SPATIAL DISTRIBUTION OF COFFEES FROM MINAS GERAIS STATE AND THEIR RELATION WITH QUALITY

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ABSTRACT: Coffee is the second most important agricultural exportation product in Brazil, constituting one of the main income sources of the Brazilian economy. The state of Minas Gerais is the country's biggest coffee producer. Recently, coffees produced in the state have won national specialty coffee contests, which has increased their commercial value and established them in the market. Due to the necessity of more information on areas with potential for producing quality arabic coffees (*Coffea arabica* L.), the objective of this work was to relate the coffees entered in the Quality Contest-Coffees from Minas Gerais, in 2007 and 2008, with the environmental characteristics of the state's districts. The samples were distributed in four stages, the first composed of all the coffees entered in the contest, and the last composed only of the pre-finalists. The samples were categorized into natural and CDs (pulped natural, demucilaged and demucilaged/pulped natural). The spatialization of the samples from both years was done using Kernel maps to visualize the intensity of sample concentrations in each stage of the contest. The results show that in the first stage the samples were well distributed, with medium, high and very high intensity focus. In the fourth stage, a high concentration in the Sul de Minas region was observed in both years for both coffee categories.

Index terms: Spacialization, sensorial quality, environment.

DISTRIBUIÇÃO ESPACIAL DE CAFÉS DO ESTADO DE MINAS GERAIS E SUA RELAÇÃO COM A QUALIDADE

RESUMO: *O café é o segundo produto na pauta das exportações agrícolas do Brasil, constituindo uma das mais importantes fontes de renda para a economia brasileira. O estado de Minas Gerais destaca-se como o maior produtor. Os municípios mineiros vêm conquistando concursos de qualidade de café no âmbito nacional, abrindo espaço no mercado e agregando valor ao produto. Diante da necessidade de se conhecer as áreas com potencial de produção de cafés arábica (Coffea arabica L.) de qualidade, objetivou-se, neste trabalho, relacionar a qualidade sensorial dos cafés participantes do Concurso de Qualidade – Cafés de Minas nos anos de 2007 e 2008, com características ambientais dos municípios do Estado. Para a realização das avaliações, o conjunto de amostras foi distribuído em quatro fases, sendo a primeira constituída por todos os inscritos e a última apenas pelos cafés pré-finalistas. Os cafés foram categorizados em natural e CDs (cereja despolpado, descascado e desmucilado). A espacialização das amostras de ambos os anos foi realizada utilizando-se mapas de Kernel para a visualização da intensidade de concentração de amostras, em cada fase do concurso. Os resultados evidenciaram uma boa distribuição das amostras, com focos de intensidade amostral média, alta e muito alta. Na quarta fase observou-se uma alta concentração de amostras na região do Sul de Minas, para ambos os anos e categorias. Com esses resultados conclui-se que a região Sul de Minas destaca-se pela produção de cafés com qualidade da bebida, por permanecer até a quarta fase do Concurso de Qualidade – Cafés de Minas, realizados nos anos de 2007 e 2008.*

Palavra-chave: Espacialização, qualidade sensorial, ambiente.

1 INTRODUCTION

Minas Gerais state is Brazil's main coffee producer, with a share of 50,99% of the country's total production (COMPANHIA NACIONAL DE ABASTECIMENTO - CONAB, 2008), almost only arabic coffees (*Coffea arabica* L.) Due to its size and its particular charateristics, the state's coffee lands are distributed in four main environments, constituted by the regions Sul de Minas (South/Southeast), Matas de Minas (Zona da Mata/Rio Doce), Cerrados de Minas (Triângulo Mineiro) and Chapada de Minas (Vale do Jequitinhonha/Mucuri). These regions present different environmental, social and economic

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conditions. The coffees from Minas Gerais are characterized by a diversity of flavors and aromas. This diversity, which has distinguished them in both the national and international markets, is mainly due to variations in climate, altitude and production systems, among others. Climate has a direct influence on coffee's development phases. The reproductive phase begins with floral induction; floral initiation; differentiation, growth and development of the button's floral pieces; dormancy of the floral button and blossom (flower opening). Each of these phases is affected by particular exogenous and endogenous factors, which determine different growth and development patterns in the floral organs according to the coffee cultivar and the predominant environmental conditions (ALVES, 2008; ALVES; LIVRAMENTO, 2003).

Coffee maturation begins with an increase of respiratory activity and ethilene synthesis, accelerating sugar and acid metabolization, clorophile degradation and pigment synthesis (CLIFFORD, 1985). The mature coffee fruit is rich in sacarose, an important substance in beverage quality as it is an imporant precursor of coffee flavor and aroma, although aroma formation involves more complex reactions (GEROMEL et al., 2006).

Picking also has a direct influence on coffee quality (CARVALHO, 1997; CORTEZ, 1997; PIMENTA, 2003). The selection of the coffee fruit in the correct stage, without contamination by any residue, is important in obtaining quality coffee. According to Borém (2008), the choice of a coffee processing method must take into consideration its cost/benefit relation, the quality standard desired and the compliance with environmental legislation requirements. Coffee can be processed by the wet or dry methods. In dry processing, the fruit remains intact throughout the whole process, resulting in coffees denominated dried cherry or natural, which produce a sweeter beverage with more body and moderate acidity (SILVA, 1999, 2004; VILLELA, 2002). The pulped cherries and demucilaged and demucilaged/pulped natural coffees, obtained by wet processing, produce a softer beverage with moderate acidity and body (LINGLE, 2001).

In Minas Gerais state, institutions such as the Empresa de Assistência Técnica e Extensão Rural de Minas Gerais (Technical Assistance and Rural Extension of Minas Gerais), in association with the Universidade Federal de Lavras-UFLA (Federal University of Lavras) and other research institutes and private organizations, promote anually the Quality Contest-Coffees from Minas Gerais. To encourage coffee producers to constantly improve their product, the contest awards prizes to the winners. The contest encompasses many stages in which, first the physical aspects and, from the second stage onwards, the sensorial attributes of the coffees produced in the state's municipal districts are evaluated.

