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The COVID-19 pandemic redefining the mundane food packaging material industry?

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A B S T R A C T

COVID-19 pandemic has been the talk of the globe, as it swept across the world population, changing innumerable aspects. The pandemic affected all sectors directly or indirectly. The food sector took a direct hit. The food packaging sector rose to the occasion to serve and feed the pandemic affected, but there were interactions, reactions, and consequences that evolved through the course of the journey through the pandemic. The aim of this perspective is to address the importance of the food packaging industry (from the COVID-19 point of view) and to highlight the unpreparedness of the food packaging materials, for times as these. As the world has been asked to learn to live with Corona, improvisations are definitely necessary, the lapses in the system need to be rectified, and the entire packaging industry has to go through fortification to co-exist with Corona or confront something worse than Corona. This discussion is set out to understand the gravity of the actual situation, assimilating information available from the scattered shreds of reports. Food packaging materials were used, and plastic wastes were generated in bulks, single-use plastics for fear of contamination gained prominence, leading to an enormous turnover of wastes. Fear of Corona, sprayed loads of sanitizers and disinfectants on food package material surfaces for surface sterilization. The food packages were tailored for food containment needs, never were they planned for sanitizer sprays. The consequences of these sanitization procedures are unprecedented, neglected and in the post-COVID-19 phase no action appears to have been taken. Corona took us by surprise this time, but next time at least the food packaging industry needs to be fully equipped. Speculated consequences have been reviewed and plausible suggestions have been proposed. The need for extensive research focus in this direction in exploring the ground-reality has been highlighted.

1. Introduction

Food packaging is one of the largest growing sectors in the synthetic plastic packaging domain (Attaran et al., 2017; Cazón et al., 2017; Ignatyev et al., 2014; Lam et al., 2022; Muller et al., 2017). Different materials such as paper, glass, plastics, go into the manufacture of packaging materials, of which nearly two-thirds are applied to the food sector industry. These percentages are growing rapidly owing to the changes in food habits (Piergiovanni and Limbo, 2016). The food packaging industry is thus the largest consumer of plastics, leading to generation of plastic waste into the environment at an alarming rate (de Kock et al., 2020). The reason for the high rates involved in plastic waste generation is because of the increased usage of single-use plastics and consumption of on-the-go snacks and ready-made meals. Food Packaging Petrochemicals are popular food packaging materials because they are primarily cheap, have good ten-sile properties, and function as an effective barrier against carbon dioxide, oxygen, and water vapor.

Flexible and rigid forms of plastics are in use when it comes to food packaging. These plastics can be broadly classified as thermoplastic or thermosets. Thermoplastics can be processed and reprocessed using heat. The ability to reprocess this group of plastics makes them recyclable, as they can be easily molded to different shapes, and so are more suitable for food packaging. Thermosets cannot be reprocessed by heat once they are formed, hence they are generally not used in food packaging (Marsh and Bugusu, 2007; Marsh, 2016). Thermoplastics such as low-density polyethylene (LDPE), polypropylene (PP), polystyrene (PS), expanded polystyrene (EPS), and expanded polyethylene terephthalate (PET), high-density polyethylene (HDPE), polystyrene (PS), and expanded polystyrene (Jacob et al., 2020; Muncke, 2016) are popularly used as food packaging materials. Multiple upgraded types of plastics such as: polylefin, polyester, polyvinyl chloride, polylvinylidene chloride, polystyrene, polyamide, and ethylene vinyl alcohol is also in use. The list of plastic food packaging materials keeps expanding, >30 types of plastics have been used as food packaging materials (Lau and Wong, 2000). Flexible plastic films made of PVC, LDPE, HDPE, PP are a few of the key options when it comes to the making of food packaging materials. These films are light in weight, solid, and moisture-proof. In addition to this, they render excellent shielding from external oxygen and other atmospheric contaminants and so
nearly 20% of all food items are packed in flexible film. Table 1 summarizes the predominant packaging materials used for food. It is extrapolated that by 2050, there will be a 50% increase in global food supplies to meet the global population growth demands (Guillard et al., 2018) and with this increase, the demand for food packaging materials will also escalate. Packaging materials need to meet multiple expectations, such as to maintain quality of the contained food, meet consumer demands, as well as producer demands and impose less impact on consumer health as well as on the environment. This is quite a lot to ask from a single source, but on the other hand, it also emphasizes the kind of dependency that exists on food packaging materials.

