*, 2015).

Microbiological concern

Present understanding of insects shows that insect pathogens do not harm vertebrates (Eilenberg *et al.*, 2015), therefore, there is a low risk for transmission of zoonotic diseases such as bird flu and mad cow disease by insects (Rao, 2016). Unlike in the vertebrate animals used as a source of protein, insect pathogenic viruses occurring in a farmed insect cannot be transmitted to humans, therefore, farmed insects are not considered to be biological vectors (Finke *et al.*, 2015). Insects contain a wide range of microorganisms, González-Escobar *et al.* (2018) reported 299 and 285 genera of microorganisms in the larva and adult escamolera ants respectively, included are the following species: *Pseudomonas, Bradyrhizobium, Flavobacterium, Burkholderia, Methylobacterium, Corynebacterium, Brevundimonas, Arsenophonus, Sphingomonas, Rhizobium*, and *Sphingobium*. Several pathogenic microorganisms including *Acinetobacter, Bacillus, Buttiauxella, Campylobacter, Clostridium, Staphylococcus, Pseudomonas*, and Neisseria were identified by Ssepuuya *et al.* (2019b) in grasshopper. Clostridium perfringens spores, Enterobacteriaceae, lactic acid bacteria, yeasts, and molds were found in processed cricket, locusts, and mealworm larvae (Garofalo *et al.*, 2017). In general, microbial population and diversity are significantly affected by growing habitat, trading location, swarming period, and plucking methods (Ssepuuya *et al.*, 2019).

Consumption of raw insects can be dangerous as they may harbor pathogenic microorganisms (Garofalo *et al.*, 2019) such as Salmonella, Campylobacter, and Escherichia coli (Finke *et al.*, 2015). Higher total aerobic mesophilic bacterial and Enterobacteriaceae counts were reported by Grabowski and Klein (2017) in a variety of raw insect samples collected from pet shops and private breeders. House cricket was reported to have higher aerobic bacterial counts and spore-forming bacteria after thermal processing (Fernandez-Cassi *et al.*, 2019). The natural microbiota of insects withstand rearing and processing conditions, bacteria found in insects possess heat resistance and spore-forming potentials (Frigerio *et al.*, 2020), these organisms required special attention during processing and storage. Vacuum cooking and boiling are the most effective methods for destroying microorganisms in insects (Megido *et al.*, 2018). Raheem *et al.* (2019) recommended the application of strict critical control points along the processing chain to prevent cross-contamination. The microbiological quality of edible insects can be improved by improving the rearing and harvesting conditions (Grabowski & Klein, 2017), also by starving them until they empty their stomach before harvesting (Megido *et al.*, 2014).

Chemical contaminants and allergens

Limited data on the heavy metals content and other dangerous chemicals are the leading challenges regarding insect safety (Fernandez-Cassi *et al.*, 2019). Accumulation of chemical contaminants such as heavy metals, mycotoxins, and veterinary drug residuals in insects depends on their food and occurs more in insects with a longer life cycle (Finke *et al.*, 2015). Hazardous chemicals such as allergens, heavy metals, anti-nutrients, pesticides, etc. are the potential threat (Raheem *et al.*, 2019). Chemical hazards, toxicology, allergy, and other safety issues must be investigated to ascertain the wholesomeness of edible insects (Kelemu *et al.*, 2015). Issues to be considered include microbial safety, toxicity, and inorganic contaminants (van Huis *et al.*, 2013). Consumption of wild-harvested insects can be dangerous as they are often treated with insecticides (Van Huis, 2020). Organic contaminants, Zn, and Cu in edible insects are similar to that in conventional proteins, while As, Co, Cr, Pb, Sn are found in lesser amounts (Poma *et al.*, 2017). The levels of pesticides, veterinary drugs, and mycotoxins in mealworm, grasshopper, house cricket and black soldier fly obtained from pet stores and research centers in Belgium were below the permitted maximum residue limits for other edible foods (De Paepe *et al.*, 2019). Insects such as the black soldier fly can bio-accumulate non-essential elements such as barium, bismuth, and gallium in addition to essential elements (Proc *et al.*, 2020). Köhler *et al.* (2019) reported a low level of arsenic, cadmium, lead, and mercury in Bombay locust, scarab beetle, house cricket, and mulberry silkworm. Tannin and phytic acids were reported by Chakravorty *et al.* (2016) in Oecophylla smaragdina and Odontotermes sp.

Research on insect allergy is still at the infancy level and current EU regulation on edible insects does not force producers to include insects in the list of allergenic substances (Garino *et al.*, 2020). Caution must be taken to avert allergic response in sensitive people (Ayensu *et al.*, 2019), new allergic reactions are expected to emerge as insect consumption is continuously encouraging and insect foods are introduced to more people (Fernandez-Cassi *et al.*, 2019). The phylogenetic relationships of insect with crustaceans and house dust mites prompted the need for assessing edible insect safety, many studies revealed the occurrence of cross-reactivity between tropomyosin and arginine kinase in crustaceans (Ribeiro, Cunha & Sousa-pinto, 2019). These allergens were well-known in arthropods, also found in insects (Rumpold & Schlüter, 2015). Mealworm-based products can cause an allergic reaction to persons that are allergic to crustacean (Garino *et al.*, 2020). Francis *et al.* (2019) reported cross-reaction in mealworm and cricket arginine kinases, the researchers also concluded that cross-reaction with/between arginine kinases from other insect species is also possible.

Availability

Inaccessibility creates a barrier to the acceptance of novel foods (Tuorila & Hartmann, 2020). The availability of insects is the primary determining factor for their consumption, the insect species consumed by humans are the most abundant naturally (Raubenheimer & Rothman, 2013). Seasonality is among the major challenge that hinders insect consumption, many species are only available for some months because their life depends on a particular seasonal plant (Jacob *et al.*, 2013). Insects are overexploited in some parts of the world and many species are on the verge of been exhausted. The population of an edible caterpillar is seriously declining in South Africa, this may be associated with over-harvesting and climate change (Langley *et al.*, 2019).

Making insects more available through commercialization will reduce disgust and encourage acceptance (Sidali *et al.*, 2019). Large scale production of insects is important to provide significant quantities and prevent overexploitation of species (Yen, 2015b).

Harvesting insects at their exponential growth rate prevent overexploitation of species (Ramos-Elorduy, 2009). The use of modern technology in insect harvesting can increase collection efficiency but may put more pressure on the natural source (Yen, 2015a). Depending on the natural source of insects will not ensure a continuous supply as many species are known to be seasonal (Tang *et al.*, 2019). A sustainable supply of insects will only be achieved when their potentials are considered and attention similar to that given to the production of other sources of protein is given to their production (Jacob *et al.*, 2013).

Affordability

Affordability is among the major limitations in promoting insect consumption, overcoming this will increase the demand for insect foods (Ruby, Rozin & Chan, 2015). Insects proteins are more expansive than conventional proteins in Western countries (Pippinato *et al.*, 2020), and in some cities of Central Africa (Odongo *et al.*, 2018). In the United States, cricket powder is more expensive than conventional protein (Morales-Ramos, Rojas & Dossey, 2018), and some edible insects can cost twice the price of beef in Nigeria (Jacob *et al.*, 2013). In many cases, insects are not available year-round, therefore, they can be expensive even in places with abundant wild species. In South-eastern Nigeria high cost of harvesting and shortage during the dry season are the major barrier to entomophagy (Ebenebe *et al.*, 2017). Some processing methods also propel the price of insect products, for example, extraction of insect protein is very expansive; more profitable processing methods are required to make insect proteins more affordable (van Huis *et al.*, 2013). Another challenge is the production of insect products with amazing sensory properties that will cost less than conventional protein (Gjerris, Gamborg & Röcklinsberg, 2016). Pleasant sensory attributes can be derived from insects' protein when they are subjected to appropriate and adequate processing conditions.

Legislation constrains

Insects are considered as an impurity with specific permissible limits in the food regulation guidelines of many countries, legislation that will guide insect utilization as food and food ingredients need to be developed (Mariod, 2020). Legislations on edible insects are not enough (Gahukar, 2016), authorities need to be convinced that using insects as either food or feed is safe for both humans and animals (van Huis, 2017). Lack of well-defined legislation on edible insects is a serious burden to entomophagy (Mariod, 2020), also a misinterpretation of existing law by authorities as reported by Arppe *et al.* (2020) in Finland. Presently there are no specific regulations for breeding and marketing of edible insects in many countries (Mézes & Erdélyi, 2020). Lack of clear legislation and norms also hinders the industrial development and farming of insects in developed nations (van Huis *et al.*, 2013). Many Insect producers do not report information related to traceability, veterinary drugs, farming, storage, and transportation conditions (Fernandez-Cassi *et al.*, 2019). It will be important to display the results for risk assessment for the attention of the consumers (Mariod, 2020). Ulrich *et al.* (2017) developed a procedure for determining insect ingredients in processed food using Matrix-Assisted Laser Desorption Ionization-Time Of Flight Mass Spectrometry (MALDI-TOF MS). This will help in checking adulteration and contaminations.

Entomophagy is receiving less attention in the West because is considered as a new culinary art that many are not ready to accept (Lotta, 2019). Edible insects were captured in the new EU novel food regulation but there are still controversies regarding insect farming, slaughter, and processing regulation (Lotta, 2019). Marketing is only allowed when the insect or it is product is duly authorized by the food regulatory body, a protocol that entails safety assessment (Goumperis, 2019). Clear legislations are required to guide insect farmers and to control insect application in food (Liceaga, 2019), they are also needed in the area of feedstuff, hygiene, the permissible limit of undesirable substances, microbiological criteria, and guideline for import (Goumperis, 2019). The approval statement for the use of insects as food in the US is not clear, details were not provided on whether insects are to be used as additives or their use shall be generally recognized as safe (GRAS) (Lotta, 2019). Inadequate communication, lack of mutual vision, and inter-firm linkages among stakeholders are affecting the realization of unanimous policy (Marberg, van Kranenburg & Korzilius, 2017).

Another important legislation challenge is on insect welfare during production and slaughter (Goumperis, 2019). There is a need for research in the areas of insect welfare, health, farming system, and humane killing method, it is necessary to include insects into the scope of animal protection law (Pali-Schöll *et al.*, 2019). It's important to determine whether insects are sentient or not because there is no established scientific evidence that proves the emotional consciousness of insects (Pali-Schöll *et al.*, 2019). Using organic waste as feed for edible insects also requires a legal framework (Mariod, 2020), as this is among the factors that strengthen the rejection of insects as food by regulatory organizations in the Western world (Hartmann & Bearth, 2019).

Over-Reliance on Wild Species and its Consequences to the Environment

More than 90 % of edible insects are sourced through wild gathering (Yen, 2015a). There is a discrepancy between insect conservation and entomophagy, indiscriminate harvesting of insects can be a threat to some insect species and the environment (Yen, 2009). Care must be taken as some potential solutions to food security problems are incompatible with the solutions of other problems (Dicke, 2018). Anthropogenic activities and climate changes are affecting the availability and distribution of insects and presently many species are in danger (van Huis *et al.*, 2013). Edible insect species in tropical countries are on the verge of extinction (van Huis & Oonincx, 2017). Harvesting edible insect randomly can have ecological and environmental implications by reducing insect population and altering ecological interaction between insects and plants (Choo, 2008). Ecologists considered entomophagy as a barbaric act that destroys a natural relationship in the ecosystem that allows other animal and plant species to prosper (Rao, 2016).

Enlightenment on sustainable practice on wild insect collection and habitat preservation are essential in maintaining ecological balance (Nadeau *et al.*, 2015). Economical rearing, harvesting, and processing techniques are necessary to prevent population depletion and ecological imbalance (Kelemu *et al.*, 2015). Domestication of insects and sustainable harvesting practices will reduce the dangers associated with over-reliance on the wild source (van Huis, 2017). The development of entomophagy requires upscaling the entire production chain to include technologies for mass rearing, harvesting, processing, and packaging, also extensive studies on socio-economic and marketing patterns (Kelemu *et al.*, 2015).

Tendencies for Incessant Rejection

Westerners continue to reject edible-insects despite their enormous role in the global consumption of animal proteins (Shockley & Dossey, 2014). Their acceptance will have a great impact on global entomophagy recognition (Alexander *et al.*, 2019). There is a high disposition that the Western world will continue to reject entomophagy as recent findings by many researchers expressed persistent resistance to entomophagy by Western people, therefore, a lot of work needs to be done by entomophagy advocates in Western countries to influence the majority of the population. Lombardi *et al.* (2019b) reported that neophobia is still a trending hurdle to insect acceptance in Italy. They also have little awareness of the environmental impacts associated with conventional protein production, and only a few are willing to consume meat alternatives (Hartmann & Siegrist, 2017). Even persons that are familiar with entomophagy and possess high environmental consciousness continue to reject edible insect in Germany (Orsi, Voege & Stranieri, 2019). The high level of consciousness on food choice commonly observed by many in the Western world increases their disgust and lower their willingness to accept insects as food (Chan, 2019), most consumers insisting on knowing the ingredients used in the production of any strange food (Cicatiello *et al.*, 2020).

The results of online surveys recently conducted by researchers continue to show a negative attitude toward entomophagy among Western people, these include the work of Jensen and Lieberoth (2019) conducted among Danish undergraduate students and that of Orsi *et al.* (2019) conducted among Germans. Similarly, German children and adolescence prefer to consume culture meat bugger than insect bugger (Dupont & Fiebelkorn, 2020). A survey conducted by Hwang and Choe (2020) in South Korea shown that the overall image of edible insect restaurants is negative due to taboo, consumers are also cautious about the insect quality and alleged that edible-insects can cause health problems. The results of an interview conducted by Myers and Pettigrew (2018) with 77 elderly Western Australians, aged 60 years and above, showed a low level of awareness on nutritional and environmental benefits of using insects as food, and most of the interviewees believe that entomophagy is incompatible with their cultures and values. Videbæk and Grunert (2020) reported multidimensional regression results indicating ambivalence attitude among Danish consumers, the individual difference concerning disgust may lead to this kind of uncertainty (Powell, Jones & Consedine, 2019).

Another challenge that will continue to deter the acceptance of entomophagy in the West is the unavailability of insects in these countries, Gómez-Luciano *et al.* (2019) reported that consumers in UK, Spain, Brazil, and the Dominican Republic are more willing to accept plant proteins as an alternative to meat than insect proteins because plant proteins are more readily available. The type of insect used as food is also of concern to many consumers, online survey conducted in Germany by Lammers *et al.* (2019) showed that 41.9 % of the respondents are willing to consume insect burger but only 15.9 % of the survey respondents are willing to consume burger containing buffalo worm used as the principal ingredient.

PROMOTING INSECT CONSUMPTION : THE CURRENT PRACTICES

Elimination of Sociocultural and Psychological Barriers

Disgust, food neophobia, lack of awareness, unavailability, and personality traits are the major barriers to edible-insect acceptance among consumers. Entomophagy depends greatly on location, eating habits, prior experience, and age, gender, and religion of a consumer. Payne *et al.* (2016)

and Terrien (2017) opined that acceptance of insects as new food will suffer serious impediments due to social and psychological barriers that are in many cases intimately attached to the location, culture, believes, and eating habits. Introducing novel food may require a solid understanding of the values and believes related to the culture of the targeted population (Bisconsin-Júnior *et al.*, 2020). Consumers must be informed about the nutritional benefits of using insects as food (Gahukar, 2016) and insect must be seen as a source of protein and not feculent (Terrien, 2017). Introducing insect food into different cultural settings may require different approaches, people with different cultural backgrounds have a different perception of using insects as food (Bisconsin-Júnior *et al.*, 2020). Facilitating edible insect acceptance is a complex and difficult task, it requires understanding the psychology and behavior of the new consumers (Dermody & Chatterjee, 2016). Promoting entomophagy after adopting western foods requires a broad record of insects consumed in the past (Ebenebe *et al.*, 2017). There is a need to overcome these obstacles by convincing new consumers particularly Western people, with the evidence that will conquer their reluctance on using insects as food (New, 2013). To fast track this, the benefit of using insects must be observable to consumers (Terrien, 2017). Deroy *et al.* (2015) opined that a place must be created for insects in the circle of nutrition, they should not be portrayed as a conventional protein substitute.

Insects' appearance, their sensory attributes, and the availability of information regarding their safety and origin are among the key factors determining their acceptance (Mishyna, Chen & Benjamin, 2020). Recommendation by other consumers and shopping locations also affect willingness to consume insects (Alemu *et al.*, 2017). A substantial milestone was recorded in the last five years, and capacities were exponentially developed in the areas of rearing, processing, awareness, and marketing of edible insects globally (van Huis, 2020). The tremendous effort by the Association of African Insect Scientists in securing research funding and convincing policymakers to accept insects as an alternative source of protein promote insect consumption in Sub-Sahara Africa (Niassy *et al.*, 2018)

The nutritional benefit of insects cannot be realized if people chose not to consume them (Stull *et al.*, 2018). Lombardi *et al.* (2019b) reported that the perception of consumers can be change by explaining the benefit of using insects as food. Insect consumption is presently promoted through scientific comics, diffusing rural dietary cultures to an urban setting, and the use of attractive marketing including strategic packaging ideas (Payne *et al.*, 2016). Another means for promoting entomophagy is by the bottom-up approach in ingredients substitution, and by preparing insect meals in more delicious and attractive manners (Ruby, Rozin & Chan, 2015). Incorporation of insects into other products increases convenience and reduced psychological barriers to insect acceptance (Telfser & Temmes, 2015). The use of modern food technologies and standards can enhance insect consumption through the provision of insect products that are safe and attractive (Jacob *et al.*, 2013). Ethical concerns are important in promoting entomophagy, (Gjerris, Gamborg & Röcklinsberg, 2016) identified five critical ethical areas that are relevant while promoting entomophagy viz. environmental influence, human and animal health, human inclinations, social satisfaction, animal welfare, and animal ethics issues

The potential of social influences in promoting insect acceptance was reported by Berger *et al.* (2019). Entomophagy advocates are using sustainability aspects of edible insects in convincing European entrepreneurs to start edible insect's business (Telfser & Temmes, 2015). Consumer education and public enlightenment about entomophagy can influence the attitude of new consumers (Lensvelt & Steenbekkers, 2014), these include active communication and outreach programs that smartly combined information, education, and exposure (Telfser & Temmes, 2015), also changing the attitude of consumers through motivations (Tuccillo, Marino & Torri, 2020). In addition to the sociocultural practice, price and quality, benefits, risks, naturalness, trust, attitude and culture, and fit with consumer needs also reported to affects insects acceptance (Lensvelt & Steenbekkers, 2014).

Strategies and Methods for Improving Sensory Qualities

Fear and negative attitude toward insect consumption can be minimized by allowing consumers to compare insect protein with conventional protein in a sensory session (Megido *et al.*, 2014; Barton *et al.*, 2020). Researches involve tasting sessions provide positive results than online surveys which are mostly characterized by strong rejection (Gere *et al.*, 2018). Revealing product information can influence consumer perception during a sensory session (Pambo *et al.*, 2018), therefore, a combination of semantic manipulation and practical sensory evaluation will play an important role in introducing edible insects to new consumers (Ali, 2016). The first eating experience is critical to acceptance, positive perception during the first trial will motivate consumer's willingness in accepting insects (Hartmann & Bearth, 2019). Improving sensory characteristics of insect based-food will minimize the negative perception of the overall liking of the insect products (Cunha & Ribeiro, 2019). Introducing insect-based foods during childhood will reduce disgust by ensuring early familiarisation (Tuorila & Hartmann, 2020).

Products without visible insects or visible parts, such as legs or wings are more acceptable (Gere *et al.*, 2018). Used of insect flour in the production of insect-based food is a noble approach that can mask the insect (Zocca *et al.*, 2018). Entomophagy can be promoted by incorporating insects into familiar products (Lensvelt and Steenbekkers, 2014; Van Huis, 2015; Liceaga, 2019), because many people are very uncomfortable with the natural appearance of the insects (Tang *et al.*, 2019; Jensen and Lieberoth, 2019; Tuccillo *et al.*, 2020). The possibility of integrating edible insects into the meal of Western Europe was reported by (Megido *et al.*, 2014). Recent findings reported an increase in the acceptance of insect protein incorporated into familiar foods (Pambo *et al.*, 2018; Liceaga, 2019). Foods produced from processed insects with no visible components (Pippinato *et al.*, 2020) and unaltered sensory (appearance, aroma, flavor, texture) characteristics (Liceaga, 2019) are more acceptable. Cicatiello *et al.* (2020) studied the acceptability of different insect products using sensory panel, the results of their research revealed that chocolate bar prepared with insect powder was more acceptable than other foods with visible insects. Defatting of insects can improve their acceptability, Ribeiro *et al.* (2019b) reported improved sensory properties and overall acceptance in cereal bar produced from defatted cricket powder.