As an example of the contest's success, in its last edition in 2008 the winning products in the natural and pulped natural coffee categories were sold for U$ 605 and U$ 880 (R$ 1,030.00 and R$ 1,500. 00) respectively. These values are significantly above the non-specialty coffee market, where a 60kg sack is sold for approximately U$140 (R$ 240.00).

The state's coffee regions present different environmental characteristics. The Sul de Minas region, which encompasses the geographic areas in the parallels 21º 13' to 22º 10' latitude S and 44º 20' to 47º 20' longitude W, is characterized by mountainous areas, with altitudes between 700 and 1.080m, and climate classified between the B_2 and B_3 types (humid), predominant in a large part of the region (FUNDAÇÃO CENTRO TECNOLÓGICO DE MINAS GERAIS - CETEC, 1983; MINAS GERAIS, 2008; SCOLFORO et al., 2007).

The Cerrados de Minas region encompasses the areas in the parallels 16º 37'to 20º 13' latitude S and 45º 20' to 49º 48' longitude W and is characterized by plateaus, with altitudes between 820 and 1.110m, and B1 type climate (humid). The region has potential for producing a fine coffee beverage with more accentuated body (CETEC, 1983; MINAS GERAIS, 2008; SCOLFORO et al., 2007).

The Matas de Minas region, encompassing the areas in the parallels 40º 50' to 43º 36' latitude S and 18º 35' to 21º 26' longitude W, is characterized by mountainous wet areas, with altitudes between 400 and 700m, annual mean precipitation between 1534 to 1647 mm and 1077 to 1190 mm and climate varying from Humid (B_4, B_2 e B_1) to Sub-humid (C_2) and Dry Sub-humid (C_1). The region is also subject to fog and may produce a hard to rio beverage (CETEC, 1983; MINAS GERAIS, 2008; SCOLFORO et al., 2007).

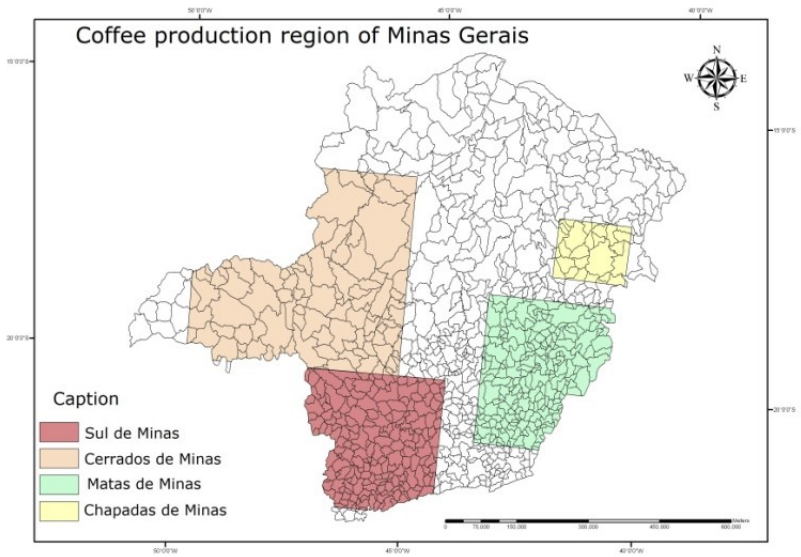

Figure 1 – Coffee Production Regions – MG.

The Chapadas de Minas region encompasses the geographic areas in the parallels 17º 05' to 18º 09' latitude S and 40º 50' to 42º 40' longitude W. The region is characterized by an altitude of 1.099 m, annual mean precipitation which varies considerably, reaching extremes of 1191 to 1305 mm and 733 to 847 mm, and Dry Sub-humid (C_1) and Semi-arid (D) climate. It presents reduced insolation, lack of frost, high humidity levels and potential for producing a hard to rio beverage (CETEC, 1983; MINAS GERAIS, 2008; SCOLFORO et al., 2007).

The climate in the state's different coffee production regions is influenced by the interactions between altitude and longitude. Laviola et al. (2007), working with coffee production at different altitudes, observed that it influences the allocation of photoassimilates in leaves and fruits. Decazy et al. (2003) affirm that altitude and climate play an important role, through temperature and light availability, during the crop's maturation period.

According to Cortez (1997), the relations between climate and beverage quality in the Matas de Minas region is somewhat similar to the Jequitinhonha region, with a low humidity deficit and accumulation of water in the planting and drying sites.

The Cerrados de Minas coffees were distinguished in the Brazilian Sustainable Coffees Program, promoted by the Associação Brasileira da Industria do Café-ABIC (Brazilian Coffee Agribusiness Association) in association with the Conselho das Associações dos Cafeicultores do Cerrado-CACCER (Counsel of the Cerrado Coffee Producers' Associations)[7]. This region, the first in Brazil to have an internationally recognized geographic demarcation, also has a certification of origin, traceability and sustainability program. In the national and international coffee markets there is a growing demand for specialty coffees with exceptional aroma and flavor and distinct sweetness, acidity and body characteristics. There is also a growing demand for products whose qualities and characteristics are related to climate and the geographic environment.

The objective of this work was to study the spatial distribution of the quality of the coffees entered in the Quality Contest-Coffees from Minas Gerais, in 2007 and 2008, and its relation to the environmental and geographic characteristics of the districts in which they were produced.

2 MATERIAL AND METHODS

This work was based on data from the Quality Contest-Coffees from Minas Gerais, promoted annually by Emater-MG and the UFLA. In 2007 and 2008, the contest accepted only samples of arabic coffees (*Coffea arabica* L.), type 2 and upwards, in

[7] http://www.cafedocerrado.org

compliance with the Brazilian Ministry of Agriculture Normative Instruction nº 8 (BRAZIL, 2003), only soft or superior beverage, sieve 16 or above, with a maximum 5% leakage and maximum water content of 11,5%. The coffee samples, separated into natural and CDs (pulped natural, demucilaged and demucilaged/pulped natural) categories, were evaluated by a panel of at least ten classifiers and tasters.