The properties sought for in food packaging applications include: thermal, mechanical, chemical reactivity, optical, gas and moisture barrier properties (Berk, 2018; Olaimat et al., 2020). Since the plastic food packaging industry is a major consumer of plastic and a major source of plastic waste. Hence, more sustainable means of food packaging have been sought after. Using biodegradable polymers will lead to the positive utilization of agricultural waste and resolve environmental issues involved when using petroleum-based plastics. The problem is aggressive since plastic degrade they break down into microplastics and easily enter the food chain. The health impacts involved when plastics interact with packed food is another issue. For example, polystyrene, which is used as coffee cup lids, causes a range of health problems when it leaches into the food or beverage it encloses. The top chemicals noted for interacting with the contained foods include bisphenols including bisphenol-A, Per- and polyfluoroalkyl substances (PFAS), and phthalates (Marsh and Bugusu, 2007).

Green composites based on polyactic acid (PLA) and natural fillers and fibres from agro waste are being investigated for their possibility to serve as sustainable packaging. PLA is the most promising material with a lot of research potential (Gonçalves de Moura et al., 2017; Hu, 2014; Nurul Fazita et al., 2016; Popa et al., 2017). PLA possesses a wide range of desirable properties including biocompatibility, and favourable mechanical properties and it can be molded into various shapes making its performance comparable to petroleum-based plastics (Dahman, 2012; Karamanlioglu et al., 2017; Qin et al., 2011; Saeidlou et al., 2012; Zhao et al., 2011). Pure PLA slowly degrades over a period of months to two years while petroleum-based plastics take 500–1000 years (Kumar et al., 2017; da Silva et al., 2019). Also, it is possible to accelerate the degradation of PLA by composting with other biomass such as compost soil, in this way PLA can be completely degraded within 3–4 weeks (Ncube et al., 2020; Siakeng et al., 2019).

The year 2019 onwards, faced the greatest catastrophe of this generation, the COVID-19 pandemic nucleated in one part of the world, and then ravaged right across the entire globe. This arrested all the usual routines and permanently revolutionizing the way things existed before the pandemic. COVID-19 took the world off guard and shook the foundations of various industrial, academic and clinical processes. Nobody was ready for it, and neither was the existing system geared up to confront it. All along the pandemic, mistakes were committed, and lessons were learned. Various sectors, depending on their depth of interaction with the pandemic condition, took different dimensions of hits. This discussion will exclusively address the fact on how ready the food packaging materials sector were for