PROSPECTS OF EDIBLE INSECTS

The Entomophagy Attitude Questionnaire (EAQ) recently developed by La Barbera *et al.* (2020), which was cross-validated and recommended by Verneau *et al.* (2021) will be used as a standard scale for entomophagy perception and willingness studies when fully accepted. Entomophagy is among the trending topics in food and feed research because of the expanding interest in using insects as both food and feed (Niassy & Ekesi, 2016). In the last two decades, scientists thoroughly investigated and reported reasons for considering insects as food based on their nutritive, health, and economic significance (Ruby, Rozin & Chan, 2015). Edible insects provide protein to many traditional diets and are an important livelihood in many cultures (Choo, 2008).

Researchers are working hard to promote the consumption of edible-insect among European and American consumers. Entomophagy may be accepted by the Western world because scholars and policymakers begin to consider insects as an alternative source of conventional protein (Chan, 2014). More attention was given to entomophagy in the Western countries after the FAO report on edible insects in 2013, since then, acceptance of insects as food is growing both in academia and in commercial spaces (Payne *et al.*, 2019). Entomophagy is gradually becoming popular in the Western world (Pippinato *et al.*, 2020; Poelaert *et al.*, 2018) and the campaign is yielding positive results as a significant increase is observed in the production and marketing data (Pippinato *et al.*, 2020). There is also a substantial increase in the researches trying to reveal the potentials of edible insects as a safe and novel source of protein (Jantzen da Silva Lucas *et al.*, 2020). Many companies showed interest in joining the edible-insects industry and entomophagy was also added to the curriculum of many institutions (Dunkel & Payne, 2016). European Commission is investing vastly in researches to explore the feasibility of using insects as food and feed in the future, policies that will allow insect utilization as food and feed are also underway (Testa *et al.*, 2016). With the enactment of the amended Novel Food regulation in January 2018, the marketing of edible insects is fully regulated by the European Union (Schlüter & Rumpold, 2019).

There is growing interest in insect farming for food in the West (Berenbaum, 2016), and some consumers have shown a positive attitude towards direct and indirect entomophagy (La Barbera *et al.*, 2020). The acceptability of insects by Western people depends on the commitment of the key stakeholders in the food chain. Producers, researchers, food regulatory bodies, entomologists, and processors should provide consumers with supportive information that will assist in convincing the consumers to consider insects as a good and novel source of protein (Hunts *et al.*, 2020). An online survey conducted by Ruby *et al.* (2015) shows that a significant proportion of Americans are willing to accept insects as food. A bright future is foreseeing with the start of the commercial production of insects in the United State (Morales-Ramos, Rojas & Dossey, 2018). The consumption of mealworm and cricket is increasing in Europe as the two insects are now commercially available as a whole and as an ingredient (Francis *et al.*, 2019). Western acceptance of entomophagy is critical to global acceptance of insects as food due to the status of European food laws in global food policy (Telfser & Temmes, 2015). Creating awareness on the health and environmental benefits of using insects as a novel protein source, adequate processing to completely mask insect presence, and smart processing to produce products with a close resemblance with meat will certainly promote global insect consumption.

Katayama *et al.* (2005) and Katayama *et al.* (2008) proposed the use of edible insects in the design of a space agricultural system to be used as a source of protein in space diet. This is because insects can survive in a wide diversity of ecological conditions (Rao, 2016). In addition to protein, insects can also contribute to the production of other foods in the space, can be used as feed for other animals, and can also serve as pollinators in crop production (Katayama *et al.*, 2008).

Insects are predominantly consumed more in tropical countries because they occur naturally in mass (van Huis, 2015). Insects are favored food in some parts of Latin America, West Africa, and Southeast Asia (Ruby, Rozin & Chan, 2015). They are also an important diet to Australian indigenes, Middle East, and South and Central Americans (Chung, 2008). Insects are consumed more in Thailand, China, Japan, Korea, and Indonesia than in any other nation (Chung, 2008). Thailand's insect industry is well developed with more than 20,000 registered insect farming enterprises (New, 2013).

CONCLUSION AND RECOMMENDATIONS

Conclusion

Edible-insects contributed to the nutrition of many and will remain very relevant to the nutrition of many in the years to come. Insects consumption depends greatly on location, eating habits, prior experience, age, gender, and religious belief. The consumption of edible-insect is gradually declining in some societies; the practice is predominantly left with elderly people. The major barriers to global edible-insect acceptance are sociocultural influences, psychological factors, and religious belief. Edible-insects are rejected by new consumers, predominantly due to cultural reasons, disgust, fear of disease and contamination, food and food technology neophobia, lack of awareness, inaccessibility, personality traits, and alleged poor sensory attributes which in many cases w ecological and environmental as trigger by fear and negative attitude towards entomophagy.

Researchers are working hard in promoting the consumption of edible-insect in Europe and America. Accepting edible-insects by the western world will brighten their global image and recognition due to the position and contribution of Europe and America to the global nutrition policy. Policymakers and researchers in the West are giving more attention to entomophagy in recent years, there is a growing interest in both commercial and academic spaces. The start of commercial production of edible-insects in these regions is an indication of a bright future for both direct and indirect entomophagy. Commercial production will make edible-insects more versatile, large-scale industrial production will prevent overexploitation of species, save the environment and natural ecosystem relationships by preventing ecological imbalance, and significantly reduce the price of edible-insects. To overcome legislation constraints, regulatory authorities need to be convinced that edible-insects are safe and fit for human consumption.

Recommendations

There is a looming danger of protein scarcity in decades to come due to the rapid population growth, unsustainability in animal breeding and unbearable hike in the animal feeds price. The conventional sources of proteins are not reliable and cannot satisfy the world population in years to come, therefore, alternative sources of proteins are necessary to tackle the foreseeing challenges. There is an urgent need for swift action on the promotion of entomophagy to ensure edible-insects acceptance particularly in developing countries with acute food shortages. Many knowledge gaps need to be addressed in promoting and adopting insects as food. Consumers should be educated on the safety of edible insects as many have serious concerns about dangerous microorganisms and toxins in insect products. Insects can provide significant amounts of proteins and other essential nutrients to the accelerated global population when more attention is given to their production, processing, safety, and marketing. Accepting insects as food will improve the nutritional status of many, particularly in developing countries. Insects can also contribute to the development of many novel food products and also change the nutritional content of many existing foods.

Entomophagy cannot be fully accepted when the promoting strategy relies mainly on educating target consumers on the various benefits of edible-insects using scientific evidence alone, ethical issues need to be given due considerations. The psychology, emotion, and the belief of the consumers need to be understood, this will provide clues on their perception of edible-insects. Another factor to be considered is cultural variations, consumers with a different cultural background will have a different perception. Understanding these will give ideas on how to introduce the edible-insects in the first place since the first bite is always critical to acceptance and continue eating. Introduction to children will ensure early acquaintance and minimize disgust when they grow up. The attitude of consumers can be changed by motivations, innovation in insect business should be consumption-to-production because the consumer is critical to any business, and the power of culture, habit, and heritage is very strong.

Attention should be given to scientific evidence in the occasions of ensuring the safety of edible-insects to the consumers, information on the non-existence of pathogens, allergens, or any other contaminant should be back up with laboratory evidence. Convincing new consumers by explaining the various benefits of insect consumption should be back up with tangible and observable evidence.

Safety must be ensured by taking precautionary measures throughout the production and processing chains. Insect species, breeding ground and its premises, feed, and water should not be a source of any contamination. Processing into delicious, attractive, and irresistible meals with no visible insects, or their parts, and the use of an appropriate and eye-catching packaging system will promote edible-insects' acceptance. This can be achieved through the addition of insects into familiar foods, development of new products, or by imitating commonly consume products

Entomophagy will certainly continue to be rejected by people whose religion believes is against consuming foods from animal origin, this will remain the toughest hurdle to be overcome in promoting entomophagy.

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EFFECTS OF WASHING TREATMENT ON THE CHARACTERISTICS OF ROADSIDE FRESH FRUITS

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ABSTRACT

Roadside fruits are very possible to be contaminated by heavy metals and microbial contamination, especially fruits that are usually consumed unpeeled, such as grapes, water guava, apples, and starfruit. Heavy metal contaminants that are hazardous to health include lead (Pd), cadmium (Cd), and arsenic (As), while harmful microbial contaminants include *Escherichia coli* and *Salmonella thypii*. This study aims to determine the effect of washing treatment on the characteristics (heavy metal and microbial contamination) of some fresh fruit. Washing process using running water and food grade soap. The design of the study used is Randomized Block Design, if it had a significant effect, it was further tested using the Duncan Multiple Range Test (DMRT). The results of study showed that washing with food grade soap is preferable, as it shows a significant reduction in the levels of heavy metal and microbiological contents up to 0.000 mg / kg for Pb and Cd; 0.041 mg / kg for As; 0 kol / g for E. coli and 0 kol / 25g for *Salmonella thypii*.

Keywords: food grade soap, Fruits, heavy metal, microbial contamination

INTRODUCTION

Fruits are an essential part of the human diet. They are sources of many essential nutrients, vitamins, minerals, have high water and fiber content. Fruits that can be directly consumed without needing to be peeled such as grapes, apples, water guava, star fruit, and many others. Farmers or sellers often sell fruits at roadside stands. Road side fruits are potentially exposed to exhaust gases or vehicle fumes that contain heavy metal contamination. Lead, cadmium, and arsenic are among the most risky heavy metals when consumed through contaminated fruits. Of all the heavy metals, cadmium and lead have more significant side effects on human health since they are easily accessible through food chain transmission (Rahimi, 2013). Consumption of roadside fruits also potentially increases the risk of foodborne illness caused by microbial contaminants. The common microbial contaminants are *Esceherichia coli* and *Salmonella thypii*. Another way to reduce heavy metal contamination and microbiology in roadside fruits is washing treatment. Most people wash fruits only by using water. However, this has not guaranteed the contamination of heavy metals and microbiology lost from fruits. Nowadays there are several food grade soap products that contain anionic and antibacterial agent surfactants that are safe to use to wash fresh foods.

This study aimed to measure the effectiveness of washing treatment for reduce the presence of heavy metals and microbiology contamination in road side fruits. The study was carried out using fruits that were purchased directly without washing, compared to washed fruits with running water, and washed fruits using food grade soap. The samples used for research are fruits that are usually consumed directly without peeling, such as grapes, apples, water guava, and star fruit. The results of this study are expected to provide information to the public about the dangers of heavy metals and microbiological contamination of fruits, and can educate the public to do proper washing of fruits, especially fruits that are usually consumed directly without peeling.

MATERIALS AND METHODS

Materials

This study uses four types of samples, there are red grapes, Washington apple, Semarang water guava, and Dewi starfruit. Red grapes and Washington apples represent imported fruits while Semarang guava fruit and Dewi star fruit represent local fruits. The fruits used in the study were purchased in the same place, which is in the stalls along the roadside of Pulo Jahe market, East Jakarta. The washing solution used is food grade soap. The active ingredients used in food grade soaps are anionic surfactants and anti-bacterial food grade agents that can clean pesticides and kill germs up to 99%. The concentration of washing solution used for fruit washing was also the same for each type of fruit, the formulation is 1⁄2 tbsp (7.5 ml) dissolved in 1 liter of water.

Materials used for testing include, aquadest, acidic solution, Pb standard solution; CD; and As, Modified Letheen Broth media; Nutrient Agar and Sabuoraud Dextrose Agar; Cromocult Agar; and Xylose Lysine Deoxycholate. The tools used for testing included a basin, hollow and plastic basin, beaker glass, stirring rod, hot plate, measuring flask, glass funnel, filter paper, Atomic Absorption Spectrophotometry (AAS), Gas Chromatography (GC), magnetic stirrer, bottles sterile, test tube, finnpipette, pipette tips, autoclave, Bio Safety Cabinet (BSC), and incubator.

Procedure

The steps of determining the effect of washing on heavy metal and microbiological contamination on fresh fruit can be seen in Figure 1 and Figure 2. In the first step, the fruits analyzed were selected through screening results including the selection of all types of fruits that can be consumed without peeling the skin that are sold in fruit stalls along the Pulo Jahe market road using descriptive methods. The microbiology test carried out was the total calculation of microbes including bacteria, fungi, and yeast using the Total Plate Count (TPC) method. While the chemical test using the Gas Chromatography (GC) method.

Chemical Test

Heavy Metal Contents

Fruit samples prepared before reading with AAS instrument. The fruits were initially deconstructed, which was weighed as much as 100 grams in a porcelain dish, burned, and ashed in a furnace at 900°C for 1 hour. Then the ash filtrate was acidified with the addition of 1 ml of 1: 1 HCl and being heated. After dissolving, put the solution into a 100 ml measuring flask and add aquadest to the boundary mark. The solution is filtered and ready to read the content of heavy metals with the AAS instrument at the wavelength specified for each heavy metal.

Moisture Content (AOAC, 2006)

Weighed each dish that will be used. weighed ± 5 grams of sample into the dish, and put the dish in the oven at 105°C for ± 4 hours or until the weight is constant, then cooled in the desiccator, and weighed at the final dish with its sample. The calculation of wet and dry base water content was used. The formula for calculating water content is as follows:

Moisture content (wet base) (%) =

$$\frac{initial\ weight - final\ weight}{initial\ weight} x\ 100\%$$

Moisture content (dry base) (%) =

$$\frac{initial\ weight - final\ weight}{final\ weight} x\ 100\%$$

Ash Content (AOAC, 2006)

Prepare the porcelain dish to do the obfuscation, then dry it in an oven for 15 minutes and then cool it in a desiccator and weighed (A). The sample is weighed ± 3 grams in a porcelain dish (B), then it is burned in chamber until it doesn't smoke again. Then put it in electric furnace at a temperature of 400 – 600°C for 4 – 6 hours until white ash was formed or had a fixed weight. The ash and cup are cooled in a desiccator then weighed (C).

$$\text{Ash Content (\% bb)} = \frac{(C - A)}{B} \times 100\ \%$$

Protein Content (AOAC, 2006)

Samples of ± 100 mg were weighed (A) and put into a 30 ml kjeldahl flask. Then added 1.9 ± 0.1 gr K_2SO_4, 40 ± 10 mg HgO, and 3.8 ± 0.1 ml H_2SO_4. Boiling stone is added to the flask and the sample is boiled for 1-1.5 hours until the liquid becomes clear. The contents of the flask and the rinsed water are transferred into a distillation instrument. The 125 ml erlenmeyer flask was filled with 5 ml of H_3BO_4 solution and added with 4 drops of indicators, then placed under a condenser with the tip of the condenser submerged in either H_3BO_4 solution. 8-10 ml $NaOH\text{-}Na_2S_2O_3$ solution was added to the distillation apparatus until it obtained distillate ± 15 ml in erlenmeyer. The distillate in the erlenmeyer is then titrated with 0.02 N HCl solution until there is a green to blue color change. Calculated the amount of nitrogen after previously obtained the amount of volume (ml) blank.

Amount of N (%) =

$$\frac{(\text{ml HCl} - \text{ml blank}) \times \text{N HCl} \times 14.007}{A} \times 100\ \%$$

Fat Content (AOAC, 2006)

Fat flask is provided according to the size of the soxhlet extraction tool used. The flask was dried in an oven at a temperature of 105 - 110 oC for 15 minutes, then cooled in a desiccator then weighed (A). Weighed as much as ± 5 g of sample (B) in filter paper, then covered with fat-free cotton. Filter paper and its contents are put into the Soxhlet extraction and installed on the condenser. The hexane solvent is poured into the Soxhlet flask to taste. Then it is refluxed for 5 hours until the solvent that comes back becomes clear. The solvent remaining in the fat flask is distilled and then the flask is heated in an oven at 105oC. After being dried to a fixed weight and cooled in a desiccator, the flask and the fat are weighed (C) and the following fat content is calculated.

$$\text{Fat content (\%)} = \frac{C - A}{B} \times 100\ \%$$

Carbohydrate Content by difference (AOAC, 2006)

Carbohydrate content is calculated based on by difference method with the following calculation:

Carbohydrate content (% ww) = 100% - (moisture content + ash content + protein content + fat content)

Microbiological Test

***Escherichia coli* Identification**

Microbiological testing on fruits was carried out by quantitative identification of E. coli-Coliform. Where fruit samples are weighed 1 gram and dissolved in media (Modified Letheen Broth) 9ml MLB in aseptic conditions. Then 1 ml was taken to be planted on selective media for E. Coli-Coliform that is Cromocult Agar (CA). After it being solid, incubated at 36°C for 2x24 hours. Positive *E. coli* samples will grow purple colonies, and Coliform positive samples will grow red colonies.

***Salmonella thypii* Identification**

Microbiological testing of fruits for the identification of *S. thypii* was carried out qualitatively. Fruit samples were weighed 25 grams and dissolved in media (Modified Letheen Broth) 225 ml in aseptic conditions. Then incubated at 36°C for 24 hours, to enrich microbes. Then 1 ml was taken to be planted on selective media for *S. thypii* that is Xylose Lysine Deoxycholate (XLD). After it being solid, it was incubated at 36°C for 2x24 hours. Positive samples of *S. thypii* will change the color of the media from brown to red and grow black colonies.

Statistical Analysis

The analysis technique used in this study is variance analysis (ANOVA), using the Statistical Package for Social Science (SPSS) application program. The design of the study used is Randomized Block Design, if it had a significant effect, it was further tested using the Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Fruits Screening

Roadside fruits may become contaminated with pathogenic microorganisms either during their growing in fields or greenhouses, or during harvesting, postharvest handling, and distribution (Beuchat, 2002).

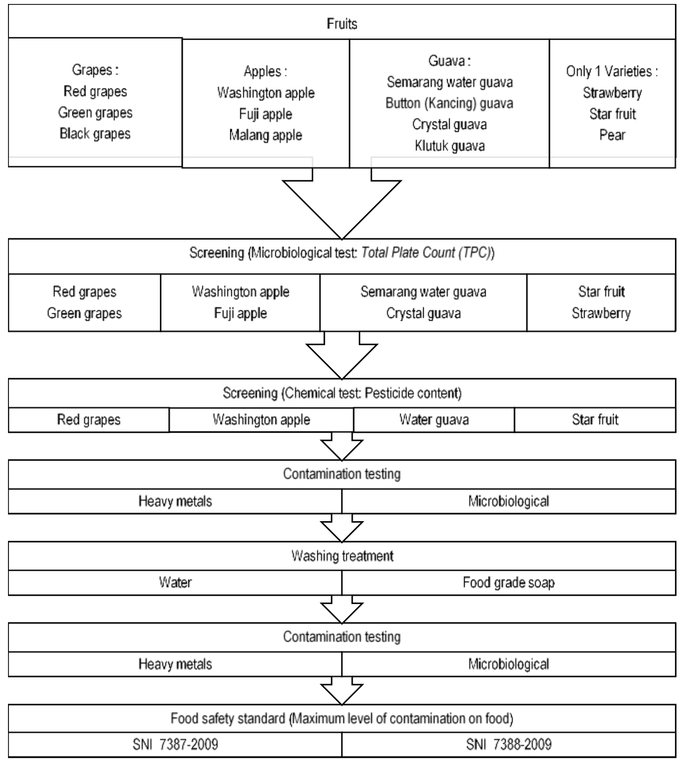

Figure 1. The steps of determining the effect of washing on heavy metal and microbiological contamination on fresh fruit

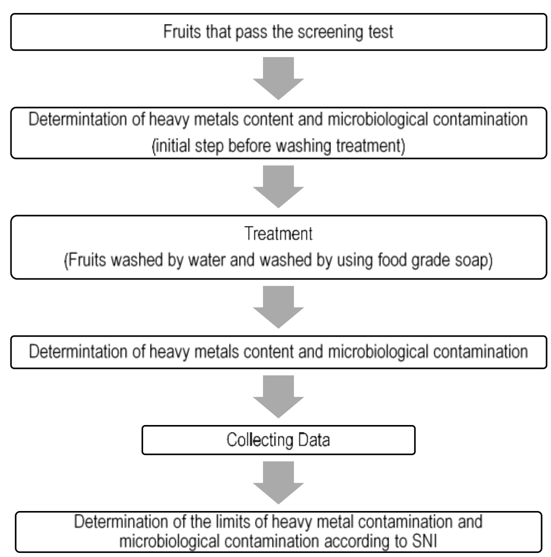

Figure 2. Flow Chart of determining the effect of washing on heavy metal and microbiological contamination on fresh fruit process

Postharvest sources of contamination include faeces, harvesting equipment, human handling, insects, wild and domestic animals, methods of transportation, processing equipment dust, and rinse water (Gil, et al., 2015). The result from fruits screening in microbilogical testing and chemical testing can be seen on Table 1 and Table 2. Table 1 and 2 showed that all roadside fruits showed bacterial, fungi, and yeast contamination, the most contaminated was grapes (red grapes and green grapes). Fruits like grapes, apple, guava, etc are mostly handled with bare hands during harvesting, packaging, and distribution; hence, it has been established that many fruits in the country are contaminated before they are sold, which, when not properly washed, will result in food-borne illnesses (Boateng, 2016). Each of the fruit varieties with the highest results of chemical analysis is selected one type that will proceed to the main study to determine the presence of heavy metal and microbiological contamination as well as the effect of washing on the decrease in content of heavy metal and microbiological contamination in fruits.