The samples were classified according to their physical characteristics. Those that presented yellow, white or discrepant coloring, and those that did not meet the above regulation's minimum requirements, were disqualified. The classified samples were evaluated according to the Associação Brasileira de Cafés Especiais-BSCA (Brazilian Association of Specialty Coffees) regulations. In the sensorial analyses, the beverage flavor, aroma, body, acidity, sweetness and fragrance were evaluated.

The data from the contest was provided by Emater-MG in an electronic spreadsheet. To characterize the environment in the participating districts, the temperature, precipitation and humidity index from the climate normals in the period 1961/1990, provided by the ZEE-MG (SCOLFORO et al., 2007) in Geotiff format, were used. The environmental characterization and spatial distribution of the samples was done using the Geographic Information System (GIS) and TerraView open code.

The samples from 2007 and 2008 (1161 and 1189, respectively) were spatialized based on the geographic location (latitude and longitude) of the seat of their district of origin. In GIS, this data was integrated into the state's districts' digital geographic database, issued by GeoMinas (MINAS GERAIS, 2009). Kernel maps of the samples (1161:2007 and 1189:2008) were generated by TerraView for each phase, evaluating the natural and pulped natural coffee categories and the total samples in each year. The areas containing the greatest number of events, or the greatest number of samples inside the specified adaptive radius, were denominated *Hot Points*. Kernel Maps for phases 1, 2, 3, 4 of each category, in both years, were generated.

3 RESULTS AND DISCUSSION

3.1 Analysis of phases 1, 2, 3 and 4 of the natural coffee category in 2007

In Figures 2, 3, 4 and 5 different regions are represented in different colors. The red represents a region with a very high concentration of samples denominated *Hot Point*. Orange is the region with a high concentration. The regions with medium, low and very low concentrations are represented, respectively, by the colors yellow, green and blue.

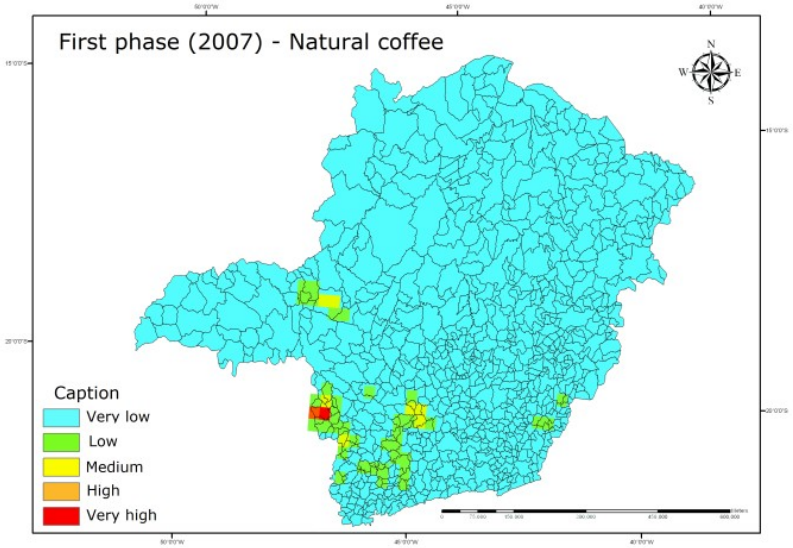

Figure 2 – Concentration of the natural coffe samples in the first phase of the quality contest, in 2007.

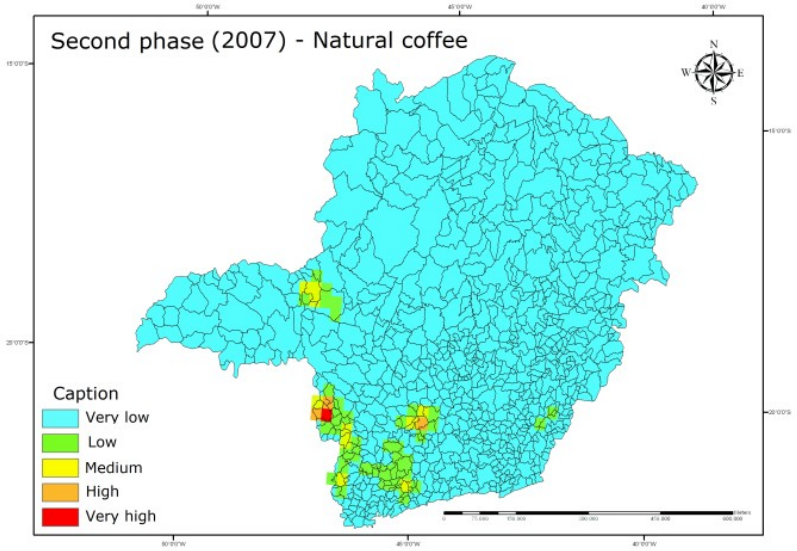

Figure 3 – Concentration of the natural coffee samples in the second phase of the quality contest, in 2007.

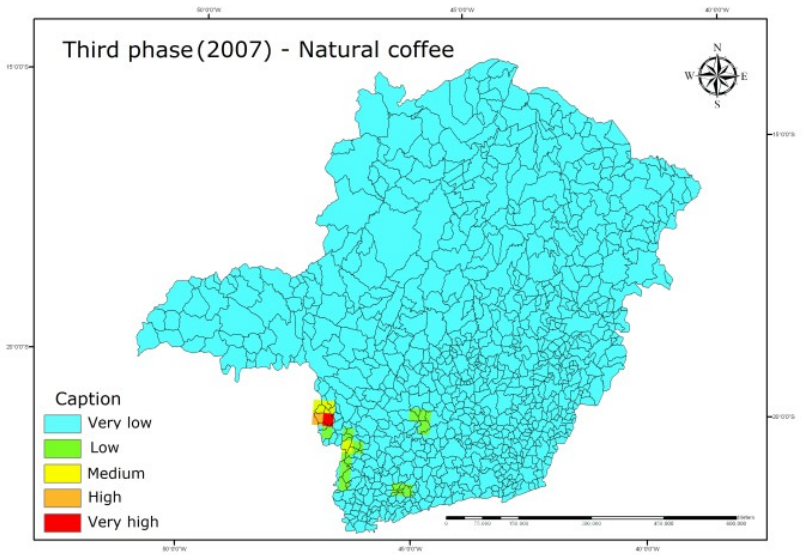

Figure 4 – Concentration of the natural coffee samples in the third phase of the quality contest, in 2007.

