Ioannis Skartsaris

Thesis proposal on

'' The future potential of 3D food printing technology, environmental benefits and nutritional alterations''

Mechanization has been one of the prominent driving forces behind the major societal transformations since the industrial revolution to the present. The shift from hand labor, consisting of repetitive movements and standard patterns, to full machinery implementation in all aspects of production, had brought about unparalleled cost savings and efficacy. More specifically, mechanization in food production has given rise to substantial agricultural yields, but is yet to be implemented efficiently in the final stages of meal production. This opening had been targeted by miscellaneous innovations so far, the most captivating of which being state of the art androids mimicking common human movements and cooking patterns capable of fully preparing, cooking and serving meals. This is the evolution of yielding arm robot technology, originally orientated for mass producing demand driven meals like Pizzas, schnitzels and pancakes. Such aspirations however, have fallen flat so far due to the high costs they are associated with. In the pivotal stages these technologies currently find themselves in, equilibrium points between marginal costs and benefits are rendered rather improbable.

3d food printing, however, favors mass implementation. Even on the domestic level, the entry barrier in most cases remains as low as some hundred dollars. Should the technology eventually take off and competition kick in, this entry barrier is expected to decline even more. Apart from the financial liability it offers though, what is most remarkable about it, is not just the mere potential it holds to simplify meal preparation, but also the plethora of direct effects and positive externalities associated with the very nature of the medium itself. These externalities and effects hold direct and vital humanitarian, societal and environmental benefits either when the technology is applied on the domestic level, as well as adopted by the industry. The discourses this thesis hopes to deliver, will appertain to the both ends of the spectrum. This means targeting both microscopic agents like households, artisanship and small industries, as well as, multinational corporations, state agencies, and the industry.

With present day production patterns, there is a significant market failure occurring in several aspects of food production. Fordism production patterns are mostly inapplicable in developing countries due to the high entry barriers associated with machinery acquisition and the wider industrial reformation of production. Consequently, developing countries lose a significant portion of added value they would otherwise benefit from, if they indulged in producing and exporting finished food products instead of raw materials instead. Moreover, this constitutes a less effective supply chain structure as food processing has no direct proximity to material production. Food printing technology, if diffused accordingly, holds potential to ease access to domestic production by disentangling food manufacturing from the complexity of Fordism production patterns and even render reformation of wealth accumulation outlines, realizable in the level of rural communities in the developed world.

As is the case with all major technological breakthroughs however, additive technology bears significant alterations to the very nature of (future) nutrition. The medium works in the favour of easily applicable, high in demand, but of low nutritional quality products like pizzas, candies, burgers, chocolate or cookies. At the moment, any significant interest in complex meals with higher nutritional value cannot be seen. As is the case with all industrial reforms, in the spotlight initially come products which appeal to mass demand while being of low cost. Especially in the sector of food production,

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health concerns, can be mostly seen left aside. Similar adoption patterns, we have seen in the past with every alteration in the global food production and consumption structures. Contrary to that though, on the other hand, 3d food printers are able to manufacture meals of exact nutritional qualities tailored to each individual's needs. That can be achieved by constant monitoring through biometric sensors, or pre-determined by individualized dietary plans. All in all, edible additive technology is a double-edged sword with both positive and negative effects to future food consumption. In the scope of this thesis, I will attempt to scrutinize and make the most out of published information regarding possible impacts on the nutritional quality of a 3d-printed food nourished reality.

Additive technology has taken an accountable interest in the field of entomophagy presenting innovative breakthroughs in food and foodstuffs fabrication. Insect eating carries the weight of great hope against malnutrition and hunger while offering the most efficient, sustainable and environmentally friendly way to convert vegetative biomass to high-quality protein. Supplementary to that, insects are abundant, cheap to acquire, easy to cultivate and reproduce. Should the taboo of entomophagy in the western societies be overcome, an ever-growing world would be substantially fed without further environmental tolls. This is where 3d food printing takes the lead by realizing meal manufacturing that suits western aesthetics and answers to a structuralized constant demand. Burgers and cereal bars are two examples amongst the multitude of possibilities.

There is also ambitious research carried out in producing edible lab–grown proteins without slaughtering animals but rather, using them as donors for the acquisition of the principal cells from which entire animal tissue can be reproduced and printed to resemble miscellaneous food products -or even generate originals-. Exotic as it may seem, this has already met with success on the lab scale. The technology to bio-print artificial edible animal tissue is already here and constitutes but a fraction of ''Bioprinting'' that has proven successful in areas of far superior complexity like reproducing fully functioning and transplantable human organs from scratch. What remains still unclear, however, is the extent to which such a feat proves realizable on the industrial level. Moreover, though the technological background driving this evolution is getting researched and developed day by day, there has been no significant study for the societal, environmental, economic or even humanitarian effects it holds in store yet. This leaves a significant margin for both this thesis as well as future studies to scrutinize upon.

To sum it up, on one hand we can clearly conceive negligible industry interest for nutritional and complex meals that seem too demanding, thus less profitable for the current technology; on the other hand, cannot neglect aspiring steps in the field of healthy nutrition by most prominent key players in the field. Inquiries about the future nutritional qualities in a 3d printed food society though, cannot be adequately tackled based on just current bibliography and published data. Such resources are rather limited during the infant steps additive technology is treading upon presently.

Therefore, through a qualitative research approach and semi-structured interviews, the thesis targets a double front. Firstly, to assess the present-day status quo of additive technology, in conjunction with evaluating the potential to humanitarian and ecological betterments whilst debunking any

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over-optimistic and unlikely claims and aspirations of the industry. This shall be achieved through data accumulation from both academic publications and the internet. Secondly, to appraise the stakeholder's knowledge and interest in the altruistic and environmental perks additive technology holds. This will be achieved through interviews or questionnaires to small and middle scale startup enterprises of the field.

Study Program	Bioeconomy M.Sc.
Timetable	6/17 until 12/17
Supervisor	Dr. Cinzia Piatti
First examiner	Prof Dr Claudia Bieling
Second examiner	TBA

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