| Material | Food packaging application | Advantages with limitations | Resistant to Anti COVID-19 sanitizers |
|----------|-----------------------------|-----------------------------|-------------------------------------|
| Polyethylene terephthalate (PET) | Drinking bottles, Microearable packaging, Soft-drink bottles, Food jar for butter, Jelly and Plastic films | Shatterproof, non-reactive when in contact with food or water, and provides a high strength-to-weight ratio. Being lightweight also provides for cost savings when transporting products | Unassessed |
| Poly vinyl acetate (PVA) | Common packaging material | Multiple food friendly properties, gaining popularity | Unassessed |
| Low density polyethylene/high density polyethylene LDPE/HDPE | Wide variety of food packaging | Wide variety of uses, Low cost, Resistant to acids and bases, Easy to process and mould, Good electrical insulation, Waterproof property. More prone to crack stress. Not useful in extremely high or low temperatures. High permeability to carbon dioxide and other gases. Little to no UV resistance | Unassessed |
| Polypropylene | The most common takeout packaging material, used for chicken roasters, deli tubs, bakery and microwaveable takeout containers. | Highly rigid, leak resistant, crack resistant, sealable, can be coated with anti-fog coatings to retain clarity, can be easily made into many shapes and compartmentalized. High temperature resistant | Unassessed |
| OPS/HIPS | Used for packing sandwiches, salad, bakery, deli, catering services also as lids for sandwiches | Versatile, crystal clear, good aesthetic appeal, leak resistant, anti-fog material when used for hot/cold foods. Non microwaveable | Unassessed |
| Foamed polystyrene | Clamshells and other hinged lid containers, tableware, meat tray. Coffee and hot beverages | Range of colours, excellent heat retention, insulation, strong, lightweight, good presentation. Moderate temperature resistance | Unassessed |
| CPET | Frozen dinner trays, take outs, reheatable containers, frozen foods | Good design flexibility, excellent formability, can be made into multi-compartmented containers, crack resistant on freezing. | Unassessed |
| Foamed propylene | Good for clamshells and other hinged containers, tableware, meat trays, new product with wide market | Excellent heat retention and cold insulation. Strong, light, soak resistant, can be heat sealed with film. Contain hot foods and microwaveable | Unassessed |
| PVC | Food for cold food packagings, snacks, deli, bakery, clamshells for sandwiches, cakes, pies, drinking cups, frozen foods | Extremely high clarity, durable, tough, clear, flexible, for coke-bottles, has durable hinges, resists cracking in freezer. Moderate temperature resistance and priced. Cannot be used in oven/microwaves. | Unassessed |
| Pressed paperboard | Frozen foods, film sealed meals, ready to cook meals and takeouts. | Printing graphic friendly, superior strength, not very leakproof. Temperature friendly, microwave/oven/freezesafe. Moderately priced. | Unassessed |
| Aluminium | Bulk carry-out containers, bakery containers, party platters, frozen entrees | Silver coloured may be coated with different colours, smooth walled, retains heat and cold, leak resistant, numerous lid options. Freezer/oven safe, selectively microwaveable, inexpensive. | Unassessed |
| Glass | Package jams, juices or liquids, baby foods and pickles | One of the main advantages of glass is that it is harmless. It is a material that guarantees that the consumption of the product in question does not entail any harm to our health. It provides great visibility towards your interior. With it, we can make a very clear idea of what is inside the container. It is a moldable packaging material and, therefore, many ways can be done when using it as a container. Finally, it is recyclable and can be reused without problems. It is a fragile material. It can break with the blows, heavier than the other materials, cost of production and manufacturing is very high. | Unassessed |
the pandemic and more so, how unqualified it was to sail through the demands of the pandemic season. We address the mistakes committed and we propose the need to gear up to stay armed, to co-exist with COVID-19 or confront a more notorious pandemic sequel than COVID-19. Fig. 1 addresses the perspective of this article.

2. COVID-19 pandemic and its safety precautions

COVID-19 has changed the way we live. Every area of our lives had/has been impacted and our lifestyles transformed by the pandemic. The food industry saw enormous spikes and massive landslides. The wheels of dining practices transitioned, dine-ins got thoroughly shut down, take-outs became the lifestyle. With many stranded at home and entire households being quarantined, including the homemakers (cooks), ordering food online became the only resort. The food industry had to gear up manifold to rise to the occasion to meet the rising demand. Delivering food implies an increased requirement for food packaging materials. The demand caused a dearth in the availability of food packaging materials. Hence, people resorted to settling for what was available, crude food packages were also welcome. The food packing materials were not prepared for this situation. The other side of online food orders was the fear of corona transmission through the packaging material. What were seen as mundane activities before, such as ordering food from online delivery services or eating take-away, was now being viewed as a commodity of high demand, as well as a source of fear about possible virus transmission.