In the map of the first phase of the natural coffee category in 2007 (Figure 2), the *Hot Point* is located in the southeast of the Sul de Minas region. Medium intensity sample events are also observed in the Cerrados de Minas and Sul de Minas regions. In Figure 3 the medium and high intensity sample focus are better distributed between the Cerrados de Minas and Sul de Minas regions and a low intensity sample concentration is observed in the Matas de Minas region. The *Hot Point* remains in southeast of the Sul de Minas region, as shown in Figure 3.

In the third phase of the contest (Figure 4), the same characteristics as shown in Figure 3 were observed. However, part of the high and medium intensity sample focus, located in the regions Cerrados de Minas and Campos das Vertentes (South of Minas Gerais state), disappeared in this phase (Figure 4) and the *Hot Point* remained fixed in the southeast of the Sul de Minas region.

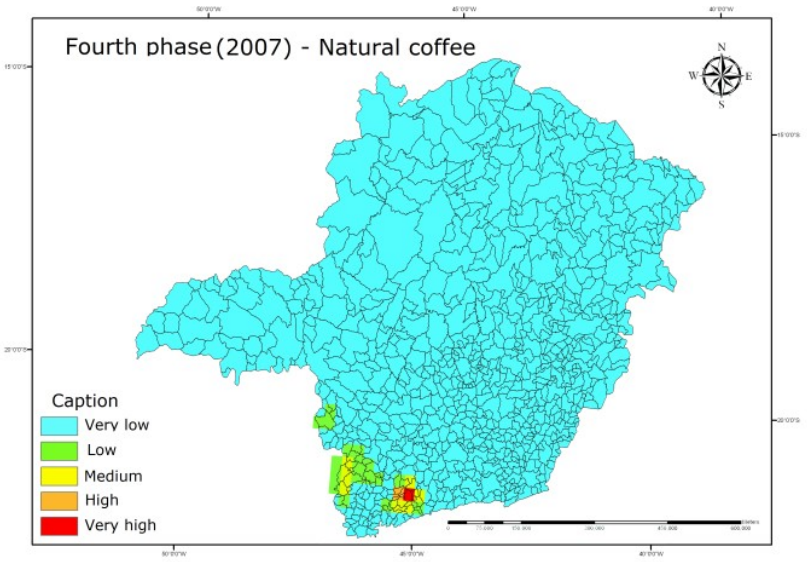

Figure 5 – Concentration of the natural coffee samples in the fourth phase of the quality contest, in 2007.

In the map of the fourth phase (Figure 5) the *Hot Point* migrated from the southeast to the south of the Sul de Minas region. In the Cerrados de Minas region, specifically in the Triangulo Mineiro area, there is a difference between the maps generated for the first phase (Figure 2) and the second (Figure 3). A migration of the *Hot Point* was observed from Patrocínio district to Monte Carmelo in the Cerrado region. According to the database, 50% of the samples from Patrocínio were disqualified in the contest's physical evaluation, while the samples from Monte Carmelo had a 100% approval, which might explain the region's distribution. In the third phase (Figure 4) of the contest, the *Hot Point* was concentrated in the south of the Sul de Minas region. The region is mountainous, with a peculiar topography that is influenced by the Mantiqueira chain of mountains. Its altitude varies between 1000 and 1800 m and it is geomorphologically constituted by the Canastra mountains complex and the plateau of the Paraná river sedimentar basin. The region's climate is characterized as superhumid, with annual mean temperatures between 12 and 19 °C (CETEC, 1983). Working with *"terroir"* specialty coffees from Costa Rica, Avelino et al. (2002) observed that annual precipitation data characterize a region's climate and this portion of annual precipitation, when similar to the others, could equal the climate conditions of the other regions geographically near.

The appearance of the *Hot Point* in the south of the Sul de Minas region in the contest's fourth phase (Figure 5) is highly influenced by the samples from Carmo de Minas. This district has a tradition of producing quality coffees and, in the last few national coffee quality contests, one of its producers greatly impressed the international tasters[8]. Some authors affirm that climate and altitude play an important role during coffee's maturation period due to temperature, light and water availability (CLIFFORD, 1985; DECAZY et al., 2003, cited by BERTRAND et al., 2006), which could explain the sample distribution pattern in the Sul de Minas region.

3.2 Analysis of the pulped natural coffee category in phases (1, 2, 3 and 4) in 2007

Figures 6, 7, 8 and 9 present the first, second, third and fourth phases, respectively. In the map of the first phase (Figure 6), where all the samples entered in the pulped natural coffee category were concentrated, there was a medium intensity sample focus in the Matas de Minas region, while the *Hot Point* was located in the south of the Sul de Minas region. In the second phase map (Figure 7), high

[8] http\www.revistacafeicultura.com.br

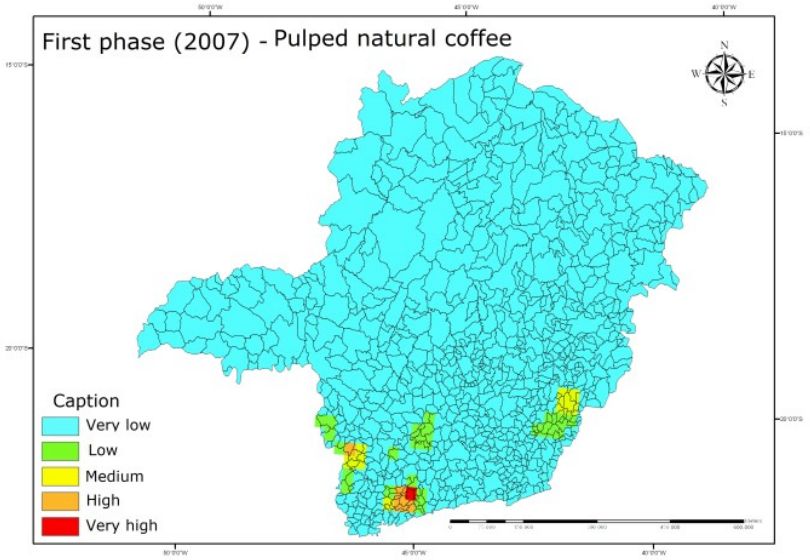

Figure 6 – Concentration of the pulped natural coffee samples in the first phase of the quality contest, in 2007.