Table 1. Result from fruits screening in microbiological testing

No	Varieties	Sample	***Total Plate Count (TPC) colony/gram***		
			Bacteria	**Fungi**	**Yeast**
1	Grapes Vitis vinera	Red grapes	9.8×10^4	4.2×10^3	1.0×10^4
2		Green grapes	7.4×10^3	$<1 \times 10^1$	5.0×10^3
3		Black grapes	1.5×10^3	$<1 \times 10^1$	1.1×10^2
4	Apple Malus domestica	Washington apple	3.0×10^4	4.8×10^3	5.8×10^3
5		Fuji apple	1.6×10^4	1.8×10^3	1.3×10^3
6		Malang apple	4.7×10^3	3.0×10^2	2.5×10^3
7	Water guava Syzygium aqueum	Semarang water guava	2.2×10^5	1.3×10^3	2.5×10^3
8		Button guava (Jambu kancing)	1.1×10^5	$<1 \times 10^1$	$<1 \times 10^1$
9	Guava Psidium guajava	Crystal guava	1.8×10^5	2.3×10^3	1.2×10^3
10		Klutuk guava	1.4×10^4	2.0×10^3	1.2×10^3
11	Only 1 variety	Strawberry	2.4×10^4	5.3×10^3	2.5×10^3
12		Dewi star fruit	2.9×10^4	1.1×10^4	5.7×10^3
13		Pear	1.4×10^4	2.0×10^3	1.2×10^3

Table 2. Result from fruits screening in chemical testing

No	Varieties	Sample	Result (mg/kg)
1	Grapes	**Red grapes**	**0.90**
2		Green grapes	0.43
3	Apple	**Washington Apple**	**0.33**
4		Fuji apple	0.16
5	Guava	**Semarang water guava**	**0,07**
6		Crystal guava	0,03
7	Only 1 variant	Strawberry	0,03
8		**Dewi star fruit**	**0,06**

Heavy Metals Content

The results of the content of heavy metals analysis for Pb, Cd, and As from each fruit can be seen in the Table 3. Test results of heavy metal content in fruits can be seen from Table 3 have decreased. Test results of variance Pb heavy metal content in fruits showed that washing treatment (treatment significance = 0.204) did not significantly affect Pb content at the level of significance (α) 0.05. PB is very dangerous for the environment. The period of stay of Pb particles in the air is 4-40 days. Pb particles can be spread by the wind to reach distances of 100-1000 km from the source (Ayu, 2000). While Cd heavy metal, the test results of variance Cd heavy metal content showed that washing treatment (treatment significance = 0.371) did not significantly affect the levels of Cd heavy metals at the level of significance (α) 0.05. Cd is a toxic pollutant in water from metal mining, melting, plating, batteries, pesticides, oil paint, pigments, and alloys (Li et al., 2007 and Chen et al., 2008). Large dosages of Cd in humans can cause proteinurea and anemia (Horsfall et al., 2005).

Arsenic (As) is one of the major global environmental pollutants because of its highly toxic and carcinogenic properties (Bhattacharya, et al., 2010). The epidemiological studies show that the chronic As poisoning can cause cancers, diabetes mellitus (DM), hypertension, melanosis, hyperkeratosis, restrictive lung disease, peripheral vascular, and ischemic heart disease (Mazumder et al. 2000; Morales et al. 2000; Srivastava et al. 2001; Rahman 2002). While the test results of heavy metal content of As in fruits showed that washing treatment (significance of treatment = 0.020) significantly affected the content of As heavy metal at the level of significance (α) 0.05. Further testing in the form of Duncan test was carried out to see the effect of washing treatment on As content in the fruit group. The results of the test showed that the decrease in As content in fruits can be seen in Table 3. As the levels at the beginning before washing had a significant difference to the As content after washing using water only and food grade soap. The level of As in the fruit group after washing using water only and food grade soap has no real difference. This is because As has a difficultity to dissolve in water.

Table 3. Result of heavy metals analysis (mg/kg) on fruits

Heavy metals	Washing treatment	Grapes	Apple	Guava	Star fruit
Pb	Initiate	3,973[a]	0,216[a]	0,066[a]	1,027[a]
	Water treatment	1,390[a]	0,053[a]	0,000[a]	0,403[a]
	Food grade soap treatment	0,000[a]	0,000[a]	0,000[a]	0,023[a]
Cd	Initiate	1,177[a]	0,053[a]	0,000[a]	0,037[a]
	Water treatment	0,006[a]	0,000[a]	0,000[a]	0,034[a]
	Food grade soap treatment	0,000[a]	0,000[a]	0,000[a]	0,000[a]
As	Initiate	0,141[a]	0,141[a]	0,243[a]	0,074[a]
	Water treatment	0,089[b]	0,080[b]	0,103[b]	0,064[b]
	Food grade soap treatment	0,065[b]	0,041[b]	0,085[b]	0,053[b]

Microbiological qualities

The results of microbiological analysis of the identification of *E. Coli*-Coliform and *Salmonella thypii* can be seen in Table 4. The decrease in the number of colonies of *E. coli*-coliform and *S. thypii* due to washing treatment on fruits can be seen in Table 4. From three washing treatments used, it can be seen that washing treatment using food grade soap is better than washing using only with water to decrease the amount of E. coli-coliform and S. thypii colonies in the fruit group used. The results of the variance in the identification of *E. Coli*-Coliform in fruits showed that washing treatment (treatment significance = 0.127) did not significantly influence the decrease in the number of *E. Coli*-Coliform colonies at the level of significance (α) 0.05. While the results of the identification test for fruit *S. Thypii* showed washing treatment (significance = 0.000) significantly affected the decrease in the number of S. thypii at the level of significance (α) 0.05. Further testing in the form of Duncan test was conducted to see the effect of washing treatment on the number of *S. thypii* in the fruit group. The results of duncan test on the decrease of *S. thypii* in fruits can be seen in Table 4. It can be seen from the Duncan test results that the number of *S. thypii* at the beginning before washing and after washing using running water has no real difference, but both have real differences on the number of *S. thypii* after washing using food grade soap. This can be caused by the small number of *S. thypii* in fruits, so that antibacterial substances in food grade soaps are very effective for eliminating *S. thypii*.

Table 4. Result of microbiological identification (col/g) on fruits

Microbes	Washing Treatment	Grapes	Apple	Guava	Star fruit
E. coli	Initiate	$1x10^2$	$3,2x10^2$	$5,4x10^4$	$4,4x10^4$
	Water treatment	$3x10^1$	1,000	$1,8x10^4$	$6,0x10^3$
	Food grade soap treatment	0,000	0,000	$8,8x10^2$	$3x10^2$
S. thypii	Initiate	1^a (+)	1^a (+)	1^a (+)	1^a (+)
	Water treatment	1^a (+)	1^a (+)	1^a (+)	1^a (+)
	Food grade soap treatment	0^b (-)	0^b (-)	0^b (-)	0^b (-)

Supporting Test

Supporting tests on fruits were carried out to determine the nutritional quality of fruits and to determine the content of active ingredients and antibacterial substances in food grade soaps that have been tested. Proximate testing results and mineral content testing in fruits can be seen in Table 5. The results of the active ingredients content in food grade soap can be seen in Table 6. And the results of antibacterial substances testing on food grade soap can be seen in Table 7.

CONCLUSION

Chemical tests results showed that there was an effect (<α = 0.05) of washing treatment on heavy metal contamination in fresh fruits which are usually consumed directly without peeling the skin, and has a significant effect on Arsenic (As) heavy metal content. For the results of microbiological tests showed that there was an effect (<α = 0.05) of washing treatment on microbes in fresh fruit which is usually consumed directly without peeling the skin. And significantly affect the pathogenic microbes of Salmonella thypii. Based on the results of this study on fruits washing treatment using food grade soap which is usually consumed without peeling the skin and sold along the road is more effective in reducing heavy metal and microbiological contamination.

Table 5. Result test of proximate and mineral content in fruits

Parameter	Result			
	Grapes	**Apple**	**Guava**	**Star fruit**
Water content (%)	83.99	83,39	93,77	92,99
Ash content (%)	0,17	0,01	0,02	0,02
Fat content (%)	0.09	0.07	0.06	0,07
Protein content (%)	1,82	1,66	0,89	1,23
Carbohydrate content (%)	13,15	14,39	5,98	5,49
Fe (mg/100g)	0,326	0,132	0,073	0,077
Ca (mg/100g)	10,895	6,774	29,253	3,346
Mg (mg/100g)	7,141	5,116	5,586	10,583

Table 6. Result test of active agent (Anionic surfactant) in food

Parameter	Result (%)
Lauryl Alkyl Sulphonate Sodium *(LAS Na)*	10,85
Sodium Lauryl Ethoxy Sulphonate *(SLES)*	11,17

Table 7. Result test of active agent (Anionic surfactant) in food

Parameter	Result (%)
Triclosan	0
TCC	0
Methylisothializone	0
Methylchloroisothializone	0
Zinc Sulphate	1,06

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RELATIONSHIP OF NUTRITIONAL ANEMIA WITH THE EVENT OF WORM INFECTION IN PRIMARY SCHOOL CHILDREN IN THE WORK AREA OF AIR BILITI PUSKESMAS MUSI RAWAS

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ABSTRACT

More than 1.5 billion people or 24% of the world's population experience worm infections that are transmitted through the soil. Worm infections that occur can damage the nutritional status in the form of anemia in all children, especially school age. The purpose of this study was to determine the relationship between nutritional anemia and the incidence of helminthiasis. This research method is an analytical observational with a cross-sectional design. The population in the study was conducted on elementary school children in the working area of the Air Biliti Health Center, Musi Rawas Regency in 2021. The sample in this study was 98 with simple random sampling at five schools in the working area of the Air Biliti Health Center. The study was conducted in March 2021. The results of this study showed that most of the proportions of negative helminth infections were 60 (61.2%), not anemic 71 (72.4%), Class VI 39 (39.8%), 11 years old 32 (32,7 %), female 50 (51.0%), high parental education 53 (54.1%), farmer occupation 61 (62.2%), income 50 (51.0%). The results of the analysis of the significant relationship between nutritional anemia (p value 0.000, OR = 6.500) and infection rates in elementary school-aged children in the work area of Air Biliti Health Center, Musi Rawas Regency. Based on the results of the study, it was found that the importance of maintaining environmental cleanliness and personal hygiene, coupled with the habit of taking a worm medicine and attention from parents to reduce helminth infections that cause children to experience nutritional anemia.
Keywords: Nutritional Anemia, Worm Infection

INTRODUCTION

Worm infection transmitted through soil or called Soil-transmitted helminth infection (SHT) of intestinal worms that are transmitted through the ground to humans contaminated with media transmission caused by roundworms (*Ascoris lubricoides*), whipworm (*Trichuris trichura*), and hookworm (*Ancylostoma duodenale*, *Necator americanus*) (CDC, 2020). According to the data of the World Health Organization (WHO) over 1,5 billion people, or 24% of the world population experienced worm infection. Over 267 million children of preschool and over 568 million school-age children living in areas where the parasite is transmitted intensively, so in need of treatment and prevention interventions more. Worm infection transmitted through the ground can damage the nutritional status, worms that enter the intestine takes to host tissues, including blood resulting in the loss of iron and protein in the body, so the risk of the anemia, diarrhea and dysentry. The worm infection also causes a reduced appetite (WHO, 2020).

In Indonesia, helminth infections are still high, especially in the poor population, with poor sanitation between 2.5%-62% (Ministry of Health, 2017). Worm infections can affect everyone, but school-age children are most at risk of being infected with worms (Sigalingging *et al*., 2019). More than 60% of elementary school children in Indonesia experience worm infections, not only nutritional disorders, but also poor sanitation, especially contaminated water, drinks and food that are not cooked until cooked and not covered (Pasyanti *et al*., 2015). Riskesdas data (2018) the prevalence of anemia nationally at the age of 5-14 years is 26.8% (Ministry of Health RI, 2018). Health problems experienced by elementary school/madrasa children include nutritional problems (thin or fat and anemia. South Sumatra, based on the health screening of class 1 participants by Province (2018), 78.92% of them experienced nutritional problems such as anemia (Ministry of Health, 2018).

Anemia is a condition in which a low concentration of hemoglobin (Hb) or hematocrit based on a threshold value is caused by low production of red blood cells and Hb, increased erythrocyte damage or excessive blood loss (Citrakesumasari, 2012). Research conducted by Rajagopal *et al*. (2014) showed that the infection of worms and anemia have relationship with roundworms (*A . Lubricoides*), whipworm (*T. trichiura*) or hookworm(*N . Americanus* or *A . duodenale*). Those research have subjects aged 2-15 years in which anemia is caused by three worms which are found mainly hookworm.

This worm disease can lead to a decrease in the health condition, nutritional status, intelligence and productivity of the sufferer so that economically it causes a lot of losses. Worms cause loss of intake of carbohydrates and protein and blood loss, so it will decrease the quality of human resources (Pemenkes, 2017). Helminthiases have signs perceived as pain in the abdomen appear repeatedly, decreased appetite, anemia, as well as feeling itching in the anus (South Sumatra Provincial Health Office, 2020) . Worm disease that occurs in children aged Elementary School can disturb the concentration of learning, not focus, weakness, fatigue, and drowsiness while studying (Sarasmita, 2020).

Worm infections that occur are caused by intestinal parasites that trigger food intolerance secondary to irritation of the intestines (Gozalbo *et al.*, 2020). Research conducted (Annisa *et al.*, 2018) found a significant relationship between nutritional status and the incidence of helminth infections in schools. Worm infection also can affect children's nutritional status age of school because of less consumption in balanced eating (Hardinsyah, 2017). Worm diseases that occur in elementary school age children can have a chronic impact on the nutritional status of children infected with worms (Kamila *et al.*, 2018) .

Research (Aji *et al.*, 2017) that there is a relationship between Soil Transmitted Helminth (STH) infection and anemia in elementary school children. Results (Molla & Mamo, 2018) of 443 sample school children, 54% were infected with soil-transmitted worms (STH) and 15.4% of them suffered from anemia . According to research

(Puspita *et al.*, 2020) that there is a relationship between the incidence of worm infection with anemia in elementary school children p = 0.017, this is influenced by high knowledge, clean and healthy living behavior, provided hand washing facilities at school and at home, and active role of parents.

Based on the description above, this study aims to analyze the relationship between nutritional anemia in elementary school age children in the working area of Air Biliti Health Center , Musi Rawas Regency, in the Air Beliti Health Center working area there are no reports of anemia incidence and reports of primary school children infected with helminthiasis.

METHODS

This research is a quantitative research with a cross-sectional research design. Research was conducted in Puskesmas Air Biliti Musi Rawas, in March 2021. Based on the calculation of the samples using a sample size of two proportions formula resulted of 98 subjects. The subjects taken were 98 people using random sampling technique. The inclusion criteria were elementary school students in grades 3, 4, 5 and 6 in the working area of the Air Biliti Health Center, willing to have their blood and feces drawn and not taking worm medicine in the last 6 months. The exclusion criteria were when the subject did not return the stool bottle and the subject suffered from diarrhea/dysentry, and did not want to have blood drawn. Each selected subject received parental consent by filling in informed consent as a sign that the subject agreed to participate in the study. Hb test was done by using a strip of diagnostic rapid test. Univariate and bivariate analysis using Chi Square test.

RESULTS AND DISCUSSION

The subjects in this study came from 5 elementary schools in the working area of the Air Biliti Health Center, Ten Musi Rawas Regency. A total of 98 subjects were involved until the end of the study.

Based on Table 1. It shows that most of the proportions of the incidence of negative helminth infections are 60 (61.2 %), not anemic 71 (72.4%), Class V I 39 (39.8 %), 11 years old 32 (32.7 %), %), female sex 50 (51.0%) , high parental education 53 (54.1%), farmer occupation 61 (62.2 %), low income 50 (51.0%).

Based on Table 2, the results of statistical tests showed that subjects with worm infection experienced nutritional anemia 19 (10.5 %) compared to subjects who did not experience nutritional anemia, namely 19 (27.5 %) experienced helminth infection . The results of the analysis obtained relationship anemia with ang ka incidence of worm infection (pv alue 0.0000) with OR 6 , 5 00 that experienced anemia risk 6 .5 times more risk in worm infected compared to non-anemic nutrition.

Based on the results of this study, most of the proportions of negative helminth infections were 60 (61.2%), not anemic 71 (72.4%), Class VI 39 (39.8%), 11 years old 32 (32.7%) , female gender 50 (51.0%), high parental education 53 (54.1%), farmer occupation 61 (62.2%), low income 50 (51.0%). The results of the analysis showed that there was a significant relationship between nutritional anemia (p value 0.000, OR = 6.5 00) and the rate of worm infection in elementary school- aged (SD) children in the working area of Air Biliti Health Center, Musi Rawas Regency.

In the research results obtained results worm infection was positive in 38 (38 , 8 %)

and anemia 27 (27.6%) this is because the hygiene of individuals as well as high consumption of foods that have iron content results in high . Worm infection is a disease that is transmitted through food and drink or through the skin where soil is the transmission medium, caused by roundworms (A. lumbricoides), whipworms (T. trichuria), and hookworms (A. duodenale and N. americanus) (Sigalingging). et al., 2019) . The worms can affect the digestion and lead to lack of nutrients such as calories, protein and nutrients iron, so menghabat perkemb a n gan physical, experiencing anemia, intelligence decline and labor productivity (Midwives, 2010) . The large number of worms can cause malnutrition in children, because these worms can live in the body of children for 12-18 years, and take food, especially carbohydrates 0.14 grams, protein 0.035 grams, suck blood 0.03-0.05 ml per day. days (Purnasari, 2018) . Worms can interfere with learning concentration, not focus, weak, easily tired, and easily sleepy (Sarasmita, 2020) According to research (Sanchez, et al 2013) the overall prevalence of STH is 72.5% with a p value of 0.001 there is a relationship between helminth infections and nutritional status child.

Anemia is a condition in which hemoglobin and hematocrit levels are lower than normal levels. Anemia is strongly related to school children's learning achievement (Sudargo , 2015) Research is in line with research conducted (Pratiwi & Sofiana, 2019) that most of the female gender who experience positive anemia are 15 (18.50%), from the results of the analysis there is no relationship There is a significant relationship between worm infection and anemia, but helminthiasis is a risk factor for anemia.

Research conducted (Kamila et al., 2018) that most of the worms found during the study were T. trichiura worms (65.4%), these worms cause nutritional disorders and anemia in children aged 1-15 years, with a prevalence of anemia that occurred (71.2%). This study is in line with research conducted by Getnet (2015) that the results of the study found a significant relationship between anemia and hookworm infection (p = 0.000), infections that occur are influenced by poor sanitation conditions and low personal hygiene.

This study is in line with research (Yimam et al., 2016) that there are research results of 15.4% suffering from anemia, and 58.3% are basically infected with intestinal worms , in the study there was a decrease in helminth infections in school-age children after being given deworming medicine, so that the administration of deworming medicine is related to the hemoglobin level in school-age children who have worm infections and suffer from anemia. This study supports previous research that the importance of maintaining sanitation, as well as personal hygiene and then regularly taking worm medicine so as to reduce the incidence of helminth infections that can cause anemia.