People resorted to various preventive measures during the pandemic, because the enemy was invisible and at large. Many turned towards using disinfectant or antiseptic liquids for protection, with some going as far as spraying disinfectant on all non-living items, including plastic food packaging. Spray bottles filled with antiseptic liquid, were sprayed on food packaging, work bags and grocery items, generously. An article published in thejakartapost.com “Spraying disinfectant on food packaging unnecessary, expert says” (https://www.thejakartapost.com/life/2020/07/02/spraying-disinfectant-on-food-packaging-unnecessary-expert-says.html), throws light on these practices. The overuse of sanitizers was the sequel that followed the release of a study by Jamie Lloyd-Smith. He is one of the scientists who investigated how long SARS-CoV-2, might remain on various surfaces. The concern over virus transmission via material surfaces began in late March after the study was published in the prestigious New England Journal of Medicine. The study declared that under certain artificial conditions in the laboratory, SARS-CoV-2 was detectable for up to 3 h in aerosols, up to 4 h on copper, up to 24 h on cardboard and up to two to three days on plastic and stainless steel. However, there are no direct reports till date that COVID-19 spreads via food products. In fact, there is no direct report indicating COVID-19 can be directly transmitted via food or food packaging (Food and Agriculture Organization of the United Nations [FAO] and World Health Organization [WHO], 2020). The transmission of SARS-CoV and MERS-CoV through the consumption of foods has also not been observed/or occurred yet (European Food Safety Authority [EFSA], 2020). However, there is a report that human coronavirus 229E (HuCoV-229E) survived for at least 5 days on the surfaces of polyvinyl chloride (PVC), polyfluorotetraethylene (Teflon, PTFE), glass, ceramic tiles, and stainless steel and for 3 days on silicon rubber surfaces at 21 °C with a relative humidity of 30–40 % (Warnes et al., 2015). Similarly, SARS-CoV-2 survived on stainless steel and plastic for up to 2 to 3 days, respectively, at 21–23 °C and a relative humidity of 40 %; however, the virus was not detected on copper and cardboard, after 4 and 24 h, respectively (van Doremalen et al., 2014, 2020). Riddell et al., (Riddell et al., 2020) in their recent study, investigated the effect of temperature on the persistence of SARS-CoV-2 on common surfaces. The exhaustive study investigated various surfaces including, Australian polymer bank notes, de-monetized paper bank notes, brushed stainless steel, glass, vinyl and cotton cloth as substrates. Polymer and paper banknotes were studied for their possibility towards finite transmission of SARS-CoV-2. Glass was extensively chosen as a substrate in this study since it is prevalent in public areas, such as hospital waiting rooms, public transport windows, shopping centres, mobile phone screens, ATMs and self-serve check-out machines. Vinyl is a common substrate used in social settings, tables, flooring, grab handles in public transport, as well as mobile phone screen protector materials. Cotton was also investigated since it is a porous substrate, that goes into the making of clothing, bedding and household fabrics. Their results confirmed that the virus survived upto 1.7 and 2.7 days at 20 °C, while their survival reduced to less than a few hours when the temperature was increased to 40 °C. Viable virus were isolated for up to 28 days at 20 °C on glass, stainless steel and both paper and polymer banknotes. At 70 °C, the viruses were inactivated (Olaimat et al., 2020). These results added fuel to the actual fear

Sanitizers Kill Corona—
Explored and Confirmed

What about the impact of Sanitizers sprayed on Food packaging material surfaces? – Unexplored and Overlooked?

Fig. 1. Overview of the schematic flow of the issues addressed in this article.
that SARS-CoV-2 can be transmitted via contact surfaces because they survived on the above-listed surfaces for several days.