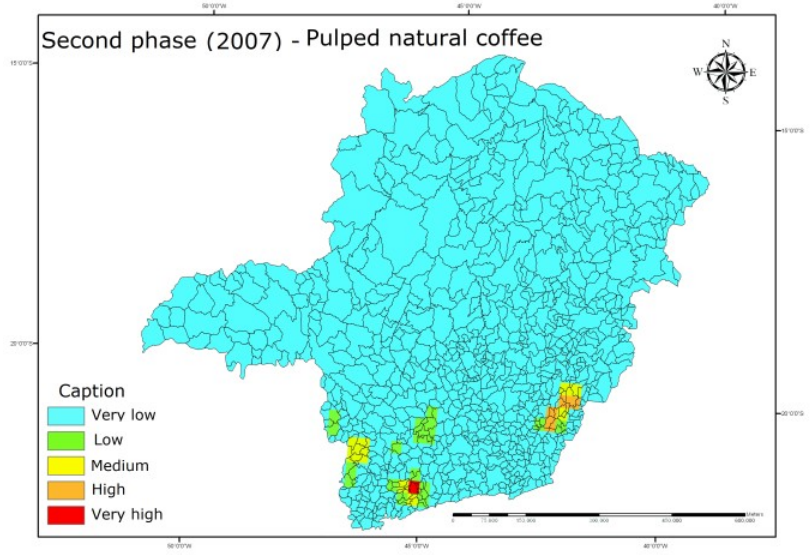

Figure 7 – Concentration of pulped natural coffee samples in the second phase of the quality contest, in 2007.

intensity sample concentrations were observed in the Matas de Minas region, while the *Hot Point* remained in the south of the Sul de Minas region. Analyzing the third phase (Figure 8) of the natural pulped coffee category in 2007, a slight increase in the *Hot Point* concentration in the south of the Sul de Minas region was observed, with a *Hot Point* appearing in the Matas de Minas region while the sample concentration intensity in the Campo das Vertentes region remained slight. In the fourth phase map (Figure 9) the *Hot Point* that was previously concentrated in the Matas de Minas region in the third phase map (Figure 8) migrated, in the contest's fourth phase (Figure 9) to the south of the Sul de Minas region. The coffees from Carmo de Minas district, 47% of which reached the fourth phase (in other words the pre-finalists) of the contest corroborated the *Hot Point* remaining in the Sul de Minas region, in the pulped natural coffee

category. This fourth phase could indicate the regions with potential for producing coffees with good sensorial quality, that is specialty coffee beverages. Regarding the Matas de Minas region, although its participation in the contest is remarkable, few of its samples reached the pre-finalist phase, as shown in the maps for 2007. Campanha et al. (2007) note that, although coffee production is one of the region's main agricultural activities, most of its producers are family farmers whose crops are located on slope soils. According to some authors, the region presents low water deficit, temperatures between 19 and 24 °C and moisture accumulation in the planting and drying sites, factors which contribute to fermentation processes that affect the product's quality and which could explain the results in the contest's phases (CARVALHO et al., 1997; CORTEZ, 1997; VILELA, 1997).

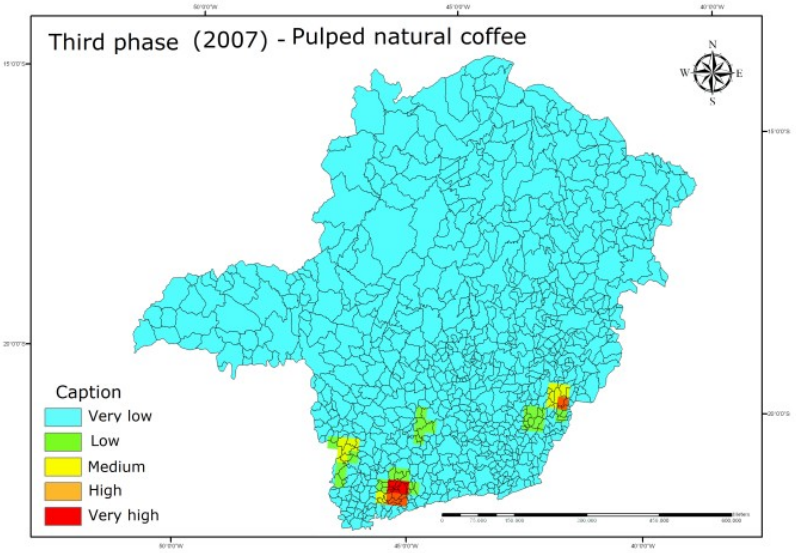

Figure 8 – Concentration of the pulped natural coffee samples in the third phase of the quality contest, in 2007.

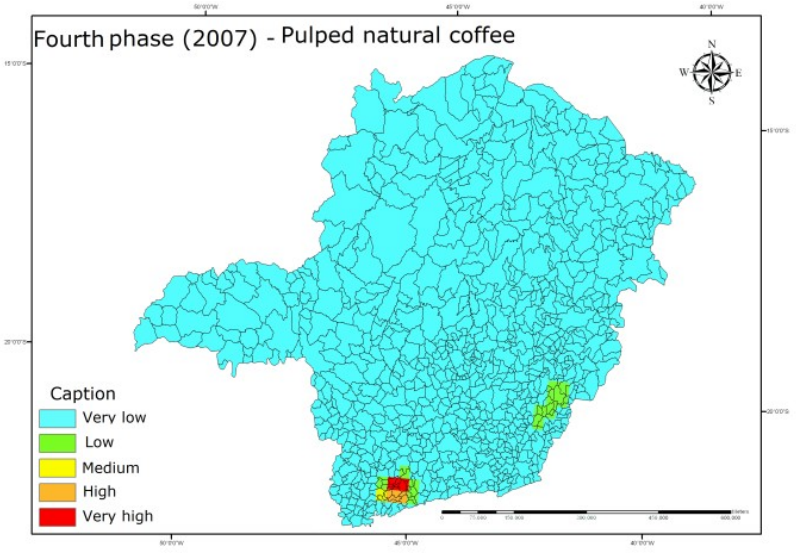

Figure 9 – Concentration of the pulped natural coffee samples in the fourth phase of the quality contest, in 2007.