CONCLUSION

Based on the results of the pen elitian that it can be concluded that based on the results of the analysis are significant relationship anatara anemia (p value = 0.000, OR = 6.500) with the numbers worm infection in children aged Elementary School (SD) with children infected with anemia risk 6 , 5 times the infected kecacinagn in the working area of the Air Biliti Health Center , Musi Rawas Regency.

SUGGESTION

Based on the results obtained that suggested to respondents infected with intestinal worms to regularly take medicines, always keeping environmental sanitation as well as personal hygiene and lack of attention from parents to their children's health so as to reduce the risk of infection by intestinal worms in children of school age resulting in anemia nutrition .

Table 1. Frequency Distribution of Subjects and Parents Characteristics in the working area of Air Biliti Health Center

No	Variable	N	%
1.	Worm Infection Incidence Rate		
	a. positive	38	38.8
	b. Negative	60	61.2
2.	Anemia		
	a. Yes	27	27.6
	b. Not	71	72.4
3.	Class		
	a. Class III	2	2.0
	b. Class IV	32	32.7
	c. Class V	25	25.5
	d. Class VI	39	39.8
4.	Gender		
	a. Man	48	49.0
	b. Woman	50	51.0
5.	Parental Education		
	a. No school	1	9
	b. Not completed in primary school	15	13.9
	c. Elementary School	25	23.1
	d. Graduated from junior high school/junior high school	29	26.9
	e. Finished high school / high school	26	24.1
	f. Graduated PT	12	11.1
6.	Age		
	a. 7 years	2	2.0
	b. 8 years	1	1.0
	c. 9 years	12	12.2
	d. 10 years	22	22.4
	e. 11 years old	32	32.7
	f. 12 years old	26	26.5
	g. 13 years old	2	2.0
	h. 14 years	1	1.0
7.	People Education		
	a. Low	45	45.9
	b. Tall	53	54.1
8.	Parents' job		
	a. Non Farmer	37	37.8
	b. Farmer	61	62.2
9.	Parent's Income		
	a. Low	50	51.0
	b. High	48	49.0

Table 2. Nutritional anemia with the incidence of helminthiasis in elementary school children

Nutritional Anemia	The incidence of helminth infections				Total		*p*	OR96% CI (Min-Max)
	Positive		Negative					
	N	%	n	%	N	%		
Yes	19	10.5	8	1 6 .5	27	100.0	0.000	6,500 (2,442-17,301)
Not	19	27.5	52	43.5	52	100.0		
	38	38 .0	60	60.0	98	100.0		

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THE EFFECT OF NATRIUM METABISULFITE IMMERSION AND DRYNG TEMPERATURE FOR TAPAI FLOUR PRODUCTION

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ABSTRACT

Tapai is one of the food ingredients that is processed into various food dishes and preferred. The shelf life of the tapai is easily damaged after being produced, because tapai has high moisture content, it is necessary to make an effort to extend the shelf life. The purpose of this research was to get the best treatment and to analyze the effect of different concentrations of Natrium Metabisulfite and drying temperatures on the quality of tapai flour. The method used in this study is an experimental research method with Completely Randomized Design (CRD). The first factor is concentration of natrium metabisulfite as much as 0 ppm, 1000 ppm, 2000 ppm, 3000 ppm and 4000 ppm. The second factor is the drying temperature of 45ºC, 55ºC, and 65ºC. The results of data analysis obtained the best treatment at concentration of 2000 ppm Natrium Metabisulfite with temperature of 55ºC, reducing sugar content of 4.35%, ash content of 1.5%, moisture content of 4.8%, yield 52.4% and value of the degree whiteness of 85.49.

Keywords: Drying, immersion, natrium metabisulfite, tapai flour

INTRODUCTION

Cassava commodities become potential product for Bondowoso Regency (Hermanuadi *et al*, 2020). According to the results of research, processed cassava products that have the potential to be a regional superior product are Tapai and it's processed products (Hermanuadi, 2018). Tapai is a processed product from cassava that involves microorganisms with the fermentation process. The process of fermentation, microorganisms involved are yeast, khamir and bacteria. Tapai has a sweet taste and soft texture. In the Bondowoso area, the production of this tapai is very abundant, and can increase economic value. But the Tapai does not have a long shelf life, the life of the tapai is only a maximum of 5 days after it is ready for consumption. Therefore, an innovation is needed to extend the shelf life of tapai.

Tapai flour is an alternative for preserving tapai. In addition, tapai flour can also be used as a substitute for wheat flour, so as to reduce the amount of wheat flour consumption in Indonesia. According to Natsir (2014) tapai flour can be made or used as a mixing material for bread, various cakes, ice cream, and biscuits, where each preparation has a variety of shapes. Tapai flour has a longer shelf life than the tapai itself. So with the tapai flour can reduce production losses due to decreased quality of tapai. There are so many products based on tapai in Bondowoso Regency, so the availability of tapai is very meaningful for several agroindustries that produce them (Novitasari *et al*, 2020).

Drying is one of the important methods to extend shelf life. This method aims to reduce the moisture content of the material, so that it can inhibit microbial growth and unwanted reactions. The drying stage can reduce the nutritional content of the tapai. To inhibit the release of nutrients and starch content in the material, before drying the tapai must be soaked in a solution of Natrium Metabisulfite. The purpose of this study was to determine the optimal process for making tapai flour, based on the concentration of natrium metabisulfite immersion with drying temperature, and flour weight.

MATERIALS AND METHODS

Tools and Materials

The main raw material used in this research is cassava tapai which is directly purchased from one of the cassava tapai entrepreneurs in Bondowoso Regency. Other materials used are citric acid, sulfite, water, aquades, and chemicals for analysis. The tools used in this research are oven, sieve, baking sheet, mixer, knife, spoon, measuring cup, scale, desiccator, porcelain cup, tray, kjeldahl flask and other equipment

Methods

Experimental Design

This research was carried out at the Food Processing Laboratory and Food Analysis Laboratory of the Jember State Polytechnic, from February to April 2021. The study was arranged in a factorial manner using a Completely Randomized Design (CRD) with two factors and three replications. The first factor is the concentration of Na-metabisulfite with a level of 0 ppm; 1000 ppm; 2000 ppm; 3000 ppm; and 4000 ppm. The second factor is the drying temperature of 45ºC, 55ºC, and 65ºC. The data obtained are analyzed by variance test at a significant level of 0.05. If there is a significant difference continued by the Tukey Test to find out the significant difference between treatments at a significance level of 5%.

Tapai flour production process

In the production of cassava Tapai flour, the first step is to reduce the size of the Tapai then dried in a cabinet dryer for 24 hours, ground, sieved through an 80 mesh sieve and packed. The flour was then analyzed for physicochemical variables. The physicochemical variables observed included: Value of reducing sugar content, moisture content, ash content, degree of whiteness, and yield.

The next stage is the application of high cassava tapai flour in the manufacture of food products (cookies) with a comparison to wheat flour (Wijaya. and Hariono, 2020).

Data Analysis

All analyses were performed in triplicate. Data analysis was performed by analysis of variance (ANOVA) using statistical software applications Minitab. The comparison of means was performed by Tukey test at 5% significance level (Bressiani et al, 2017; Rambing, 2013).

RESULTS AND DISCUSSION

Physicochemical Characteristics of Tapai Flour

Physicochemical analysis results are shown in Table 1. It consists of reducing sugar, ash content, moisture content, whiteness degree and yield.

a. Reducing Sugar

The reducing sugar content of the production tapai flour ranged from 2.47 to 4.94%. The highest reducing sugar content was found in the Na-metabisulfite immersion treatment concentration of 4000 ppm at a drying temperature of 55ºC, while the lowest was at a concentration of 0 ppm at a drying temperature of 65ºC. The sugar content produced in cassava tapai flour contains dextrin due to the microbial fermentation process that will break down starch into simple sugar components, so that the starch content decreases over time. In addition, the activity of the amylase enzyme contained in cassava will work optimally in hydrolyzing starch into simpler components (Susanto et al, 2017).

Analysis of variance showed that the initial treatment had a significant effect on reducing sugar content, because of the immersion treatment with natrium metabisulfite where the solution can inhibit the release of nutrients and starch levels in materials. According to Sudarmi et al (2010), tapai flour has a starch content of 91.92%, while according to Majzoobi et al (2011), stated that wheat flour has a starch content of 77.3%.

b. Ash Content

Ash is an organic substance left over from the combustion of an organic material. Ash content is a mixture of inorganic or mineral components contained in a food ingredient. The ash content of the resulting tapai flour ranged from 1.2 to 1.7%. This is because most of the ingredients for this cassava tapai flour still contain high inorganic components. The highest ash content was found with natrium metabisulfite immersion treatment at a concentration of 2000 ppm at a drying temperature of 65ºC, while the lowest was at a concentration of 0 ppm at a drying temperature of 55ºC. The ash content and composition depend on the material and method of ashing.

c. Moisture Content

Water in food will effect the damage to the food. Violalita (2019) said that food damage is caused by chemical, microbiological, enzymatic processes or a combination of them. The results of the analysis of the moisture content in tapai flour showed that the highest moisture content was at 0 ppm with a drying temperature of 45ºC, with a moisture content of 6.1%. The lowest moisture content in with 4000 ppm metabisulfite immersion and drying at 55ºC was 3.4%. This may be due to the moisture content of the tapai in the treatment decreased in volume, while the tapai at 0 ppm natrium metabisulfite concentration had a constant volume. Natrium metabisulfite when reacted with water will release heat. This is supported by Lisa (2013), which states that the moisture content in the control has a higher value than the moisture content in the treatment with a combination of temperature and soaking time. As stated by Estiasih (2011), that the higher the temperature of the drying air, the greater the heat carried by the air so that the more water is evaporated from the surface of the material being dried. This is also in accordance with the opinion of Riansyah et al. (2013) that the ability of the material to release water will be greater with increasing the temperature of the drying air used and the longer the drying process, so that the resulting moisture content is lower.

The hypothesis test used minitab data analysis with the results of the length of time and concentration of immersion, as well as temperature differences that affect the moisture content of Tapai flour not significantly different.

d. Whiteness Degree

Whiteness degree of the tapai flour produced based on the initial treatment ranged from 50.17 to 81.24%. Analysis of variance showed that the initial treatment had a significant effect on the degree of whiteness, where the higher concentration of natrium metabisulfite immersion treatment made the tapai flour whiter. In addition, the longer the immersion time and the higher the concentration of natrium metabisulfite, the whiter Tapai flour produced.

The addition of natrium metabisulfite solution will resolve the brown color in the flour recommended for food products (Suratno et al, 2021). According to Buckle et al (2010), natrium metabisulfite apart from being an anti-microorganism, is also used in various foodstuffs to inhibit non-enzymatic browning, inhibit other enzymatic browning catalyzed by enzymes, and as an antioxidant and reducing agent. According to Muchtadi et al (2011), besides being a preservative, sulfite can interact with the carbonyl group. The result of this reaction will bind the melanoid so as to prevent the appearance of brown color.

e. Yield

Yield is percentage number of products produced with the amount of basic ingredients used. Yield is obtained by comparing the initial weight of the material with the final weight. The yield of Tapai flour produced based on the initial treatment ranged from 42.62 - 52.41%. Analysis of variance showed that the initial treatment had a significant effect on the yield value, where the natrium metabisulfite immersion treatment with a higher concentration reduced the tapai flour. According to Rizal (2013), the low yield value is due to weight loss due to water lost due to heating. The heating process makes the membrane cells more permeable, so that the movement of water is not hampered and water is more easily removed during drying.

Table 1. Chemical properties of sausage

Na-Metabisulfite	Drying temperature	Chemical Test				
		Reducing Sugar	Ash Content	Moisture Content	Whiteness Degree	Yield
ppm	ºC			(%)		
	45	2,30^{d}	1,3^{a}	6,13^{a}	61,60^{i}	42,62^{c}
0	55	2,47^{d}	1,2^{a}	6,05^{a}	58,49^{j}	42,00^{c}
	65	2,14^{d}	1,4^{a}	5,94^{a}	56,77^{k}	41,93^{c}
	45	2,68^{c}	1,4^{a}	5,80^{b}	77,79^{f}	49,70^{b}
1000	55	2,78^{c}	1,4^{a}	5,78^{b}	74,43^{g}	46,70^{b}
	65	2,58^{c}	1,4^{a}	5,24^{b}	73,00^{h}	46,75^{b}
	45	4,33^{b}	1,4^{a}	4,80^{c}	83,31^{c}	52,40^{a}
2000	55	4,35^{b}	1,5^{a}	4,80^{c}	85,49^{b}	52,44^{a}
	65	4,32^{b}	1,4^{a}	4,53^{c}	76,66^{g}	50,17^{a}
	45	4,55^{a}	1,5^{a}	3,15^{d}	78,63^{de}	51,34^{a}
3000	55	4,67^{a}	1,4^{a}	3,16^{d}	79,66^{d}	50,33^{a}
	65	4,43^{ab}	1,5^{a}	3,05^{d}	78,64^{de}	51,70^{a}
	45	4,73^{a}	1,4^{a}	3,44^{d}	86,77^{a}	50,17^{ab}
4000	55	4,84^{a}	1,4^{a}	3,40^{d}	86,00^{ab}	50,02^{ab}
	65	4,52^{a}	1,5^{a}	3,55^{d}	85,45^{b}	51,70^{ab}

Note: Value with different notation in the same column has a significant differences at 5% (Tukey test)

Organoleptic Test of Tapai Flour Based Cookie Products

The results of organoleptic tapai flour cookies test is shown in Table 2. The sensory parameter include color, flavor, taste, and texture of tapai flour cookies.

a. Color

The panelists' level of preference for the cookies color attribute ranged from 2.68 to 3.92 or slightly disliked it to neutral. Based on the graph above, the highest value for the color parameter is in the A3 treatment (50% wheat flour: 50% Tapai flour), because the A3 treatment has a bright yellow color. The color of cookies is affected by the millard reaction. The millard reaction is a browning reaction due to the browning reaction between reducing sugars and amino acids that occurs during roasting, as well as the caramelization process that occurs due to the heating process (Winarno, 2004)..

b. Aroma

The panelists' level of preference for the aroma attribute of cookies ranged from 2.68 to 3.8 or disliked to neutral. The lower the use of tapai flour, the panelists' preference for the aroma of cookies will also be lower. This is because Tapai flour has a distinctive aroma. The panelists' highest level of preference for the aroma of cookies was in the A1 formulation (0% wheat flour: 100% Tapai flour) with a preference value of 3.8. The aroma of cookies is influenced by various mixtures of ingredients used in the manufacture of food products. Different types of flour will produce different aromas to cookies. Tapai flour has a sour and ethanol aroma (Susanto, et al., 2017).

c. Flavor

The level of panelists' acceptance of the taste parameters ranged from 3.12 to 3.88 or neutral. In treatment A1 (0% wheat flour: 100% Tapai flour) to A3 treatment (50% wheat flour: 50% Tapai flour) there was an increase in the preference value for the cookies flavor parameter. So the more tapai flour used, the lower the preference value. This is because tapai flour has a sweet taste. The sweet taste of tapai flour is obtained from the fermentation process in the tapai. In the fermentation process there is a process of reshuffling carbohydrates into glucose and fructose, as well as other compounds that will produce a sweet taste (Nirmalasari and Liana, 2018).

d. Texture

The panelists' preference for texture parameters ranged from 3.48 to 3.64 or neutral for all treatments. From the table above, it can be seen that the higher the flour used, the higher the preference value for the texture parameter. The texture of a product is closely related to the moisture content and protein content in a food ingredient. Wheat flour has a higher protein content than tapai flour. According to the Directorate of Nutrition, Ministry of Health RI (2018) wheat flour has a protein content of 8.90 g per 100 g of material, while tapai has a protein content of 0.5 g per 100 g of material. The high protein content will increase water absorption, so the resulting cookie texture will be more sturdy (Hariono et al, 2020).

Table 2. Organoleptic test results of tapai flour cookies

Tapai Flour	Cassava Flour	Sensory test			
%		Color	Flavor	Taste	Texture
100	0	3,08	3,8	2,78	3,64
75	25	3,72	3,6	3,48	3,64
50	50	3,92	3,36	3,88	3,68
25	75	2,76	3,32	3,2	3,64
0	100	2,68	2,68	3,12	3,4

Note:
1. Color: If the value is higher, the color is getting darker
2. Flavor: If the value is higher, the flavor of tapai is getting stronger
3. Taste: If the value is higher, the taste of the tapai is getting stronger
4. Texture: If the value is higher, the texture is getting thicker

CONCLUSION

The optimum conditions for production flour from cassava tapai by drying are obtained from Tapai soaked by natrium metabisulfite with concentration 2000 ppm and dried in the oven at 55ºC. The results of the analysis showed that the product of tapai flour has a reducing sugar content of 4.35%, ash content of 1.5%, moisture content of 4.8%, yield of 52.4% with a whiteness degree of 85.49. The preference level of cookies with a ratio of 50% : 50% cassava flour was preferred by the panelists with an average aroma value of 3.88 and a texture of 3.64.

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PHYSICAL CHARACTERISTICS OF KEPOK, TALAS, AND CAVENDISH BANANAS FLOUR

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ABSTRACT

Banana flour is one of the semi-finished products which processed aims to maintain shelf life, provide goods for diver food products, facilitate packaging and transportation. This research aimed to determine and compare the physical characteristics of flour from three banana species, i.e., *Kepok (Musa acuminata x balbisiana)*, *Talas (Musa acuminata* Colla var. Talas), and Cavendish (*Musa acuminata* Colla var. Cavendish). This research is a single factor experiment arranged in a completely randomized design with three (banana species) treatments and five replications. Data were analyzed by ANOVA except for wettability data, and gelatinization profile is processed using the Kruskal-Wallis test. The experimental parameters were swelling power, starch solubility, bulk density, water absorption capacity, oil absorption, and color. The results showed that swelling power and oil absorption of the banana flour from the three banana species are not significantly different ($p > 0.05$) but significantly different ($p < 0.05$) for solubility, bulk density, wettability, water absorption capacity, and color. Gelatinization temperature for *Kepok*, *Talas*, and Cavendish banana flour was 79.45°C, 81.45°C, and 78.20°C, respectively. In this research, we found that the physical properties of *Talas* banana flour are in between the physical properties of *Kepok* and Cavendish banana flour.

Keywords: banana flour, physical characteristics, *Kepok*, *Talas*, Cavendish

INTRODUCTION

Due to the high total solids content (40-70%), bananas can be processed into flour, providing broader utilization in the food industry (Vatanasuchart *et al.*, 2012). In addition, flour from immature bananas is rich in resistant starch (Virulchatapan and Luangsakul, 2020) and minerals (Vilela *et al.*, 2014), so that evaluated as a functional food. In some countries, banana flour is used as a primary food ingredient, such as mixtures for baby food, raw material for making bread, cakes, biscuits, noodles, and flakes (Fida *et al.*, 2020). However, the physical and chemical properties are very diverse due to the species/varieties (Gnagne *et al.*, 2017), the origin of the species (Vatanasuchart *et al.*, 2012), maturity level (Olawuni *et al.*, 2013), and processing method (Histifarina *et al.*, 2012; Singh *et al.*, 2017).

Indonesia has plenty of banana varieties (Poerba *et al.*, 2018), which may play an essential role in food diversification, functional food, and carbohydrate source to ensure food security. A high potential endemic banana from the region of South Kalimantan Province is *Talas* banana (*Musa acuminata* Colla, AAB) (Poerba *et al.*, 2016; Sunaryo *et al.*, 2019). Moreover, the banana also grows well in the region of East Kalimantan.

Based on morphological and agronomical characters, *Talas* banana is in between *Kepok* (*Musa acuminata x balbisiana*, ABB) and Cavendish (*Musa acuminata* Colla var. Cavendish, AA) banana, a plantain and dessert banana type, respectively (Poerba *et al.*, 2016; Sunaryo *et al.*, 2020). In addition, *Talas* banana has a unique taste as dessert banana, has a more extended maturity (20-24 days after the first harvest), and high production level (16-23 ton/ha) (Sunaryo *et al*., 2017).

Kepok banana shows a high level of consumption in the form of processed food, like banana fries, sweet banana soup, or even processed semi-finished goods like flour (Mathew and Negi, 2017; Fida *et al.*, 2020). On the other hand, Cavendish banana is usually consumed as fresh fruit (Poerba *et al.*, 2018). There are still limited reports about the utilization of *Talas* banana. This study explores the physical characteristics of *Talas* banana flour, while *Kepok* and Cavendish banana flour are used to compare.