This awareness of the longevity of corona on surfaces spiked the overuse of sanitary sprays, wipes as well as disinfectant sprays. Public awareness set off a rampage of preventive measures, one of which was, spraying sanitizers on the food packages. The Southeast Asian Food and Agricultural Science and Technology Center (SEAFAST) director Nuri Andarwulan said the practice of spraying disinfectant on plastic food packaging ‘was going a bit overboard’. It might be time to reconsider, experts say, especially if that extra effort is adding to the daily stress. Even the US Food and Drug Administration (FDA) is re-emphasizing that there’s no real risk of getting COVID-19 this way. The external and internal factors that were impacting the food package material surfaces as a consequence of COVID-19 are listed in Fig. 2.

3. COVID-19 precautions and its impact on the food packages

From the food package industry point of view, in terms of production, the industry geared up to its fullest maximum. During the pandemic, various industries were considered essential and were never locked down, including the packaging industry. In mid-April of 2020, when COVID-19 was raging across the globe, the packaging industry continued to operate at between 83 and 95 % capacity. Well, from the consumer point of view, it can be said that the highest inflow of packaging materials into households was seen during this season. The pandemic season saw the generation of voluminous plastic packing material wastes from each household. On the other hand, very few were retained and reused. This extensive use and dumping of plastic packaging material was one aspect that evolved amidst the pandemic.

The other aspect which has not been thought about nor discussed is the impact the COVID-19 precautions had on the food packaging materials. The pandemic fear pushed consumers to take over precautions, food packaging materials were sprayed generously with sanitizers, milk pouches and juice bottles were soaked in soap water and wiped with disinfection wipes. There was so much havoc that, at that point of time, all people could think of was how to kill the virus and keep themselves from contamination. The repercussions were not even given a hindsight. The food packaging materials were prepared solely keeping food safety precautions in mind, they were not fabricated for a pandemic situation, nor for receiving a sanitizer chemical treatment. Through the course of the pandemic, the more aggressive the virus raged, the more aggressive these sanitization measures became. Food packages, sealed chips packs, soft drinks were soaked in soap water for minutes to hours, sprayed with sanitizers and exposed to the sun and wiped with disinfectant wipes. There was no fixed guideline, there were blogs and what’s app messages dictating general public actions, which were taken as the basic theory from which each personally extrapolated as much as they could. The uneducated never acted, while the educated overreacted, all these were part of the pandemic havoc. The world was unprepared for this unprecedented pandemic, the food packaging industry was never envisaging a time as this. Till this point, what was on the mind when fabricating a food packaging material was its inertness, its ability to protect and nor react with the contents, its safety, its degradability, these were the factors sought after. The food packaging materials in the market were those that met these, so here we can say we have materials that were never planned for the pandemic and yet were pushed through the pandemic overloaded with COVID-19 sanitization procedures.

Packaging materials are expected to be inert, but this is not to be, ample reports have been published on the interaction of packaging materials with foods contained within them. The food packages also deliver information on the brand and composition and nutritional labelling for the foods. A single layer of material used in food packaging, increases the probability of transfer of printing dyes or inks to the food, in addition to this migrating printing ink species can initiate taints and possibly result in loss of quality and nutritional value (Bradley et al., 2013; Johns et al., 2000; Prentice et al., 2018). Migration of benzophenone, printing inks in snacks and confectionary products are reported and also migration of polyurethane-based adhesives to food has been reported (Hoppe et al., 2016; Isella et al., 2013). Numerous studies have reported plasticizers as potential migrants that could transfer to foods from the packaging materials (Pedersen et al., 2008) Thermal stabilizers, slip additives (Arvanitoyannis and Bosnea, 2004; Cooper and Tice, 1995), solvents from plastic packaging, monomers and oligomers, isocyanates (Miltz et al., 1997), Vinyl chloride (Castle et al., 1996), Polyethylene terephthalate oligomer (Lau and Wong, 2000; Nerin et al., 2013; Silano et al., 2008), Nitrosamines (Robertson, 2016), benzene are known to migrate into food from PET-, PVC-, and PS-based food packaging (Anderson and Castle, 2003). This side of the interaction between the food materials and the contained food has been well