3.3 Analysis of the natural coffee category in phases (1, 2, 3 and 4) in 2008

Figures 10, 11, 12 and 13 present the first, second, third and fourth phases, respectively. The map of the first phase of the 2008 contest (Figure 10) presents low intensity sample concentrations in the Cerrados de Minas, Matas de Minas and Sul de Minas regions. In the Sul de Minas region the *Hot Point* is located to the southeast, with high intensity sample concentrations around it.

In the second phase map (Figure 11), the *Hot Point* migrated from the Sul de Minas (Figure 10) to the Cerrados de Minas region (Figure 11), more precisely the Triangulo Mineiro area. In the southeast of the Sul de Minas region, a medium intensity sample concentration is now observed. In the contest's third phase (Figure 12), two *Hot Points* appear, one to the southeast of the Sul de Minas region and another in the Triangulo Mineiro area in the Cerrados de Minas region. In the Cerrados de Minas region higher sample concentrations were observed in comparison to the Sul de Minas region, as can be seen in Figures 11 and 12. In the fourth phase map (Figure 13), the *Hot Point* remains in the southeast of the Sul de Minas region, with only low intensity sample concentrations in the Matas de Minas and Cerrados de Minas regions.

In the natural coffee category, the four phases in 2008 were similar to the phases in the previous year. The spatial pattern of the natural coffee in the first, second and third phases of the 2007 and 2008 contests were completely different. In the maps generated for the first (Figure 10) and the second (Figure 11) phases, although there was a medium intensity sample concentration in the southeast of the Sul de Minas region in 2008, the *Hot Point* is concentrated in the Triangulo Mineiro, influenced mainly by the samples from Monte Carmelo district, with a total of 21 samples in the first phase and only 8 in the second. In the third phase (Figure 12) in 2008, the samples are concentrated again in the southeast of the Sul de Minas region. However, they did not migrate to the extreme south of the region, as in 2007. The natural coffee samples from 2007 were always concentrated more in the Sul de Minas, while in 2008 they are more distributed, with low intensity sample focus in the Triangulo and Matas de Minas regions. According to the literature (CORTEZ, 1997; PIMENTA, 2003; SILVA et al., 1997), in the Matas de Minas region, as the temperatures are higher, the picking period is prolonged and most of the region's producers carry out derriça and varrição harvesting, which can contribute to the lower quality of the product. The ideal for these regions is selective harvesting, which produces higher quality coffees (BORÉM, 2008). The difference observed from one year to the other could be due to the change in the harvesting process and also to the organization of the event.

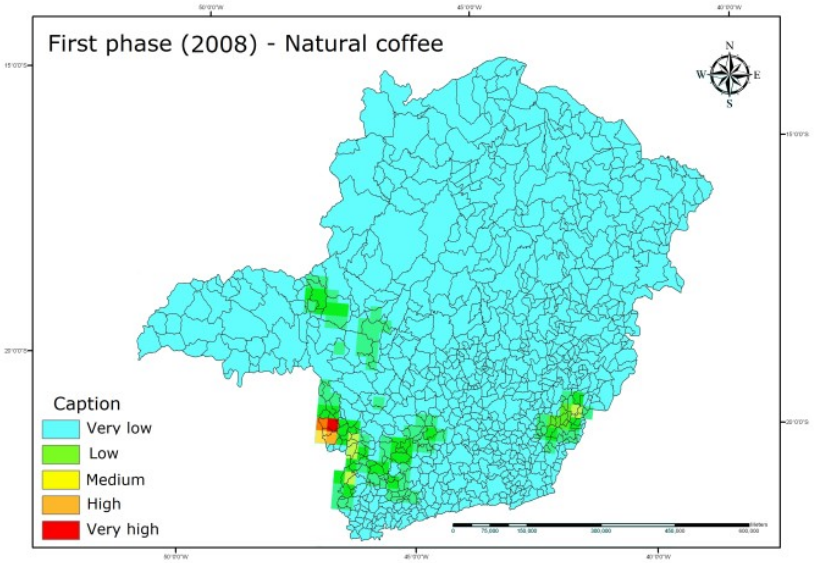

Figure 10 – Concentration of the natural coffee samples in the first phase of the quality contest, in 2008.

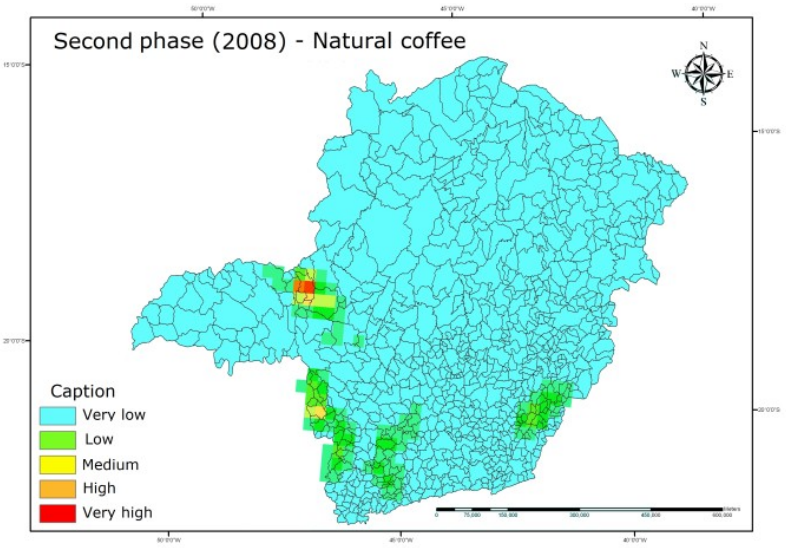

Figure 11 – Concentration of the natural coffee samples in the second phase of the quality contest, in 2008.