MATERIALS AND METHODS

Materials

All banana types were provided at the green maturation level. Farmer at Batu Besaung Village, Samarinda Utara sub-district, provided the *Talas* banana. Cavendish and *Kepok* bananas were bought from Super Market at Samarinda Central Plaza and traditional market in Samarinda, respectively. The chemical reagents, i.e., HCl, Na_2CO_3, $C_6H_8O_7$, $CuSO_4$, KI, H_2SO_4, starch, $Na_2S_2O_3$, NaOH, and phenolphthalein provided by Riedel-Haen, Germany.

Banana flour processing

Bananas were selected from dirt and damage. The bananas were washed using running water, then treated by soaking in a salt solution for ± 20 minutes to facilitate the peeling process. The bananas were peeled and sliced into 0.5 mm slices, then soaked in $Na_2S_2O_5$ solution for ±20 minutes. The soaked banana slices were drained and then dried in an oven at 50°C for ±18 hours. The dried slices of banana were floured and screened by an 80-mesh sieve

Physical characteristics analysis

Bulk density

The bulk density of banana flour was determined by the method suggested by Singh *et al.* (2017) with a bit of modification. Ten grams of flour were poured into a 100 mL volumetric cylinder. The bottom of the cylinder was tapped several times to obtain a constant volume. The bulk density was presented as the weight of flour (g) divided by its volume (cm^3).

Wettability

Wettability (wetting time) is defined as flour's time from when the flour is added to the water until all the flour is wetted thoroughly. The wettability was determined by the method suggested by Olawuni *et al.* (2013). Banana flour of 0.4 g was put into 40 mL of distilled water in a measuring cup (inner dia 4 cm x height 11 cm). The dispersion was carried out at room temperature without stirring, and the wetting time was recorded using a stopwatch.

Swelling power and water solubility

Swelling power is the flour's ability to expand (mL) after heating at a specific temperature and time. The swelling power was determined according to Onyango *et al.* (2013) with some modifications. First, a sample of 0.1 grams of the dry base in a scaled centrifuge tube was added with 10 mL of distilled water. The sample was vortexed until the mixture was homogeneous, then heated in a water bath at 60°C by stirring occasionally. After 30 min the sample was cooled in ice water for 1 minute then let at room temperature for 5 minutes. Finally, the sample was centrifuged at 3500 rpm for 15 minutes. The swelling power was calculated as the weight of starch gel divided by the weight of dry starch.

Water solubility index was obtained by pouring the resulting supernatant from the above assay of swelling power into a cup to decant and dry to constant weight at 110°C. The water solubility index was presented as the percent of dried weight of decanted supernatant based on the weight of the sample.

Water absorption capacity

Water absorption capacity was determined using the method suggested by Singh *et al.* (2017). First, one gram of banana flour was poured into 10 mL distilled water in a centrifuge tube. Then the mixer was vortexed for 30 seconds until the mixture was homogeneous. The sample was then allowed to stand at room temperature for 30 minutes and centrifuged at 3500 rpm for 30 minutes. Next, the supernatant was decanted, then the water absorption capacity was expressed as a weight percentage of water absorbed by 1 g of flour.

Oil absorption capacity

Oil absorption capacity was measured using the method suggested by Singh *et al.* (2017) with a minor modification. One gram of banana flour was mixed into 10 mL of oil and stirred using a vortex mixer for 30 seconds. Next, the mixture was put in a 10 mL conical centrifuge tube and placed in a 30°C water bath for 30 minutes. The mixture was vortexed again and then centrifuged at 3000 rpm for 20 minutes, and the free oil was decanted. The oil absorption capacity was expressed as the percentage of oil absorbed by the banana flour.

Gelatinization profile

Gelatinization profile was obtained from the sample having one cycle of heating and cooling information on initial, final, setback, breakdown, and peak viscosity. The gelatinization profile of the bananas flour was determined using the Rapid Visco Analyzer Instrument TecMaster Newport Scientific Pty Ltd., Warriewood-Australia. Sample (3.3 g on 14 g moisture per 100 g of flour) was suspended in 25 mL of distilled water. The suspension was heated to a temperature of 50°C and maintained for 1 minute. The rotational speed of the paddle started at 960 rpm and slowed down to 160 rpm in 20 min, then kept the speed during the rest of the assay. The heat was further increased until it reached a temperature of 95°C with a heating speed of 6°C per minute and maintained at this temperature for 5 minutes. After that, it was cooled to 50°C with a cooling speed of 6°C per minute, then maintained at that temperature for 5 minutes.

Color measurement

The color was determined by a portable colorimeter (chroma meter CR-400, Konica Minolta, Germany).

Data Analysis

Data were analyzed by ANOVA continued by Tukey for the normally distributed data and Kruskal-Wallis test continued by Dunn's test for the not normally distributed data.

RESULTS AND DISCUSSION

Some of the physical properties of flour from the three bananas are significantly different ($p < 0.05$), i.e., bulk density, wettability, water solubility, and water absorption capacity. However, other physical property parameters, i.e., oil absorption capacity, swelling power, gelatinization temperature, and color, as well as the chemical properties (water content and total sugar), are not significantly different ($p > 0.05$) (Table 1.).

The bulk density and water solubility index of *Kepok* and *Talas* banana are insignificantly different, but both are significantly different from Cavendish banana. On the other hand, the water absorption capacity of *Talas* and Cavendish bananas is insignificantly different, but both are significantly different from *Kepok* bananas. Similar phenomena were recorded for some physical properties, which show an insignificant difference ($p > 0.05$).

Table 1. Physical properties of flour from three banana types

Properties component	*Kepok*	*Talas*	Cavendish
Bulk density (g/mL)	0.67 ± 0.04[a]	0.63 ± 0.03[a]	0.45 ± 0.02[b]
Wettability (seconds)	3.38 ± 0.10[a]	2.37 ± 0.93[b]	0.37 ± 0.15[c]
Swelling power (g/g)	5.30 ± 1.62	4.84 ± 0.62	4.52 ± 1.15
Water solubility (% db)	11.11 ± 0.00[b]	11.11 ± 0.00[b]	33.33 ± 11.11[a]
Water absorption capacity (g/g)	7.56 ± 0.18[b]	7.49 ± 0.07[a]	7.43 ± 0.12[a]
Oil absorption capacity (%)	56.00 ± 11.40	50.00 ± 7.07	62.00 ± 13.03
Gelatinization temperature (°C)	79.45 ± 0.58	81.45 ± 0.39	78.20 ± 1.76
Color*			
L	84.70 ± 0.31	79.37 ± 1.62	64.54 ± 0.01
a	4.78 ± 0.69	5.00 ± 1.15	5.72 ± 0.00
b	6.92 ± 1.54	10.68 ± 4.04	10.01 ± 0.84

Note: Data (mean ± SD) were calculated from five replications, except the gelatinization profile and color using only two replications. Data were analyzed by ANOVA continued by Tukey test, except wettability, gelatinization temperature, and color, which used Kruskal-Wallis test continued by Dunn's test. Data within the same row followed by different letters show a significant difference ($p < 0.05$).

The value of the physical properties of *Talas* banana is in between of *Kepok* and Cavendish banana, except gelatinization temperature and color value of" b," which are higher than *Kepok* and Cavendish banana. On the other hand, the oil absorption capacity of *Talas* banana is lower than *Kepok* and Cavendish. The gelatinization profile of the three bananas flour is presented in Figure 1. and their performance is shown in Figure 2.

Talas banana flour has a bulk density of 0.63, which is between the bulk density of *Kepok* and Cavendish banana, i.e., 0.67 and 0.45, respectively. This experiment shows that other physical properties of the *Talas* banana flour are in between the *Kepok* and Cavendish, like wettability, swelling power, water solubility, and water absorption capacity. This phenomenon may regard to the phenotypic-related between the three banana types. Sunaryo *et al.* (2017) reported that *Talas* banana is in between Kepok and Cavendish based on morphological and agronomical characters. *Talas* banana belongs to the genome group of AAB (Sunaryo *et al.*, 2019), while *Kepok* and Cavendish banana belongs to ABB (Poerba *et al.*, 2018) and AAA (Pereira and Maraschin, 2015), respectively. In addition (Sunaryo *et al.*, 2020) reported that *Talas* and *Kepok* banana has a SimQual coefficient of 0.68.

However, the relationship between physical properties and phenotypic characteristics may need further study using a homogenous research methodology like flour preparation and physical properties assay. Singham *et al.* (2014) reported a different result with this experiment that flour from green matured Cavendish banana has bulk density over the bulk density resulting from this research (0.45), i.e., 0.67, which derived from the 60-mesh sieved flour. The banana flour produced in this research used 80-mesh sieve. The difference in flour characteristics may result in different measurements results in physical properties.

Rohmah (2012) reported a higher bulk density (0.77) of *Kapas* banana flour screened by 120-mesh sieve. *Kapas* banana belongs to the same AAA group genome as Cavendish banana (Poerba *et al.*, 2018). Table 2. resume the physical properties of banana flour, including banana starch and resistant starch from previous studies.

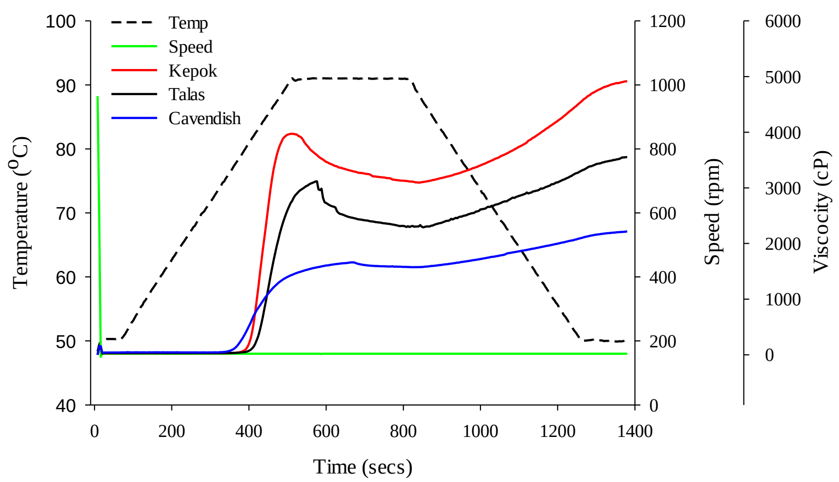
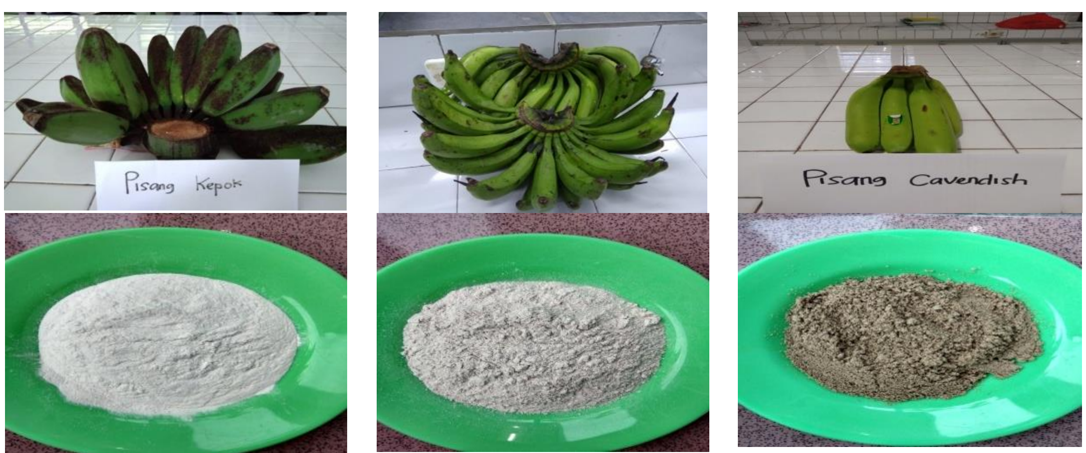


Figure 1. Gelatinization profile of *Kepok*, *Talas* and Cavendish bananas flour



(a) (b) (c)

Figure 2. Banana hand and the banana flour from (a) *Kepok*, (b) *Talas*, and (c) Cavendish banana.

Beside the physical characteristics of the Talas banana flour, preliminary research for the chemical characteristics was conducted. The water content and total sugar of the *Talas* banana were not significantly different (p > 0.05). However, the water content of flour from *Talas* banana is in between *Kepok* and Cavendish. On the other hand, *Talas* banana flour has the lowest total sugar.

The water content of the *Kepok*, *Talas*, and Cavendish bananas are 8.50, 8.98, and 9.57%, respectively. In addition, the total sugar is 21.66, 21.62, and 21.74%, respectively.

Table 2. Physical characteristics of plantain and dessert bananas flour

Banana types, Country (group genome)	BD (g/mL)	WT (secs)	SP (g/g)	WS (%)	WAC (g/g)	OAC (g/g)	PT (°C)	Refe-rences
Plantain								
Mysore, Brazil (AAB)*			3.1[a]	1.1[a]	1.19	1.18	79.1	1
Kepok, Indonesia-Central Java (AAB)			6.84	23.51	2.11		63.77	2
Awak, China-Guangdong (ABB)**			98.04[d]	3.56[d]	1.274[d]			3
Green Horn, Nigeria	0.71[c]	1.81[c]	1.66[c]		1.70[c]	2.84[c]	64.33[c]	4
Bluggoe, China-Guangdong (ABB)**			93.55[d]	1.19[d]	1.205[d]			3
Orishele, Côte d'Ivoire					0.874			5
Corne 1, Côte d'Ivoire					0.683			5
French 2, Côte d'Ivoire					0.851			5
Dessert								
Kluai Hom Thonh, Thailand (AAA)			3.5	7.59			81.72	6
Cavendish, Equador (AAA)					3.39	1.61	83	7
Cavendish, China-Guangdong (AAA)**	1.131[d]		87.76	1.69[d]				3
Cavendish, India-Allahabad (AAA)	0.67		3.57	0.99	5.7			8
Kapas, Indonesia-East Kalimantan (AAA)	0.77	26.58			8.97	7.37		9
Mas, China-Guangdong (AA)**			90.44[d]	8.68[d]	1.418[d]			3

Note: BD = bulk density, WT = wettability, SP = swelling power, WS = water solubility, WAC = water absorption capacity, OAC = oil absorption capacity, GT = gelatinization temperature. *) banana starch; **) resistant starch; a) assayed at pH 7; b) assayed at 60°C; c) sun-dried flour from the banana with 9th week maturity time; d) assayed at 70°C. 1) (Fontes *et al.*, 2017); 2) (Buwono *et al.*, 2018); 3) (Wang *et al.*, 2017); 4) (Olawuni *et al.*, 2013); 5) (Gnagne *et al.*, 2017); 6) (Virulchatapan and Luangsakul, 2020); 7) (Campuzano *et al.*, 2018); 8) (Singham *et al.*, 2014); 9) (Rohmah, 2012).

The flour produced in this experiment fulfills type B of the National Indonesian Standard for banana flour (SNI 01-3841-1995), i.e., maximal 12% of water content. The type A standard should have a maximal 6% of water content (BSN, 1995). Campuzano *et al.* (2018) reported total sugar of Cavendish banana flour is 6.33, 12.93, and 51.89% at the ripening stage of 1, 2, and 3, respectively.

CONCLUSION

Flour from kepok, talas, and cavendish banana show significant differences for several parameters of physical properties, namely, solubility, bulk density, wettability, and color. Some of the physical properties parameters of *Talas* banana flour are between *Kepok* and Cavendish, such as swelling power, bulk density, wettability, and water absorption capacity. But *Talas* banana flour has a higher gelatinization temperature than the two. Meanwhile, talas banana flour shows the lowest oil absorption. Therefore, the talas banana can be used as raw material for infant porridge and bread flour.

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THE REVIEW OF SNACK BAR FROM CHIA - MOCAF AS AN ANTIDIABETIC FOOD

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ABSTRACT

Due to the high activity, plus the problem of communicable and non-communicable diseases such as diabetes, there is an increasing public awareness of the need for food that is practical and has an effect on improving body health. the Snack bar is convenient food that has complete nutritional content. Some food ingredients that can be used as raw material for making anti-diabetic snack bars are chia seeds (*Salvia hispanica* L) and cassava (*Manihot esculenta*). Based on existing research, chia seed and modified cassava flour (MOCAF) have a hypoglycemic function which is closely related to reducing blood sugar levels so that it can reduce the risk of diabetes. Chia seeds are well known for their high oil content, are rich in polyunsaturated fatty acids, especially omega- 3 and omega-6 fatty acids, and are high in protein and fiber which increase their potential as a functional food product. The content mocaf flour in 100 grams are protein 1.2%, fat 0.4%, and 3.4% fiber. Chia seed flour has been shown to increase AMPK expression, while mocaf can increase insulin sensitivity in type 2 diabetes mellitus.

Keywords: Antidiabetic, Chia Seeds, Mocaf, Snack Bar

INTRODUCTION

In this current era, many people are becoming aware of their health so that eating patterns are not only full and delicious but can also affect the optimal level of health and fitness. The high level of community activity causes frequent consumption of fast food so that practical healthy food is needed that does not need to be cooked first, ready to eat, can be taken anywhere, and can be eaten at any time but can improve health. One of the food that contains practically complete nutrients is a snack bar.

A snack bar is a product that distant light that has a shaped rod (bar) and a mixture of different materials such as cereals, fruits, nuts are fastened to one another with the aid of a binding agent (binder). In Indonesia, the consumption of snack bars is still very rare and some people do not even know about these foods. Only 34.5% of Indonesians know about this bar (Septiani *et al.*, 2015).

Currently, there is a functional food trend due to people's concern for healthy food which is also triggered by the dual problems experienced by the Indonesian people, which are not only infectious disease problems but also non-communicable disease problems such as those caused by metabolic syndrome.

Metabolic syndrome is a symptom characterized by metabolic process disorders that lead to non-communicable diseases such as hyperlipidemia and diabetes mellitus. People with diabetes mellitus cannot control blood sugar levels within normal limits, causing hyperglycemia in the long term (Kilpatrick *et al.*, 2007; Arumsari *et al.*, 2020).

To control blood sugar can be done by eating foods that have a low glycemic index and long starch digestibility. The glycemic index value with an increase in blood sugar is closely related. If the food on the glycemic index is high, the increase in blood sugar levels will be faster, conversely, if the food on the glycemic index is low, the blood sugar will increase slowly. The condition when the glycemic index is low is called hypoglycemic. Generally, fiber-rich foods have a low glycemic index, although not always.

Healthy snacks are not only rich in energy, but should also contain dietary fiber, protein, antioxidants, vitamins, and minerals that are important for health (Christian, 2011).

Chia seeds or chia seeds (*Salvia hispanica L.*) are one of the natural ingredients with health potential, which can be used as an alternative to developing functional food products. This plant comes from Central America, especially Mexico and Guatemala. Chia seeds and their derivative products are promising sources to be developed, for example as a ready-to-eat product, or an alternative in the development of functional foods (Safari, *et al.*, 2016). It is known that chia seeds have a hypoglycemic function which is closely related to reducing blood sugar levels so that they can reduce the risk of diabetes.

Apart from chia seeds, another product that has potential as an antidiabetic is mocaf. Mocaf is cassava flour made using the principle of fermentation of cassava cell modification. Mocaf flour is usually used as a substitute for wheat flour which produces enzymes that can destroy cassava cell walls and liberate starch granules. Mocaf has characteristics like wheat flour but has a coarser texture than wheat flour, so it can be used as a substitute for flour or a flour mixture of 30% -100% and can reduce the cost of flour consumption by 20% -30% (Philia, *et al.*, 2020; Manullang *et al.*, 2018; Subagyo, 2006).

Chia Seed (*Salvia hispanica* L)

Chia seeds are generally oval, have a smooth and shiny surface, and come in various colors, namely dark brown, gray, white, and black. These chia seeds are small and flat with a length of about 2 - 2.5 mm, a width of 1.2 - 1.5 mm, and a thickness of 0.8 - 1 mm (Safari *et al.*, 2016).

Chia seeds contain protein (15-25 %), fat (30-33 %), carbohydrates (26-41 %), fiber (18-30 %), and minerals (4-5 %). Chia seeds also contain omega 3 fatty acids (linolenic acid) by 17.83 percent (Ixtaina *et al.*, 2008).