Fig. 2. Schematic indicating the external and internal factors acting on the food packaging materials, with more emphasis on the external factors arising from the COVID-19 sanitization procedures. The stress imposed on the food packaging materials are highlighted here.
established. The other external side, which is the chief concern and unexplored aspect is the impact of chemical sanitization sprays and their effects on the food packaging materials, as well as on the food contained. This aspect has not been reported, nor has it been investigated. Although, till date, nothing has been assessed with respect to the consequence of the pandemic control activities on food packaging materials, this article rising the unaddressed consequences of these practices. The use of sanitizers on food package surfaces, soap solutions and other disinfectants can lead to: (i) degrading the printing ink and dyes on the surface of the food packaging materials, leading to contact with hands while opening the package and subsequent transfer to the food contents contained in these packages while eating, (ii) interacting with the material surface weakening the original material properties, (iii) residual chemical traces on the surface, (iv) corrosive effects on the surface of the material, (v) reduction in the shelf life of the food packaging materials, (vi) possibility of COVID-19 penetrating across food package surfaces into the food contained and (vii) subtle degradation of the plastic food package materials to release toxic microplastics. These are speculations of plausible ways in which COVID-19 precautions could impact food package materials, however, there are no conclusive, confirmatory studies that can authoritatively approve or disapprove of these. Hence, it is in this post-COVID-19 era, that all these doubts and unexplored grey areas have to be resolved. To create a sensitization, and awareness in this direction, is the major focus of this article.

4. Challenges and future research directions

The concerns expressed in the previous section, are not the only concerns, there could be many others and associated ones too, in fact, none of these have even been brought to a discussion forum. This is the first perspective in this direction. There was a time, in the years 2019–2021 when COVID-19 was raging across the globe, it was indeed a life and death situation, one that the world never confronted before, that was a time when every attention, every research, and every action was COVID-19 centered. We did everything possible to get us alive through that dark phase, as said, ‘every action has an equal and opposite reaction’. What was done was to step up to the need of that hour, and what was done cannot be undone, but a precise and careful review of the situation and the consequences is crucial in this post-COVID-19 phase, failing to do so, will be ensuing loss indeed. Experts say the worst of COVID-19 in form of mutants and variants is yet to come, microbiologist declare, that ‘we need to learn to live with COVID-19’, this being the case, we need to step-up and upgrade. Various sectors need to rethink, review and get into a retrospective mode, in order to meet up to the expectations of an ongoing/future pandemic season. Here, we basically present a view-point of what needs to be done from the materials point of view with respect to food packaging materials, in order to be prepared to coexist with COVID-19 or even for the worst. With basic necessities circumventing, food, shelter and clothing, the food sector will need primemost attention. Fig. 3 puts forth the consequences and proposed action plans. Our pubmed search indicated only as few as 38 hits on a keyword search on, ‘COVID-19 and food packaging material surfaces’ (Fig. 4). This indicates the lack of interest and negligence of the scientific community on a prime topic close to human welfare.