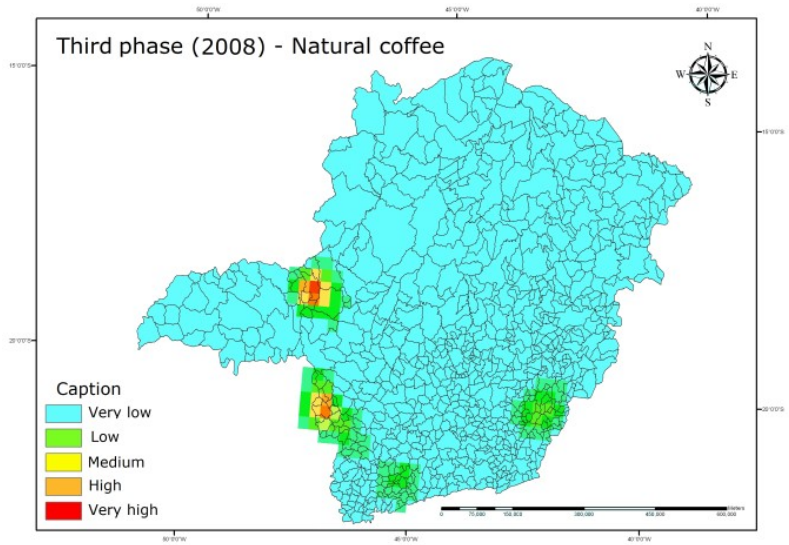

Figure 12 – Concentration of the natural coffee samples in the third phase of the quality contest, in 2008.

3.4 Analysis of the pulped natural coffee category in phases (1, 2, 3 and 4) in 2008

Figures 14, 15, 16 and 17 present the first, second, third and fourth phases. In the first phase map of the pulped natural coffee category (Figure 14) there is a greater distribution of the samples. The *Hot Point* is concentrated in the extreme south of the Sul de Minas region and a medium intensity sample concentration appears in the Triangulo Mineiro, which did not occur in 2007. Comparing the medium intensity sample concentrations in the first (Figure 14) and second phases (Figure 15), there is a migration of these samples, which in the first phase (Figure 14) were concentrated in the Cerrados de Minas region, more precisely in the Triangulo Mineiro area, to the micro-region of Poços de Caldas, Sul de Minas region. In the analyses of the first phase map of the pulped natural coffee category, in 2007 the medium intensity sample focus remains in the Matas de Minas region (Figure 16). However, this

is not observed in 2008 (Figure 14), when low intensity sample focus appeared in the Triangulo area. In the third phase map (Figure 16), the highest sample intensities were concentrated in the Sul de Minas region and the *Hot Point* was concentrated in the extreme south of the region. Comparing the pulped natural coffee category in both years, in the third phase of 2007 (Figure 8) two *Hot Points* were observed, one concentrated in the extreme south of Sul de Minas and the other in the Matas de Minas region while, in 2008, according to Figure 15, the *Hot Point* was fixed in the extreme south of the Sul de Minas region. In the fourth phase maps (Figure 17), the *Hot Point* is concentrated once more in the Sul de Minas region. In this phase, no significant sample means were observed in the other regions. This demonstrates the potential of the Sul de Minas region for producing quality coffees in the Quality Contest-Coffees.

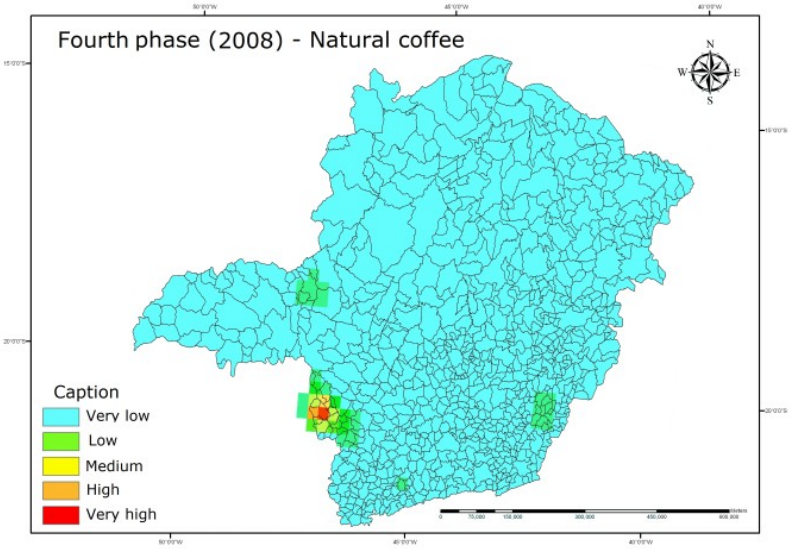

Figure 13 – Concentration of the natural coffee samples in the fourth phase of the quality contest, in 2008.

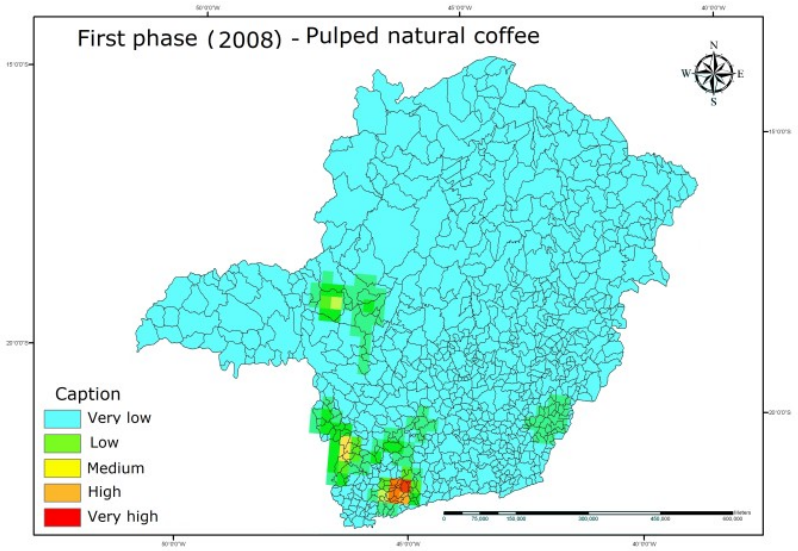

Figure 14 – Concentration of the pulped natural coffee samples in the first phase of the quality contest, in 2008.