Making chia seed flour is done by preparing 250 grams of chia seeds which are roasted for 6 minutes while stirring. The results of the toasted chia seeds are then blended until smooth and sieved with a 60 mesh flour sieve (Arumsari *et al.*, 2020).

Cassava (*Manihot esculenta*)

Modified Cassava Flour (MOCAF) is a renewal product from cassava or cassava flour (*Manihot esculenta*) with the principle of modifying cassava cells by fermentation with the help of lactic acid bacteria (LAB). Mocaf flour is often and widely used in various food products (Putri *et al.*, 2018).

Mocaf has advantages over ordinary cassava flour, namely whiter color, higher viscosity, better rehydration power, and a covered cassava flavor. 100 grams of mocaf flour contains 1.2% protein, 0.4% fat, and 3.4% fiber (Asriasih *et al.*, 2020).

Mocaf does not contain gluten and has the potential to be processed to produce resistant starch 3 (rs3) which is needed by diabetics so that it can be used as food processing for diabetics (Philia *et al.*, 2020).

Making mocaf begins by selecting cassava that is 10 months old, then peel the cassava and wash it clean using water. After that, cut it into thin strips using a slicer until it becomes chips. The cassava chips are then subjected to a fermentation process with the addition of a starter and 1: 1000 water. There are two different grinding methods. In the method of dry milling, cassava chips fermented dried by the sun (sun drying) to produce chips Mocaf, then ground using a blender for one minute and finally sieved with a 100 mesh sieve. In the wet milling method, the fermented cassava chips are ground by adding 6: 1 water using a wet blender for one minute until they become pureed. The slurry is then dried in the sun then milled again using a dry blender for one minute and finally sieved with a 100 mesh sieve (Putri *et al.*, 2018).

SNACK BAR PRODUCTION

The making of this snack bar begins by preparing all the ingredients and weighing them according to the snack bar making formulation, then mocaf flour and chia seed flour are mixed with other ingredients (sugar, salt, margarine, eggs, and pineapple jam), then mixed for 20 minutes. After everything is well blended, put the dough into a sized baking sheet 26.5x10x3.5 cm. After the printing process, then bake the snack bar dough at 120 ^{o}C for 40 minutes, then bake it again at 140 ^{o}C for 5 minutes. The cooked snack bar is left to stand for 30 minutes at room temperature (Septiani, *et al.*, 2015).

The more concentration of mocaf flour is used, the resulting color will be slightly lighter. The color produced on the snack bar with 75% mocaf flour formulation is slightly lighter than the non- mocaf flour at all which produces a brownish snack bar. The resulting texture is not too hard, the resulting protein content of 5.6% is low because it is caused by roasting using high temperatures. The higher the temperature and the longer the processing time, the higher the protein damage that occurs in these foodstuffs. However, this snack bar has a low water content so that it can be stored for a long time (Septiani *et al.*, 2015; Sundari et al, 2015).

Based on research by Singh *et al.* (2020), snacks made with the addition of chia flour show a high fiber content in the product. Because 100 g of chia seeds contain up to 50 g of dietary fiber which provides good water holding capacity and high emulsifying activity. So that the more the concentration of chia seeds, the moisture content in the snack bar will decrease causing an increase in product shelf life. The amount of protein concentration increases gradually as the concentration of chia seeds increases because the high amount of protein in chia seeds increases the mineral content. The trend of increasing this mineral is because chia seeds have a high mineral content, especially Mg, Ca, Fe, Zn, Mg, Co, and Se. Organoleptic test results showed a high value of the public interest in snack bars with a mixture of 10% chia seed flour.

MECHANISM AS AN ANTIDIABETIC

Diabetes mellitus type 2 is a complex disease related to lifestyle and diet. Many studies have shown the addition of type 3 resistance starch in the daily diet may play a role in the route of treatment of diabetes associated with or without gut microbes. Mocaf contains high amylose so that it can increase resistance starch (Firdaus, *et al.*, 2018). Resistant starch is a starch fraction that is resistant to hydrolysis of digestive enzymes because it has a compact molecular structure and starch granules which can prevent damage to the starch structure by digestive enzymes, causing a slow increase in glucose in the blood (Herawati, 2010).

Amylose affects the response of increasing resistance starch through the retrogradation process. Besides, in foods containing high amylose, it can decrease the glycemic response. The research of Firdaus, *et al.* (2018), showed that administration of Mocaf and Mocaf type 3 resistant starch can increase insulin sensitivity in people with type 2 diabetes mellitus. Resistance starch granules from a special adhesion pattern in the upper intestine so that probiotic bacteria such as Lactobacillus sp. Resistance starch is then fermented to produce short-chain fatty acids (SCFA). SCFA plays a role in increasing the production and secretion of endogenous GLP-1 and Peptide YY (PYY) in the intestinal wall. Increased GLP-1 will induce pancreatic beta-cell proliferation, increase insulin secretion, and control glucagon while increasing PYY will decrease appetite.

On chia seeds, Marineli, *et al.* (2015), found that chia oil and chia flour can improve glucose and insulin tolerance in mice fed the HFHF diet. According to Enes, *et al.* (2020), Chia flour can increase AMPK expression, which increases glucose uptake and oxidation, as well as enzyme glycolysis that results in improved glucose tolerance. AMPK, which is considered a sensor for energy deficiency, is lowered during bouts of obesity and metabolic syndrome, and in conditions of an imbalanced diet, as HFHF and disturbs energy balance. To activate this compound, you need to do exercise, restrict calories, and eat foods that contain antidiabetic compounds such as chia seeds. The results of this study indicated that the expression of the liver AMPK gene increased after consuming chia flour as much as 3.8 times that of HFHF. AMPK activation can reduce blood glucose levels by phosphorylation of AS160 protein. This protein plays a role in overcoming glucose transporters, increasing glucose uptake in non-insulin-dependent pathways. Therefore, chia flour appears to modulate AMPK expression as an insulin-independent mechanism for enhancing glucose metabolism. Besides, chia flour was effective in increasing levels of AKT and PFK mRNA (Enes *et. al.*, 2020).

OTHER ANTIDIABATIC SNACK BARS FLOUR

The existence of snacks for people with diabetes mellitus needs further attention. What needs to be considered in the diet for diabetics is the low fiber content and glycemic index. This is because eating foods high in fiber and low on the glycemic index can improve insulin sensitivity, reduce glucose absorption rates, and are useful in controlling blood glucose so that it can reduce the risk of complications in people with diabetes mellitus. Generally, food materials that have a low glycemic index and high fiber are in the cereals, seeds, nuts, tubers, and products like flour (Marlina *et al.*, 2019).

In a snack bar made with sorghum flour as a base, it contains high amylose and resistant starch so that the anti-diabetic mechanism in the body is the same as that of the consumption of Mocaf flour. However, after becoming a food bar, the resistant starch content in sorghum flour decreased. Sorghum flour can also reduce systolic blood pressure ≥ by 20 mmHg so that it can be called an antihypertensive. Hypertension is a result of the pathological process of diabetes that occurs simultaneously with diabetes (Fathurrizqiah and Panunggal, 2015; Arifani, *et al.*, 2019).

Also, the nutrimat bar of soybean and red bean flour from the research results of Wiranata, *et al.* (2017), the best formulation of soybean flour 25%: 75% red bean flour has a delicious taste, savory aroma, brown color, and soft texture, and contains nutrients in the form of energy 232.18 kcal, protein 12.75 g, fat 4, 71 g, carbohydrates 35.36 g and antioxidants 84.69 mg /L GAEAC. The resulting brown color is the result of the presence of high proanthocyanidins (condensed tannins). These compounds are the best source of antioxidants. The anti-diabetic mechanism of processed food is different from chia flour and Mocaf flour. The presence of these secondary antioxidants can help fight free radicals that cause oxidative stress. In patients with type 2 diabetes mellitus, oxidative stress can cause a decrease in the function of primary antioxidants in the body so that secondary antioxidants are needed to help the primary antioxidant function. Secondary antioxidants work by breaking the lipid peroxide oxidation chain and also act as an antidiabetic by protecting pancreatic beta cells from oxidative stress due to increased glucose. Another food ingredient that also has secondary antioxidants is sweet potato flour (Wiranata, *et al.*, 2017; Muslimin, *et al.*, 2018).

CONCLUSION

Chia seed flour (*Salvia hispanica L.*) and mocaf flour have been shown to reduce the risk of diabetes mellitus from literature review of research. To be able to consume and enjoy it easily, the chia seed flour and mocaf flour are processed in a snack bar. A snack bar is a block-shaped snack that is processed by mixing chia seed flour and mocaf flour which is then molded and baked. Even though they have the same function, these two flours have different antidiabetic mechanisms. Chia seed flour can increase AMPK expression so that oxidation and glucose uptake in the body increase. Whereas in mocaf flour, resistance starch helps increase insulin sensitivity in people with diabetes mellitus.

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THE POTENTIAL OF POLLARD AND RICE BRAN WITH FRACTIONATION PROCESS AS RAW MATERIALS FOR HIGH FIBER PROCESSED FOOD

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ABSTRACT

Rice bran and pollard are by-products of the rice and wheat milling process. These two ingredients are generally not used as the main raw material for food products and are diverted as feed ingredients due to their low nutritional content. The nutrient content that is still present in pollard and rice bran, especially fiber and anti-nutrients, is very useful for people with diabetes and obesity. The aim of this study was to analyze the effect of fractionation on nutrient content and to separate the components of pollard and rice bran using a gravity and molecular weight approach. The experimental design used was CRD (Completely Random Design) Factorial 2 × 3 × 3 for physical test data. Factor A is the material, namely pollard and rice bran, factor B is the position of the fraction, namely top, middle and bottom. Data analysis was performed by analysis of variance (ANOVA) and the significant one will be further analyzed using Duncan's test. The chemical property values were analyzed descriptively. The results showed that the value of bulk density (g l^{-1}), compacted bulk density (g l^{-1}), specific gravity (kg l^{-1}), angle of purpose (^{o}) of pollard and rice bran were significantly different ($P<0.05$) on all three fractions. The highest physical parameters for pollard were at the bottom fraction with the value 386.47 g g l^{-1}, 537.28 g l^{-1}, 1.42 kg l^{-1}, ST 46.98^o. The highest physical parameters for rice bran were at the upper fraction with the value of 394.09 g l^{-1}, 526.33 g l^{-1}, 1.50 kg l^{-1}, 46.01^o. Crude fiber content (%) of pollard and rice bran were the upper fractions 6.77 and 21.69, middle fractions 8.19 and 34.70, lower fractions 5.52 and 32.76. Fractionation technology can separate food ingredients based on chemical components, especially crude fiber. The physical properties of pollard and rice bran after fractionation generally improved in quality. The fraction that has the best physical and chemical quality is the lower fraction for pollard and the upper fraction for rice bran. The middle fraction has the highest crude fiber content, so it has the potential to be a raw material for making high fiber processed food.

Keywords: Processed food, fractionation, molecular weight, pollard, rice bran

INTRODUCTION

Indonesia's rice production in 2017 has reached 81.38 million tons of dry milled grain with a harvested area of 15.79 million hectares (BPS 2018). The milling process produces by-products in the form of broken rice, husks and bran. The use of rice bran as raw material for food products is very rare because of the high fiber content and anti-nutrient components. The protein content of milled rice bran is 11.01% and carbohydrates 53.29% (Hadipernata *et al*, 2012).

Another agricultural by-product that is rarely used as the main raw material for food products is an energy source in the form of a pollard. Crude protein in pollard 17.98%

(Nadhifah *et al*. 2012), crude fiber 8.81% (Arditya 2010) and carbohydrate levels rice is generally 78% (Hernawan & Meylani, 2016). The characteristics of pollard are almost the same as rice bran. The quality of rice bran depends on the proportion of its constituent components, namely pure bran, husks and rice grains. Sukria and Krisnan (2009) added that the factors that can affect differences in the chemical composition of rice bran are agronomic factors (fertilization, soil), rice varieties and the milling process. A better milling process will produce pure rice bran with a higher protein content because protein is more important in the aleurone portion which will be wasted along with rice bran during milling, especially in the grinding process erodes the bran layer (Patiwiri 2006). One of the efforts that can be made to increase the percentage of pollard and rice bran use as raw materials for food products is the application of fractionation processing technology. Fractionation aims to identify and separate components in materials that have different nutritional content and molecular weights. Rice bran and pollard that have gone through the fractionation process may be used as raw materials for high-fiber processed food. All this time, bran only used as animal feed because there are not many people who know the benefits of both for health i.e. biscuit, food bar (Made and Andi 2010). Biscuits are snacks that are consumed as a hunger delay and are easy to obtain and are a type of snack that has a long shelf life (Caleja *et al*. 2017; Klunklin and Savage 2018). Biscuits are made from flour, butter and sugar, making this food less fiber and protein (Park *et al*. 2015). The development of people's lifestyles who are starting to realize a healthy lifestyle has resulted in an increasing demand for highly nutritious foods. These conditions create opportunities to make biscuit products rich in protein so that they can become functional foods. Functional food is a food ingredient that has a healthful effect and reduces the incidence of disease in the body (Siró *et al*. 2008; Lordan *et al*. 2011).

Problems in using bran in food products is its low stability, due to hydrolytic rancidity and oxidative rancidity. This study aims to analyze the effect of fractionation with a molecular weight approach on the physical (bulk density, compacted bulk density, specific gravity, angle of purposes) and chemical (moisture content, crude protein, crude fiber) properties of pollard and rice bran which have potential as raw materials high fiber processed food.

MATERIALS AND METHODS

The materials used in this study were pollard and rice bran obtained from a poultry shop in the Parung area, Bogor, and chemicals required for proximate analysis.

Pollard and rice bran were sieved using a 20 mesh sieve to uniform particle size and separated between the materials that passed the sieve and those that did not. Proximate analysis for chemical component in the form of water content, crude protein and crude fiber using the AOAC 2005 method.

Particle size

The particle size of pollard and rice bran can be determined with the help of a vibrator ball mill consisting of several sieves. The filters are arranged vertically from the coarsest to the finest (4, 8, 16, 30, 50, 100, and 200 mess). Each sample weighed as much as 250 grams and poured on the top filter, then the ball mill vibrator was vibrated for 10 minutes. The weight of each material that did not pass in each shaker was recorded to calculate the average diameter of the material (ASAE 1983). Modulus of Fineness (MF) or the level of fineness is a measurement of the coarseness or fineness of certain aggregates calculated using the formula:

$$MF = \frac{\sum(\%\ material\ left\ on\ each\ mesh\ \times Agreement\ Number)}{100}$$

Furthermore, the materials were categorized based on the MF value with the provisions of 4.1 x 7.0 coarse category, 2.9 x < 4.1 medium category, < 2.9 category. The average particle size (D) was calculated using the formula (Henderson and Perry 1976):

$$D = 0.0041 \times 2^{MF} \times 2.54 \text{ cm} \times 10 \text{ mm}$$

Pollard and Rice Bran Fractionation

The glass column is in the form of a beam with a length of 15 cm, a width of 15 cm and a height of 150 cm with a faucet to drain 20 cm of water from the bottom of the column. The glass column is filled with 25 liters of water and then inserted a 60 mesh sieve in the form of a beam with a length of 13.5 cm, a width of 13.5 cm and a height of 25 cm to a depth of 130 cm. Pollard and 1.25 kg of rice bran were put together in a glass column and stirred so that the material did not agglomerate. The material is allowed to settle for 3 hours in a sieve. After 3 hours, the material that floats on the surface of the water is taken and separated. The water in the column is removed, the filter is removed and drained for 45 minutes. The filter containing the drained sediment is opened on a predetermined side slowly in a vertical position. The height of the precipitate formed was measured using a ruler. The fraction whose height has been measured is then divided into 3 parts, namely the top 1/3, middle 1/3 and bottom 1/3. The three fractions were separated and placed in separate containers. The material that has been separated based on the fraction is put in an oven at 60°C for 48 hours.

Specific Gravity (SG)

Specific gravity is the ratio of the weight of a material to its volume. Specific gravity is measured using the principle of Archimedes' Law. Calculation of specific gravity is carried out using units modified from g ml^{-1} to kg l^{-1} (Syamsu *et al.* 2015)

$$SG\ (kg\ L^{-1}) = \frac{\text{Weight of Feed Ingredients (kg)}}{\text{Aquades Volume Change (l)}}$$

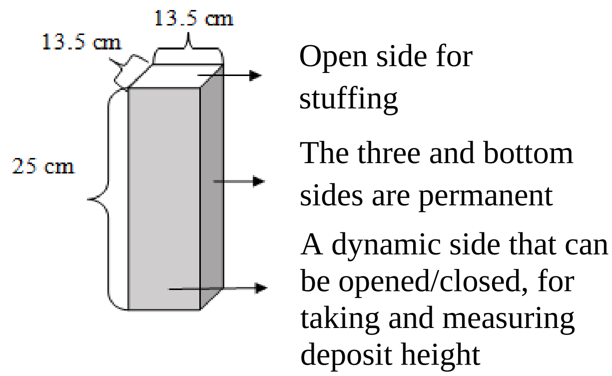

Figure 1. A sieve with a mesh size of 60 as a place for the material to settle

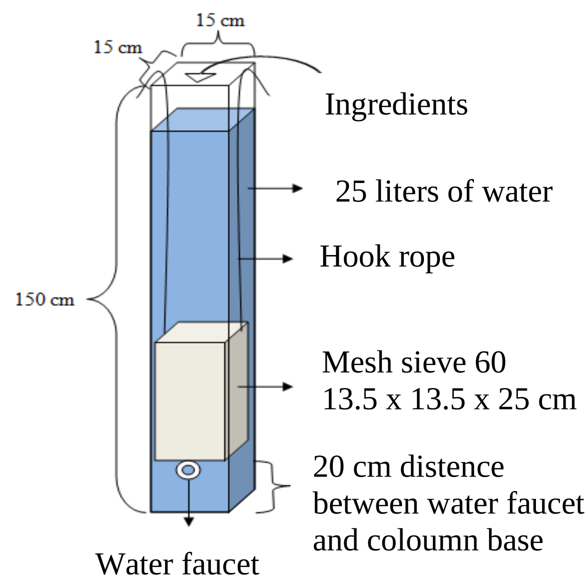

Figure 2. Glass column and fractination equipment.

Bulk Density (BD)

Bulk density is the ratio between the weight of the material and the volume of space it occupies. The value of bulk density is inversely proportional to the water content and foreign particles in the material (Fasina and Sokhansanj 1993). Samples weighing 60 grams were poured into a 250 ml measuring cup with the help of a plastic funnel. Then measure the height of the sample in the measuring cup by looking at the volume of the measuring cup (Syamsu *et al*. 2015). The bulk density is calculated by the formula:

$$\text{BD (g L}^{-1}\text{)} = \frac{\text{Weight of material (g)}}{\text{Volume of space of material (L)}}$$

Compacted Bulk Density (CBD)

The compacted bulk density is the ratio of the weight of the material to the volume of space it occupies after the compaction process is carried out. The value of compacted bulk density is influenced by the particle size and moisture content of the material. The compacted bulk density was measured by the same method as the bulk density, but the volume of the sample was measured after the compaction process by shaking the measuring cup until the volume was constant. The compacted bulk density is calculated by the formula (Syamsu *et al.* 2015)

$$\text{CBD (g L}^{-1}\text{)} = \frac{\text{Weight of material (g)}}{\text{Volume of material space after compaction (L)}}$$

Angle of Purpose (AP)

The angle of purpose is the angle formed between the plane and the slope of the pile of material when poured from a certain height onto a flat plane. The angle of purpose indicates the material flow rate. The angle of purpose was measured by dropping the sample from a certain height using a funnel until the sample fell on a flat surface with a white manila cardboard. The diameter of the sample was measured by the flat part formed (Syamsu *et al*. 2015). The value of the angle of purpose is measured by the height (t) of the pile and the diameter of the base (d), then calculated by the formula:

$$\text{AP (tg } \alpha\text{)} = \frac{2t}{d}$$

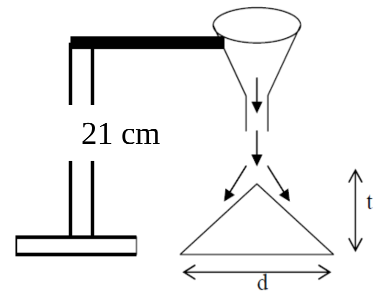

Figure 3. Angle of purpose measurement Method

Experimental Design and Data Analysis

The experimental design used was CRD (Completely Random Design) Factorial 2 × 3 × 3 for physical test data. Factor A being pollard and rice bran and factor B being the position of the fraction (1/3 top, 1/3 middle, 1/3 bottom) and 3 replications.