5. Concerns and prospective recommendations

At the onset of the global pandemic in 2019, the food industry has faced many impediments, especially in food packaging. Most of the food packaging materials involve non-biodegradable plastics, this has resulted in two major issues: (a) the global lockdown and surge in food delivery services leading to increased utilization of plastic-based packaging that led to a subsequent increase in non-biodegradable municipal solid waste and (b) transmission of viral infection by cross-contamination caused by the packaging material. Therefore, the need to revise the food packaging materials to meet the post-COVID-19 expectations became crucial. Consumers’ concern regarding the ability of SARS-CoV-2 to survive on the surface of packages led to the development of polymers and biopolymers with antiviral properties. These polymers and biopolymers with antiviral properties have been proven for their high efficacy against hepatitis A virus (HAV) and human norovirus (HuNoV) (Randazzo et al., 2018). Priyadarshini et al., (Priyadarshi et al., 2022) have recently reviewed and proposed polymer based antiviral coatings and food materials as post-COVID_19 solutions. Their recommendations projected biodegradable, antiviral biopolymers as prospective food packaging material for the post-COVID-19 era. Biopolymer-based food packaging materials are possible
alternatives to non-biodegradable packaging and could solve many underlying issues. Since biopolymers are biodegradable, their contribution to municipal solid waste will be markedly reduced, this will solve the issues rising from single use packages. Several biopolymers, such as alginate, carrageenan, and chitosan, have been commonly used in the fabrication of biodegradable food packaging films, and have been reported for their antiviral activity. Packaging materials made from antiviral biopolymers act on the viral particles on their surfaces and, hence, will avert cross-contamination. Addition of sustainable additives such as nanomaterials, natural oils, and herbal extracts into these polymer films is also reported to enhance the antiviral potential of these films. From a sustainability perspective, the use of natural oils and plant extracts could be a completely natural, economic, safer, and eco-friendly solution (Bianculli et al., 2020; Cermelli et al., 2011; Falcó et al., 2019; Ito et al., 1987; Mallapour et al., 2021; Merigan and Finkelstein, 1968; Priyadarshi et al., 2021; Roy et al., 2021; Saedi et al., 2021; Sharif et al., 2021; Witvrouw and De Clercq, 1997).

Functional carbon dots, metal-nanoparticle-based graphene oxide, and other nanomaterial-based coatings can be employed to develop antiviral food packagings (Basak and Packirisamy, 2020; Delumeau et al., 2021). The organic compound cinnamaldehyde with virucidal activity has been reported against norovirus surrogates, murine norovirus, feline calicivirus, and hepatitis A virus (Fabra et al., 2016). Investigations have proved that antiviral materials prepared incorporating rosemary, raspberry, and pomegranate extracts, were empolyed to cover low-density polyethylene (LDPE) films to yield functional food packaging, exhibiting antiviral activity on 6 bacteriophage (a surrogate for airborne viruses) (Ordon et al., 2021a, 2021b). ZnO nanoparticles, carvacrol, and germiloid-based antiviral coatings have also been proven against 6 bacteriophage (Mizielińska et al., 2021). An electropun coating based on silver nanoparticles, silver nitrate, and polyhydroxyalkanoates proved effective against norovirus surrogates (Castro-Mayorga et al., 2017), and is proposed to be extrapolated to feline calicivirus and murine norovirus. These are few recommendations based on the available resources from biopolymers.

Other researchers have confirmed that the release of copper ions can help in the inactivation of HuCoV-229E on copper or copper alloy surfaces (Warnes et al., 2015), which has been confirmed by van Doremalen et al. (2020) (van Doremalen et al., 2020). His team reported the decreased viability of SARS-CoV-2 on copper surfaces and inactivation within 2 h. The use of nanomaterial coatings or films containing copper, silver, and zinc nanoparticles has been reported to hold the potential to prevent SARS-CoV-2 contamination of food packaging surfaces and reduce its Transmisión (Sportelli et al., 2020). The lack of proper trials on food matrices and associated food regulations are hurdles against the planning of novel food packaging. The major inference is that there are only shreds of evidence regarding the duration of coronavirus survival on different contact surfaces and in foods. The current guidelines issued by public health authorities and the government are obviously not prepared for the novel coronavirus SARS-CoV-2, it is documented that people will have to modify their “normal behaviour” to a “new normal.” This review highlights that the government and industrial sectors are yet to address and reevaluate the food packaging norms, post COVID-19. This is also a striking lacunae in this research area.