To evaluate the spatial distribution of the quality of coffees produced in Minas Gerais state, coffee samples from the 2007 and 2008 Quality Contest – Coffee from Minas Gerais were used. Spatial analysis was carried out using the software TerraView 3.2.0 and the Kernel intensity estimator. The Kernel method was applied to estimate sample concentration in the state's mesoregions in each of the contest's phases. Although the approach of applying kernel estimation to evaluate coffee quality is new, the results obtained were in line with the objectives of the study. In both years, there was a migration of samples to the Sul de Minas (South) region, from the first phase of the contest to the last, verifying a larger concentration of these samples in the region.

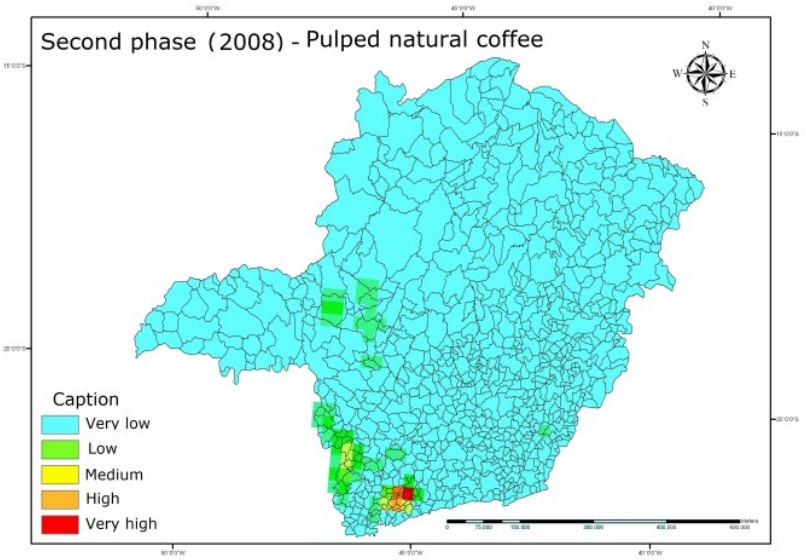

Figure 15 – Concentration of the pulped natural coffee samples in the second phase of the quality contest, in 2008.

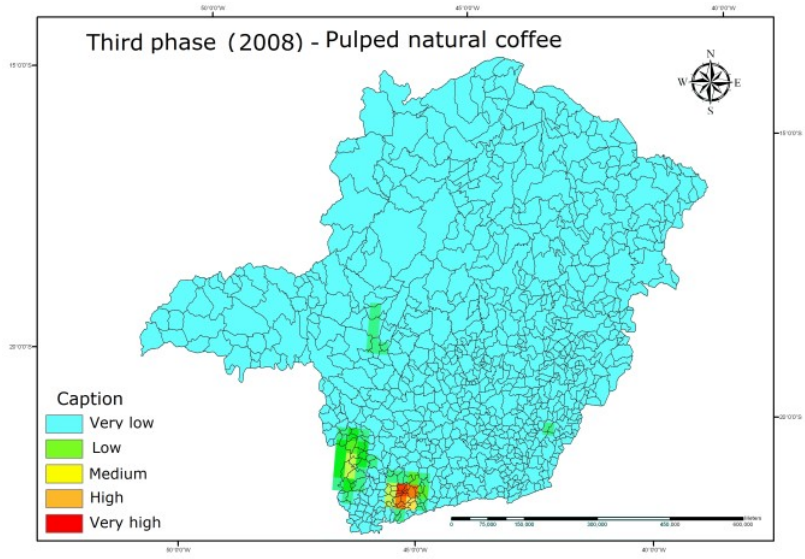

Figure 16 – Concentration of the pulped natural coffee samples in the third phase of the quality contest, in 2008.

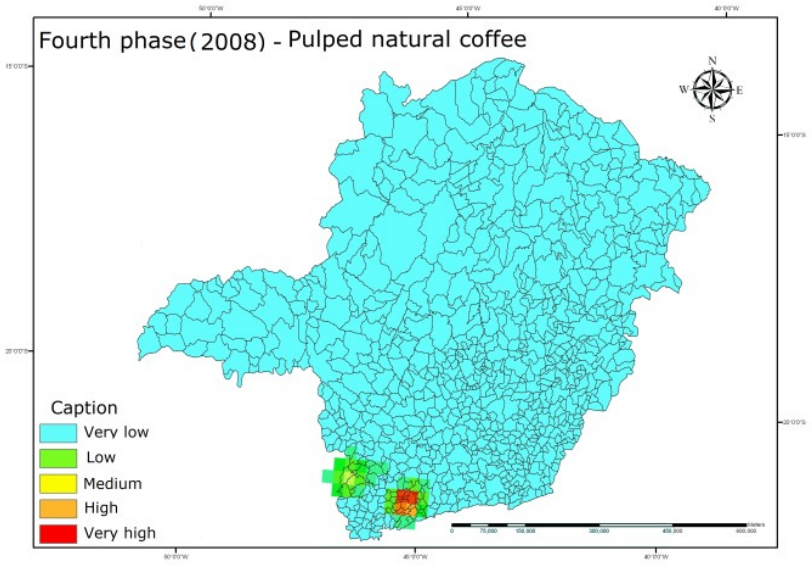

Figure 17 – Concentration of the pulped natural coffee samples in the fourth phase of the quality contest, in 2008.

4 CONCLUSION

The evaluation of the spatial distribution of the 2007 and 2008 Coffee from Minas Gerais Quality Contest's samples showed a higher concentration in the Sul de Minas (South) region in all of the contest's phases. This pattern is related to the region's adequate temperature and precipitation levels and high altitudes, all of which favor a higher quality product. Although the kernel method is an exploratory form of spatial analysis, the results obtained confirmed the region's potential for producing specialty coffees. Its increasing status in the international market and the awards received in national and international quality contests are a reflex of this potential.

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