The physical properties data obtained were analyzed using variance (ANOVA), if there was a significant difference, the data would be further tested with Duncan's test. Chemical test data in the form of moisture content, crude protein and crude fiber obtained were analyzed descriptively.

RESULTS AND DISCUSSION

Physical Properties of Pollard and Rice Bran

Evaluation of physical properties is one method of testing the quality of raw materials which is very important in formulating formulas, determining the quality and efficiency of the production process including processing, storing, and packaging food products in an industry. A physical evaluation is generally carried out in the first stage because this method is simple and applicable or does not require complicated chemicals and equipment. Some important physical properties, namely specific gravity, bulk density, compacted bulk density and angle of purpose. The data in Table 1 and Table 2 show that different materials will have different physical and chemical properties. Raw materials cannot be compared with one another due to different chemical or nutrient components and physical characteristics.

Table 1. Physical properties of pollard

Pollard	BD (g L^{-1})	CBD (g L^{-1})	SG (kg L^{-1})	AP (^{o})
Before Fractionation	320.86 ± 1.06	433.51 ± 2.42	1.29	42.32 ± 0.13
After Fractionation				
Upper Fraction	350.67 ± 3.05b	520.01 ± 2.62b	1.28 ± 0.02b	44.35 ± 0.95b
Middle Fraction	338.39 ± 4.78c	493.83 ± 9.87c	1.12 ± 0.02c	41.81 ± 0.76c
Lower Fraction	386.47 ± 1.71a	537.28 ± 4.39a	1.42 ± 0.04a	46.98 ± 0.54a

Different letters in the same column indicate significant differences (P<0.05), BD: bulk density; CBD: compacted bulk density; SG: specific gravity; AP: angle of purpose.

Table 2. Physical properties of rice bran

Dedak padi	BD (g L^{-1})	CBD (g L^{-1})	SG (kg L^{-1})	AP (^{o})
Before Fractionation	352.95 ± 0.70	509.34 ± 0.71	1.29	40.53 ± 0.08
After Fractionation				
Upper Fraction	394.09 ± 4.75a	526.33 ± 1.60a	1.50 ± 0.00a	46.01 ± 0.51a
Middle Fraction	281.03 ± 5.05c	484.15 ± 3.37c	1.25 ± 0.00c	39.80 ± 0.29c
Lower Fraction	355.62 ± 1.99b	503.41 ± 1.76b	1.36 ± 0.00b	41.36 ± 0.28b
Rice Brand[1)]	340.52	525.40	1.21	41.60
Rice Brand[2)]	319.19	367.06	1.1	31.99
Rice Brand[3)]	270 – 362.5	425 – 557.5	1.01 – 1.11	43.87 – 45.47
Rice Brand [4)]	238.7 – 273.65	300.01 – 345.47	1.15 – 1.29	34.11– 42.92

Different letters in the same column indicate significant differences (P<0.05), [1)]: Anita 2014, [2)]: Maulana 2007, [3)]: Irawan 2006, [4)]: Aryono 2008, BD: bulk density; CBD: compacted bulk density; SG: specific gravity; AP: angle of purpose.

The values of BD, SG and AP pollard (Table 1) were higher than those of Irawan (2006) which were 293.75 g l^{-1}, 1.11 kg l^{-1} and 41.15^o. However, the value of pollard CBD before and after fractionation was lower than 443.75 g l^{-1}. The difference in the physical value of pollard and rice bran from the research results with the literature is caused by several factors, one of which is the difference in nutrient content. Problems that are often encountered in the milling process is separation bran tightly bound to the endosperm so that the help of mechanical forces and treatment the heat applied can cause endosperm rupture of various sizes. Endosperm damage during the process milling can provide yield low head rice, reduction of milling degree, as well as a decrease in nutritional components which exceeds the desired limit (Slamet and Aziz 2011).

The physical properties of rice bran before and after fractionation have different values from the literature. This is because the sources of rice bran used are not the same. Patiwiri (2006) stated that the diversity of rice bran is caused by rice varieties, milling or processing during grain drying. This can cause the quality of the obtained bran to vary (Tris *et al*. 2007). The rice milling process needs to be considered because the different settings and use of the machine will produce various qualities of rice bran. Sukria and Rantan (2009) added that the difference in the rice milling process has more influence on the quality of the bran compared to rice varieties. White rice grain (Setra Ramos) has water content of 11.46%, brown rice grain (Inpari 24) has a moisture content of 11.05%, and unhulled rice Black (Cempo Ireng) contains a water content of 11.44%. The moisture content of the grain has met the standard level safe water for grain storage. Quality and the shelf life of grain is affected by the moisture content of the grain. The water content can affect the quality of milled rice generated. Damage to grain chemically, biochemically, and microbiology triggered by high water content (Aryunis 2012). Rice quality is influenced by the degree of milling. The high degree of milling will reduce the quality of rice because of the low level of milled rice produced and the percentage of broken rice produced. This quality has an influence on the level of public acceptance and purchasing power of rice. The high degree of grinding can affect the content the main nutrients of rice such as the digestibility of starch correlated with the fiber content of rice. Rice color will be brighter (white) with a higher degree of grinding high because of the color pigment in the outer layer of rice red and black rice wasted in large quantities (Aryunis 2012). Mechanical milling can reduce the content of vitamins B1, B2, B3, and B6 on brown rice (Indrasari 2011).

Table 3. Chemical properties (%DM)

	DM (%)		CF (%)		CP (%)	
	Pollard	Rice Bran	Pollard	Rice Bran	Pollard	Rice Bran
Before Fractionation	86.91	89.48	8.50	29.14	19.40	11.64
After Fractionation						
Upper Fraction	92.42	92.75	7.33	21.55	16.69	12.60
Middle Fraction	94.23	93.25	8.69	33.98	19.49	7.70
Lower Fraction	91.79	93.24	6.01	33.85	21.03	8.20

DM: dry matter; CF: crude fiber; CP: crude protein.

Bulk Density

The bulk densities of pollard before fractionation were 320.86 g l^{-1} and after fractionation 338.39 g l^{-1} until 386.47 g l^{-1}. The density value of the heap of rice bran before fractionation was 352.95 g l^{-1} and after fractionation was 281.03 to 394.09 g l^{-1}. The increase in KT after fractionation was due to different particle sizes. The particle sizes of pollard and rice bran before fractionation were 0.84 mm and 0.48 mm. The particle sizes of pollard and rice bran after fractionation were 0.67 mm and 0.32 mm, respectively. The value of the particle size of the material influences the value of the bulk density and the compacted bulk density (Damayanti *et al*. 2017). The particle size of the material after fractionation is smaller than before fractionation. According to Krisnan (2008), a material with a smaller particle size means that the volume of space it occupies will be smaller so that the CBD becomes larger. The material flow rate will increase with increasing BD values (Krisnan 2008).

The value of bulk density and rice bran quality can vary if there are foreign objects in the components of rice bran (Patiwiri 2006). A low BD value will require a larger space to store the material. In addition, the existing air voids will also increase the speed of material being contaminated by fungi if in the storage process less attention is paid to controlling water content, temperature and humidity. The air cavities present in materials that have an ether extract content will be able to increase the oxidation process so that the material will go rancid quickly, shorten the shelf life of the material and decrease the quality of the material.

Further test results showed that there was a significant difference (P<0.05) in pollard and rice bran after fractionation. The difference is due to the separation of materials based on nutrient content (Table 3). The higher the crude fiber content, the lower of BD value. Ansor (2015) revealed that the BD is directly proportional to the protein content and inversely proportional to the crude fiber content.

Table 4. Correlation between physical properties of pollard after fractionation

Physical properties	BD	CBD	SG	AP
BD	1	0.900**	0.930**	0.917**
CBD		1	0.945**	0.960**
SG			1	0.939**
AP				1

BD: bulk density; CBD: compacted bulk density; SG: specific gravity; AP: angle of purpose, ** : different (P<0.01).

Compacted Bulk Density

The compacted bulk density values for the pollard and rice bran before fractionation were 433.51 g l^{-1} and 509.34 g l^{-1}. up to 526.33 g l^{-1}. The increase in the value of the compacted bulk density is also due to the particle size. Smaller particle sizes when shaken or compressed will be better able to fill the space and easy to solidify so that the required volume will be less by materials with fine particles accompanied by shaking or shaking. According to Daud *et al*. (2013) the smaller the particle size of the wafer constituent material, the wafer density value will increase and vice versa.

The middle and lower fractions of rice bran after fractionation showed the presence of a mixture of husks. A husk which has a high crude fiber content has a low cohesive force so that the bonding power between particles is low which causes the given shock to not be able to suppress the material to become denser so that it will reduce the value of the CBD. The CBD value of pollard and rice bran after fractionation was significantly different (P<0.05) in each fraction. This is due to differences in nutrient content (Tables 3 and 4). The compacted bulk density value has a negative correlation with crude fiber and a positive correlation with crude protein (Ansor 2015).

Specific Gravity

The specific gravity values of pollard and rice bran before fractionation were 1.29 kg l^{-1} and after fractionation were 1.12 kg l^{-1} to 1.42 kg l^{-1} and 1.25 to 1.50 g l^{-1}. Bulk density based on fraction showed a significant difference (P<0.05). The difference is due to differences in the chemical or nutrient content of the ingredients in each fraction, especially crude fiber and crude protein (Tables 3 and 4). According to Ansor (2015), specific gravity has a positive correlation with crude protein and a negative correlation with crude fiber. This is also related to the greater protein molecular weight compared to crude fiber. According to Cecep *et al*. (2015) the lower the value of the specific gravity of rice bran, the higher the husk content is suspected. According to Khalil (1999a), specific gravity affects the homogeneity of particle distribution and stability in a mixture of processed food products. In the food industry such as biscuits, specific gravity also greatly determines the level of accuracy in the automatic dosing process such as the packaging process and the process of removing materials from the silo to be mixed.

Angle of Purpose

The purpose angle values of pollard and rice bran before fractionation were

42.32° and 40.53°. The AP of pollard is higher than that of rice bran because the crude fiber content of rice bran is 29.14% higher and pollard crude fiber is 8.50%. The AP of pollard and rice bran after fractionation were 41.81° to 46.98° and 39.80° to 46.01°. Duncan's further test results showed a significant difference (P<0.05) in the stack angle parameter of each fraction. Differences in crude fiber and crude protein content of rice bran resulted in changes in the value of the AP. The AP has a negative correlation with crude fiber content and a positive correlation with crude protein (Ansor 2015). The AP indicates the characteristics of the material when it moves freely. The higher the value of the stack angle, the less free the particles to move (Khalil 2006). The value of the AP will increase with the increase in the moisture content of the material (Baryeh 2002). According to Fasina and Sokhansanj (1993), there are several AP based on the shape of the material. Liquid material has a stack angle of 0°, very easy to flow 20-30°, easy to flow 30-38°, medium/medium 38°-45°, difficult to flow 45°-55° and very difficult to flow >55°. The angle of purpose affects the flow rate of a material, namely when transporting and unloading using a tractor or conveyor.

Table 5. Correlation between physical properties of rice bran after fractionation

Physical properties	BD	CBD	SG	AP
BD	1	0.957**	0.970**	0.881**
CBD		1	0.989**	0.962**
SG			1	0.967**
AP				1

BD: bulk density; CBD: compacted bulk density; SG: specific gravity; AP: angle of purpose, **: different (P<0.01).

Chemical Properties of Pollard and Rice Bran

The crude fiber content of pollard before fractionation used was 8.5% and after fractionation was 6.01% to 8.69% (Table 3). The crude fiber content of pollard according to Arditya (2010) is 5 to 8.81%. This is due to the different molecular weights between pollard particles so that the particles will separate and have different falling or settling times. The crude protein content of pollard before fractionation was 19.40% higher than that of wheat bran protein according to Balderok *et al*. (2000) which is about 16%.

The crude fiber content of rice bran before fractionation is 29.14% crude fiber content. The crude fiber value of research bran is high compared to crude fiber, according to Rasyaf (2004) which is 26.8% and according to Hana (2015) which is 8.69%-13.06%. The main carbohydrates in rice bran is hemicellulose (8.7-11.4%), cellulose (9-12.8%), starch (5-15%) and β-glucan (1%). The rice bran used in this study did not fall into the criteria for rice bran according to the crude fiber content of SNI (2001) with a maximum of 11% (quality I), 14% (quality II) and 16% (quality III) and was included in rice bran. quality I according to SNI (2001) with a minimum crude protein content of 11% (quality I), 10% (quality II), 8% (quality III). The crude protein content of rice bran research is 11.64% lower than the crude protein of rice bran according to Sukria and Krisnan (2009) which is around 12.7%-13.5%, higher than crude protein according to Ansor (2015) which is 9.32%-10.175 and falls into the protein range rice bran research results by Hana (2015) which is around 11.16%-13.90%. Grain milling affects the nutritional content of rice and rice bran.

The variety is one of the factors that determine the quality of the bran because the protein and crude fiber content is determined by the diversity of the physical and chemical properties of the grain, mainly due to genetic factors carried by rice varieties and the environment. If the soil fertility is in accordance with the rice growing media, it will produce good bran production and nutrient quality (Ishaq *et al*. 2001). The content and crudeness of pollard and rice bran after fractionation have differences in each fraction. The falling time of the particles is determined by the molecular weight and chemical properties of the material, one of which is the level of polarity, which causes the separation of particles with different nutrient content. High polymers including plastics, rubber and fibers have a molecular weight of 104-106 (Sari 2018). Pollard crude fiber and rice bran in the middle fraction were 8.69% and 33.98% higher than the lower fraction, namely 6.01% and 33.85%, respectively. It was found that there were many husk components mixed into the middle fraction which caused the high crude fiber content. The high crude fiber content is caused by the silica and lignin contained in the husks (Telew *et al*. 2013). According to research Adibrata (2001), husk contains 40% cellulose and 30% lignin. Lignin has a low molecular weight resulting in a longer fall time. This causes the crude fiber content of the middle fraction to be higher than the lower fraction because the falling time of the particles in the middle fraction is longer than the lower fraction.

The decrease in crude fiber content will be accompanied by an increase in crude protein. The results are based on the nutrient distribution scheme according to proximate analysis, if there is an increase in the value or percentage of protein content, there will be a decrease in the content of the extract without nitrogen which will then result in a decrease in the percentage of crude fiber (McDonald *et al*. 1995). The crude protein content of pollard from the upper, middle and lower fractions increased respectively, namely 16.69%, 19.49% and 21.03%. This is because the value of the molecular weight of the material that has a higher protein content will decrease or settle more quickly. Saade and Siti (2009) showed that the higher the protein content in fish feed, the higher the sinking speed due to the high protein molecular weight, which is around 5000 to one million (Poedjiadi 1994). In addition, pollard contains more non-polar amino acids such as glycine and leucine, and is deficient in several polar amino acids such as lysine. Amino acids that are non-polar when put into water will not form bonds between amino acids and H_2O so that materials with high amino acids or proteins will settle more quickly. The solubility of materials with non-polar amino acids also cannot be affected by their solubility in water because they are hydrophobic. The molecular weights of the amino acids glycine and leucine were 75.07 and 131.18 g mol^{-1}, and the molecular weights of lysine were 182.65 (Mutia *et al*. 2014). Although the molecular weight of lysine is large, lysine has a bond with water so that the solubility of the material will occur which can reduce the weight of the material. This causes materials with polar amino acid content to decrease longer.

The results of rice bran fractionation had the highest protein content in the upper fraction and decreased in the next fraction, namely 12.60%, 7.70% and 8.20%. Based on the physical observation of the fractionated bran, the upper fraction found a white fine powder which is a fraction of rice. This causes the protein content of the fraction of rice bran to have a high protein content. This decrease was also due to an increase in crude fiber content in the middle and lower fractions. In addition, the solubility of the material in water also affects the protein content of rice bran. Rice bran has a limiting amino acid or is deficient in the amino acid methionine (Suprayogi *et al*. 2009). The amino acid methionine is nonpolar or hydrophobic with a molecular weight of 149.21 g mol^{-1} (Mutia *et al*. 2014). This causes other polar amino acids in rice bran to form hydrogen bonds so that it will slow down the downtime and the precipitation of rice bran which contains higher protein. Dias *et al*. (2011) explained that rice bran contains hydrophilic gluten. Materials that contain protein and are dissolved in a liquid will certainly have a viscosity value. The viscosity of a protein solution depends on the type of protein, molecular shape, concentration and temperature of the solution (Soedarmo and Sediaoetama 1987). This causes the crude protein content in the upper fraction to be higher than the middle and lower fractions.

Correlation between Pollard and Rice Bran Physical Properties

The value of physical properties is important to know because it will affect the logistics and production processes in the industry. Aspects of the physical properties of materials that are important to know to optimize the production process are bulk density, compacted bulk density, specific gravity and angle of purpose. These four aspects have a relationship with each other in the production process. The magnitude of the correlation value produced between the two materials is influenced by the physical characteristics produced so that different materials will produce different correlation values. Table 4 shows the correlation values between the physical properties of the pollard resulting from the fractionation.

The correlation results of all physical parameters were significantly different ($P<0.01$) and had a positive correlation with other physical parameters. This shows that the higher the value of a certain parameter, the other physical parameters will also increase. This value will change if there is a change in the component or chemical content in the material and the particle size of the material is not uniform. The pollard resulting from the fractionation has a particle size of 0.67 ± 0.09 mm. Each material has different physical and chemical characteristics so that it will produce different correlation values. The correlation between the physical properties of fractionated rice bran is shown in Table 5. Rice bran which has almost the same characteristics as pollard also showed significantly different results ($P<0.01$) on all parameters and positively correlated between physical parameters.

The correlation value of bulk density with all physical test parameters shows a positive correlation and a very significant value. This shows that the higher the bulk density value, the higher the compacted bulk density, specific gravity and angle of purpose will be. All parameters of the physical properties of the fractionated rice bran that have very significant different correlation values are also due to the particle size of the rice bran in the upper, middle and lower fractions being the same, namely 0.32 ± 0.03 mm.

Specific density has a very significant effect on bulk density, compacted bulk density, and angle of purpose. The higher the specific gravity, the higher the bulk density, compacted bulk density, and angle of purpose. The increase in SG will affect the increase in the value of BD, CBD and AP (Mujnisa 2007). The higher the bulk density, the higher the compacted bulk density (Khalil 1999a) and the angle of purpose, because the measurement method used is almost the same as the CBD, only different in the compaction process. The CBD has a very significant effect on the angle of purpose. The higher the BD, the higher the resulting AP (Khalil 1999b).

Rice bran and pollard have the potential to be processed into edible oil by a stabilization process (Hasnelly *et al.* 2020). On rice bran rich in nutrients that are beneficial for human health. Inside the bran can found dietary fiber, fatty acids do not saturated, sterols, proteins and minerals (Made and Andi 2010).

CONCLUSION AND SUGGESTIONS

Conclusion

The physical properties of pollard and fractionated rice bran generally improved in quality. The fraction that has the best physical and chemical quality is the lower fraction for pollard and the upper fraction for rice bran. The middle fraction has the highest crude fiber content, so it has the potential to be a raw material for making high fiber processed food.

Suggestion

Further research is needed to use more by-products from various agricultural commodities and their diversity in several regions in Indonesia due to fluctuations in the quality of rice bran caused by differences in rice bran varieties and soil conditions and a more complete proximate analysis is needed. The fractionation method is applied on an industrial scale with dry fractionation and testing of the resulting fractionated material for making biscuits in patients with degenerative diseases.

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CHEMICAL AND ORGANOLEPTIC CHARACTERISTICS OF CHICKEN NUGGET BASED ON COMPOSITE FLOUR FROM MOCAF, BROWN RICE AND CORN STARCH

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ABSTRACT

One of the most favorite food is nugget which is a fast-food group with meat-based ingredients. In this study, MOCAF, brown rice flour and corn starch were used as an alternative fillers of wheat flour substitution as a means of reducing dependence on wheat flour as an imported product and increasing the nutritional content of nuggets. The purpose of this study was to determine the effect of variations of the formulation of materials on the organoleptic characteristics and to determine chemical content of the nuggets that was preferred by the panelist. This research began with the nugget formulation, followed by organoleptic testing and chemical characterization of the nugget formula that was preferred by the panelists. The average results of the affection test showed that nugget B was preferred to nugget A with the materials formula having a ratio of MOCAF, brown rice flour and cornstarch, namely 4:1:3 (60g:15g:45g). The preferred nugget contains water content as much as 57.553%, fat content of 1.055%, ash content of 1.955%, protein content 29.195%, crude fiber content of 16.064%, and carbohydrates by different of 10.205%. By not using wheat flour as the main materials, these nuggets can be regarded as product with a high in fiber because of the content in carrots, brown rice flour, and MOCAF.