Food packaging, and their material choice, in the past, focussed on food containment and food safety points of view, now in this era, material consideration for food packaging materials need to also take into account and be prepared from the COVID-19 and its sanitization perspective. Post COVID-19 changes in the food packaging industry are mandatory to reassess their goals to upgrade, the following suggestive directions are proposed: (i) choice of antiviral material surfaces as choices for food packaging materials; (ii) need for research investigations in order to study the interaction and reactions mediated through spraying sanitizers and disinfectants and soaps with food packaging materials, in order to be able to have a clear picture to plan for scaling up the material properties, (iii) in order to reduce the possible effects of chemical and sanitizer impacts on plastic food packaging materials, leading to release of toxic microplastics, replacement of plastics with biocompatible and sanitization compatible/feasible biodegradable polymers is proposed, (iv) reusable food packaging materials, (v) fabrication of robust packaging materials that will be impenetrable for the virus to compromise, (vi) sanitizer resistant/inert labelling printing ink selection and (vii) sanitizer protective coatings on food material surfaces. These are fuel for thought for realigning and improvising the current system, with this perspective we lay out foundations, as building blocks endeavouring vision, foresight, awareness and motivation towards this rather unnoticed and neglected aspect, much need in fine-tuning the future of food packaging materials.

In this era where nanotechnological aspects have indeed taken over all domains, be it science or engineering, or medicine, there are definitely many nanomaterials that can offer towards betterment and refinement of the surfaces of the food materials. Nanostructured surfaces can act as superhydrophobic/microbial repellent surfaces, or photocatalytic surfaces which can degrade the microbes in contact (Gopal et al., 2004, 2007; Mahalakshmi et al., 2011; Muraleedharan et al., 2003; Muthu et al., 2018), this will enable the food packaging materials to stand alone in their fight against corona, without the help of chemical sanitizers that will affect the integrity of the packaging materials. Fluorescent nitrogen-phosphorus-doped carbon nanodots (NPCDs) -coated low-density polyethylene (LDPE) film crosslinked with 1 % aminopropyltriethoxy silane (APTES) via silane-hydroxyl linking as a food-grade wrap significantly reduced bacterial counts in a raw chicken food model (Bajpai et al., 2020; Dhiman et al., 2022; Sharma et al., 2021).

Of course, when talking about revising the food packaging industry with anti-COVID-19 materials, one needs to understand that high production costs are involved. To avoid this there are other sanitizer-free options that could be kept in order to do away with the corona fear with respect to food packaging material surfaces. One such method involves creating a decontamination zone outside the house that is separate from where daily life activities go on. This is where the items that have come in from outside suspected of surface contamination with COVID-19 have to be piled up for at least a period of 3–7 days and then they can be taken into the house without fear of COVID-19. This zone is the decontamination zone, which can serve as an enclosed zone. Nonetheless, the expert opinion remains, as long as hands are properly washed and sanitized after touching any food material packages, there may not be a real need for a food material face-lift. Hereagain, we zero down to the point that the gravity of the situation; whether the sanitization procedures, or sterilization methods are really affecting the food packages, is so, that is when mandatory action/changes may be required.

Fig. 4. Results of a pubmed search using the keywords, ‘COVID-19 and food packaging materials’ revealing a meagre 38 reports, indicating the lack of research awareness in this allied field.
6. Conclusions

The survival of COVID-19 on material surfaces as the fundamental mode of fomite transmission, has been a concern and has been somewhat disclosed through a handful of studies that have been published in the last decade. However, the effect of the sanitation and disinfection chemical use on food packaging material, although being an important subject has not been investigated till date. This commentary projects the chief concern that might brew up owing to the interaction of sanitizers and soaps used for disinfection with food material package surfaces. Validating these concerns that might brew up owing to the interaction of sanitizers and soaps used for disinfection with food material package surfaces. This impact of sanitation procedures on food material surfaces is unassessed.

At this stage, these are views and perspectives of possibilities, to approve the face-to-face and the dangers of COVID-19 fomite transmission facts alone. The next generation of sustainable food packaging to preserve our environment in a circular economy context. FRONT. Nutr. S. 2018.100121.

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