Keywords: Alternative Food, Nugget, Composite Flour, Corn Starch

INTRODUCTION

In this fast-changing era, people are preferring food that is practical, economical, and quickly to prepare. Fast food is food that is served in a short time and can be consumed easily (Ratnaningsih, 1999). One of the processed ready-to-eat foods whose people like is nuggets.

Nugget is one of the food products that processed meat by utilizing meat restructuring technology and using low-quality meat. This process can also increase the added value of meat (Khomairah, 2012). Nuggets were processed not only by using meat as raw materials, but also can be added with vegetables to increase their nutritional value of nuggets. Nuggets are often consumed by the people because they are easy to process.

In the nuggets manufacture process, flour serves as a filler and binder.The flour commonly used as nugget materials was wheat flour. Wheat flour contains protein in the form of gluten. The wet gluten content in wheat reaches 24-36% (Aptindo, 2012). According to Sudarminto (2015), the main difference of wheat flour and MOCAF especially in the nutritional value is that MOCAF does not contain gluten. Most people avoid gluten for health reasons, especially those with celiac disease (an allergy to the gluten protein that causes immunodeficiency). So that, food diversification become solution for the limitation usage of the wheat flour.

One solution that can be used to reduce the use of flour is to use composite flour. Composite flour is a mixture of various types of flour, such as tuber flour (cassava, sweet potato), with or without high protein flour (soy flour, peanut flour), with or without grain flour (rice flour, sorghum flour, corn flour), with addition of wheat flour or without addition of wheat flour (Bantacut and Saptana, 2014). Composite flour can be used as a substitution for wheat flour in the development of processed food products such as chicken nuggets.

Nuggets can be processed by substituting wheat flour with MOCAF, brown rice flour and corn starch. In this study, brown rice flour, MOCAF and corn starch were used as substitutes for wheat flour. This is done to increase the nutritional content of chicken nuggets compared to existing nuggets products, besides to reducing the use of wheat flour also. The purpose of this study was to determine the effect of variations in the formulation of materials on the organoleptic characteristics and to determine the chemical content of the nuggets that were most favored by the panelists.

MATERIALS AND METHODS

Materials and tools

The materials used in this study were chicken meat, corn starch, ice cubes, MOCAF, carrots, brown rice flour, garlic, salt, pepper, mushroom broth, oyster sauce, isolated soy protein (ISP), sodium tripholyphosphate (STPP) and bread flour. Materials and reagents used for chemical analysis include hexane, filter paper, vaseline, nugget samples, labels, 96% ethanol, 1.25% sulfuric acid, 3.25% NaOH, $CuSO4$, $K2SO4$, 2% boric acid, NaOH 40 %, methyl red indicator, 0.1 N HCl, NaCl powder.

The tools used in this research include tools for nugget production and for nugget analysis (chemical and organoleptic). Tools used for production include scales, pans, stoves, plastic containers, measuring spoons, trays, ice boxes or thermos, table covers plastic, and freezer. The tools used for chemical analysis include porcelain dishes, crucibles, desiccators, analytical balances, oven, spatula, mortar, hotplate, scissors, bottle, bucket, bowl, grinder, glassware, water bath, stove, furnace, condenser, destructor, soxhlet extractor, and kjedahl machine. The tools used for organoleptic testing include questionnaire sheets, stationery, cell phones.

Research methods

This research was carried out in several stages, namely nuggets processing, and product organoleptic testing using the affection method with organoleptic test types, with untrained panelists. Furthermore, the nuggets with the best formulation were subjected to chemical analysis.

Nugget processing

The stages of making nuggets begin with thawing ground chicken which is still frozen. Meat that has gone through the thawing process is weighed, then mixed with a marinade and emulsifier. Chicken meat is mixed with marinade ingredients (seasoning) to strengthen and add flavor to the resulting nuggets. Seasonings such as garlic, salt, pepper, mushroom broth, oyster sauce, are added to give chicken nuggets a taste. Next added STTP, ISP, and ice. After everything is mixed, carrots, MOCAF, rice flour, corn starch are added to the dough. The mixing process is carried out until well mixed and formed with a smooth consistency and the mixing time has been running for ±15 minutes. The next stage is forming, where the dough is shaped into a rectangular resembling a stick by manual cutting using a knife. Then the nugget dough is steamed until half cooked for further coating. Wet coating with flour adhesive (batter) is a mixture consisting of water, starch, and seasonings for dipping the product. Then proceed with the second coating with bread flour. The purpose of this coating process with breadcrumbs is to obtain an attractive appearance and a crispier texture of the nuggets. The next process is the primary packaging process (packing). Nuggets are put in Polypropylene (PP) plastic packaging which is equipped with a zipper lock and food container. Finally, low temperature storage is intended as a heat shock treatment to kill microbial activity and extend the shelf life of nuggets. The process of making nuggets is presented in Figure 1.

Procedure Analytics

The organoleptic test was carried out by the hedonic test method. Based on Setyaningsih (2010), organoleptic parameter includes changes that occur in color, aroma, texture, and taste. This test was conducted by 30 untrained panelists. The scale used is a number from 1 to 5, where 1 = very dislike, 2 = dislike, 3 = normal, 4 = somewhat like, 5 = like. The best formula was then analyzed by proximate analysis. The proximate analysis was carried out in duplo based on the National Standardization Agency of Indonesia number 01-2332-3-2006 (2006) which included water content, ash content, protein content, crude fiber content, fat content, and carbohydrates content by difference.

Data analysis

Organoleptic testing nugget, using the affection method with the type of hedonic test. This test was chosen because we wanted to find out which of the 2 formulations was preferred by the panelists based on the parameters of color, aroma, texture, and taste. The test was conducted with 30 untrained panelists. In formulation A, the ratio of MOCAF, brown rice flour and cornstarch is 6:1:1 (90 g:15g:15g). Formulation B has a ratio of MOCAF, brown rice flour and cornstarch which is 4:1:3 (60g:15g:45g). Determination of this formulation is based on the results of previous experiments. The data that has been obtained were analyzed using Microsoft Excel 2016 edition. To find out more accurate results, a one-way ANOVA calculation was carried out using the SPSS 25 edition application.

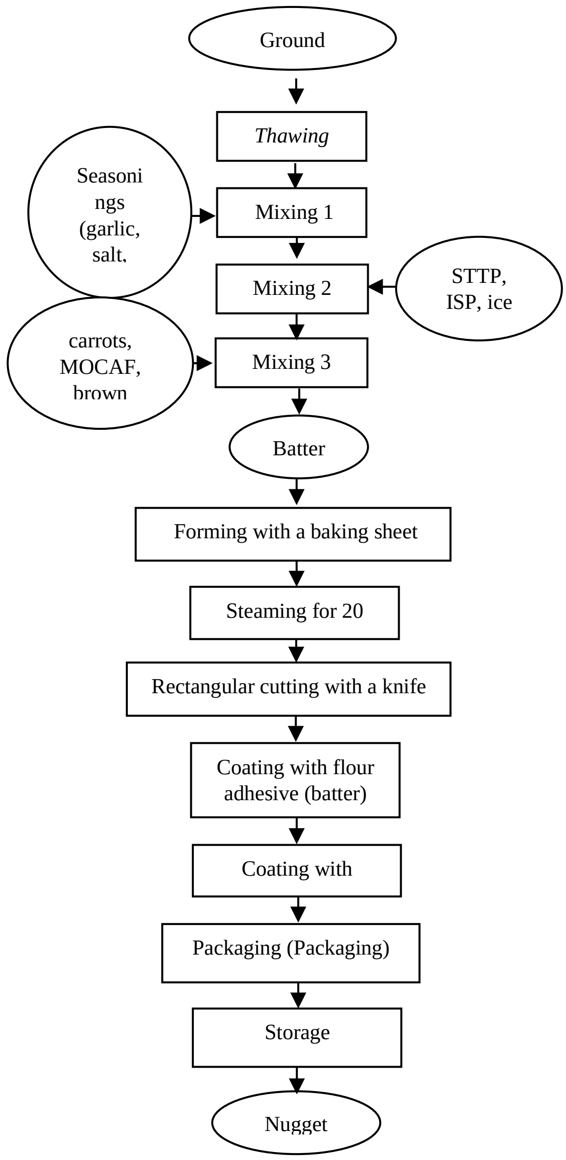

Figure 1. Nugget Making Flowchart

RESULTS AND DISCUSSION

The nuggets in this study used a composite MOCAF, brown rice and corn starch. The characteristics of MOCAF are similar to fthe wheat flour, that make MOCAF can be used as a substitute or a mixture of flour (Kurniati et al., 2012). MOCAF (modified cassava flour) can be used as an alternative raw material in food for people with celiac disease because it does not contain gluten. MOCAF has a higher viscosity and dissolves easily than wheat flour (Hanifa et al., 2013). Besides that, MOCAF has several advantages, namely the soluble fiber content is higher than cassava flour, calcium content is higher than rice and wheat flour, it has the same swellability as type II wheat (medium protein content), has higher digestibility than cassava tapioca (BKP3 Bantul, 2012).

Based on Rahmah and Mustika (2018), vegetable nuggets added with 20% MOCAF produced nuggets with the best sensory and chemical properties. Vegetable nuggets with the addition of 20% MOCAF have sensory characteristics that have been accepted by the panelists. In addition, with the addition of 20% MOCAF has chemical characteristics which is better than other treatments, because it has a higher value.

Besides that, wheat can also be replaced with corn flour. The replacement of wheat flour with corn flour is caused by several things, including the provision of food products for people with gluten intolerance. corn was wildely use as raw materials in Indonesian food Industry because Indonesia has corn production averages of 23.95 million tons of dry matter in 2020. The use of corn flour can reduce raw material and production costs and can reduce dependence on the use of wheat flour raw materials. The largest component in corn flour is starch. Based on research (Juniawati, 2003), corn flour has a starch content of 68.2%.

In a study conducted by Yuanita and Silitonga (2014) using corn starch as the manufacture of nuggets, the water content and ash content produced will be lower than using flour, while in terms of protein and fat content, corn starch has a higher content than wheat flour used for making nuggets. So that, the addition of corn starch for nuggets can increase the yield of better nuggets.

Brown rice flour is a processed product of brown rice, which can be used as a raw material in the manufacture of food products. Brown rice flour has the advantage of being high in fiber content. Fiber in food commonly called dietary fiber is very good for human health. The term dietary fiber is used to distinguish dietary fiber from crude fiber, namely all polysaccharides and those that are not hydrolyzed by the action of human intestinal enzymes (Kusharto, 2006).

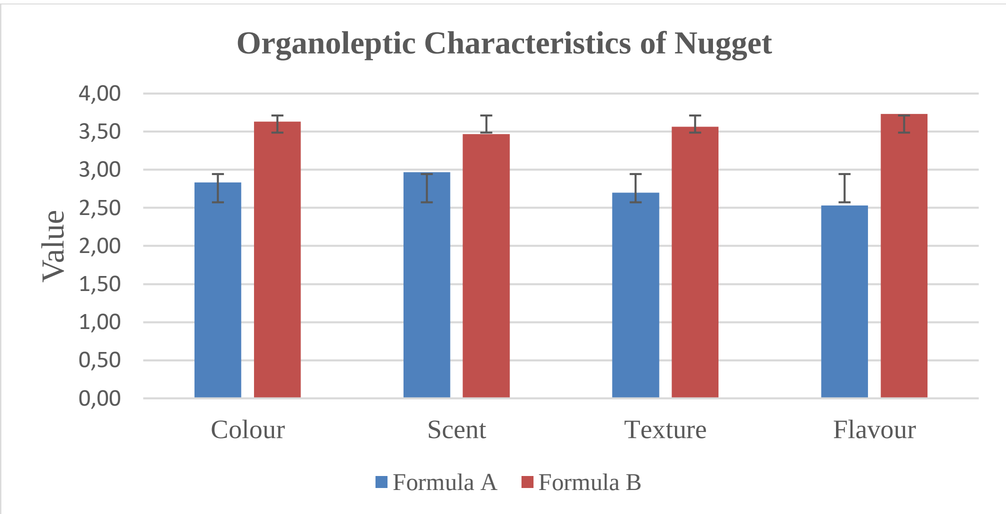

Figure 2. Organoleptic characteristics

Organoleptic Test

Organoleptic test is an analysis method that aims to measure the level of preference or level of the panelist acceptance of the product. Organoleptic tests include color, texture, aroma and taste. The hedonic method was used the level of preference. The result of hedonic test can be seen in Table 1.

Table 1. Average panelist assessment

Nuggets	Color	Scent	Texture	Flavor
A	2.83[a]	2.97[A]	2.70[x]	2.53[X]
B	3.63[b]	3.47[B]	3.57[y]	3.73[Y]

The results show that on 30 panelists, the average value on sample A are 2.83 on color, 2.97 on aroma, 2.70 on texture, and 2.53 on taste; on sample B, the average values are 3.63 for color, 3.47 for aroma, 3.57 for texture, and 3.73 for taste. Analysis data using Ms. Excel show that panelists prefer sample B to sample A. According to the panelists, the taste of sample A is sourer than sample B.

Table 2. Results of ANOVA Analysis

	Sum of square	Df	Mean square	f	Sig.
Color	9,600	1	9,600	20,521	.000
	27.133	58	.468		
	36,733	59			
Scent	3.750	1	3.750	4.684	.035
	46,433	58	.801		
	50,183	59			
Texture	11.267	1	11.267	23,619	.000
	27,667	58	.477		
	38,933	59			
Flavor	21,600	1	21,600	33,557	.000
	37.333	58	.644		
	58,933	59			

The result of ANOVA analysis using the SPSS application show that the value of F on color, taste, aroma, and texture parameters are more than the value of F table value of 0.01% and 0.05%. It means that formulas A and B are significantly different. It is caused by the amount of mocaf flour added is more and made the taste sour on sample A and panelist dislike. Panelist also gave advice to make nugget that have crunchy on the outside and soft on the inside.

Chemical Characteristics

The proximate analysis includes water, ash, fat, protein, crude fiber and carbohydrate contents. The results of this analysis can be seen in Table 3.

Table 3. Chemical Analysis Results

Parameter	Value (%)	SNI 6683:2014
Water content	57.553	Max 50%
Fat level	1.055	Max 20%
Ash	1.955	-
Protein	29.195	Min 12%
Crude fiber	16.064	-
Carbohydrate	10.205	20% max

Table 3 shows the results of the analysis of the water content in chicken nuggets, which is 57.553%. The value of water content is less than water content's value in the Indonesia National Standard (SNI) number 6683:2014. The high of water content of nugget was because of hygroscopics nature of the composite flour and processing condition. Winarno (2008) states that the water content in food ingredients also determines the freshness and durability of the food. The high quality affects the quality of the chicken nuggets produced and will make it easy for microbes to breed so that various changes will occur in the chicken nuggets product. The high amount in moisture content in the nuggets is possible due to the steaming process. During steaming, the cover of the steamer is not coated like a cloth so that it is exposed to moisture during steaming. The water vapor that rises is condensed on the surface so that the water content of the nuggets is high.

Decreasing the water content of nuggets can be done by processing such as steaming and frying. Harris and Karmas

(1989) said that the main purpose of steaming is to reduce the moisture content of the raw material so that the texture of the material becomes more dense. Harris and Karmas (1989) also stated that frying can evaporate the water content contained in the product, so that frying can reduce the water content of the product.

The results of the analysis of the fat content of the nuggets were 1.055%. According to the Indonesia National Standard (INS) No. 6683:2014 (2014), the standard for the nutritional content of chicken nuggets is a maximum fat content of 20%. Comparing to the ISN 6683:2014, this nugget has fulfilled the standard requirement although lower than standard. Suseno et al. (2007) stated that the higher the concentration of flour addition will cause decreasing the fat content of the products. The decrease in fat content is thought to be influenced by the nugget processing process like milling. In addition, the steaming process is also suspected to be the cause of the reduced value of the fat content of the nuggets. According to Lawrie (1995), fat content is strongly influenced by the cooking process, cooking temperature and cooking time of meat. High temperatures will melt the fat and tend to damage the texture left in the food product. The fat content of chicken nuggets in this study was low. Based on Yuliana et al. (2013), nugget made from chicken meat nuggets and chicken liver with the addition of tapioca have fat content ranging from 9.77 ± 12.92%. So that the aroma of chicken nuggets as a result of this study does not have a sharp aroma. According to Murtidjo (2003) that the taste and aroma of chicken meat is closely related to fat.

The analysis of ash content in nuggets was 1.955% (Table 3). The ash content of chicken nuggets as a result of this study was higher than nuggets which only added by wheat flour. The ash content of nuggets made from chicken meat is 73% and the addition of 10% wheat flour is only 0.71% (Nugraha, 2019). The ash content roughly describes the mineral content of the material, which usually consists of magnesium, calcium, iron and manganese. The function of minerals in the body is as a regulator and builder (Winarno, 2008). This shows that the minerals in nuggets made by composite flour are higher than those made from wheat flour. The high value of ash content in chicken nuggets is influenced by brown rice flour. The nutritional content in brown rice is minerals. Brown rice contains 86 mg of magnesium (of which 22% is the recommended daily intake) and 150 mg of phosphorus (of which 15% is the recommended daily intake). Comparing with the brown rice, white rice only contributes 24 mg of magnesium and 69 mg of phosphorus. In addition, the amount of salt and minerals contained in the product affect the value of the ash content in the nuggets (Prastia, et al., 2016).

The results of the analysis of protein content of nuggets showed a value of 29.195%. According to Indonesia National Standard (ISN) No 6683:2014 regarding chicken nuggets, the minimum protein content in a chicken nugget is 12%, which means that the protein content in the formulated nuggets has higher levels than ISN. The protein content of chicken nuggets made from composite flour was higher than nuggets made only form wheat flour. The high value of protein content was because the nuggets are made from chicken which is high in protein content and uses Isolated Soy Protein (ISP). ISP is refined soybean which contains 90% protein and can be used to increase protein content in food as a substitute for animal protein (Arifandy and Adi, 2016). The results of Nugraha's research (2019), the protein content of nuggets made from chicken meat is 73% with the addition of 10% wheat flour is 12.65%. The protein content in flour can trigger a perfect gelatinization process. The complete gelatinization process involves the binding of water by a network formed by a chain of protein molecules (Komariah et al, 2005). So, it will affect the texture of the nuggets.

Crude fiber is the residue of foodstuffs or agricultural products after being treated with boiling acid or alkali, and consists of cellulose, with a small amount of lignin and pentose. Fiber is very important for the process of facilitating digestion in the body so that the digestive process runs smoothly (peristalsis) (Hermayanti et al., 2006). Based on the results of this study, the crude fiber content of nugget were 16.064%. Crude fiber in nuggets comes from brown rice flour. According to Hernawan and Melyani (2016), the crude fiber content in brown rice is 3.97%. In addition, the fiber content of nuggets can be obtained from carrots and mocaf which are added to the dough. According to Abdillah (2006) chicken nuggets with the addition of carrots can increase product fiber because carrots contain high levels of insoluble dietary fiber. Based on Rahmah and Mustika (2018), vegetable nuggets added with 20% mocaf have 3.79% dietary fiber. Thus, the making of chicken nuggets with the substitution of brown rice flour and mocaf and the addition of carrots increased the fiber content of the nuggets.

CONCLUSION

The panelists preferred nugget B formulation than nugget A formulation. Panelists did not like formulation A because the taste of formulation A tends to be sour due to the large amount of mocaf added to the dough. Nugget had a water content of 57.553% higher than the Indonesian National Standard, which is a maximum of 50%, the fat content of 1.055% has fulfill the requirements, which was lower than standard with a maximum of 20%, the ash content was 1.955%, the protein was 29.195% higher than the standard recommendation, which is a minimum 20%, crude fiber was 16.064%, and carbohydrates other than fiber was 10.205% lower than the recommended INS, which is a maximum of 20%. By not using wheat flour as the main ingredient, these nuggets can be regarded as an alternative food that is low in gluten and high in fiber because of the content in carrots, brown rice flour, and mocaf.

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